DUKE ENERGY OHIO EXHIBIT______

BEFORE THE

PUBLIC UTILITIES COMMISSION OF OHIO

In the Matter of the Application of Duke Energy Ohio, Inc., for Recovery of Program Costs, Lost Distribution Revenue and Performance Incentives Related to its Energy Efficiency and Demand Response Programs.	)))))	Case No. 21-482-EL-RDR

DIRECT TESTIMONY OF

TRISHA A. HAEMMERLE

ON BEHALF OF

DUKE ENERGY OHIO, INC.

May 14, 2021

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I. INTRODUCTION

Q. PLEASE STATE YOUR NAME AND BUSINESS ADDRESS.

A. My name is Trisha A. Haemmerle. My business address is 139 East Fourth Street, Cincinnati, Ohio 45202.

Q. BY WHOM ARE YOU EMPLOYED AND IN WHAT CAPACITY?

A. I am employed by Duke Energy Business Services, LLC (DEBS), as Senior Manager, Strategy and Collaboration. DEBS provides various administrative and other services to Duke Energy Ohio, Inc., (Duke Energy Ohio or the Company) and other affiliated companies of Duke Energy Corporation (Duke Energy).

Q. PLEASE SUMMARIZE YOUR EDUCATION AND PROFESSIONAL QUALIFICATIONS.

A. I graduated from Ohio University with a Bachelor's Degree in Marketing. I started my career with Cinergy in 1997. I worked for Cinergy and Duke Energy from 1997 to 2010 developing, managing, and analyzing survey activities, as well as market research projects. Starting in 2009, I also managed the coordination of verification for the energy efficiency and demand response programs. I assumed my current position in 2010.

Q. HAVE YOU PREVIOUSLY TESTIFIED BEFORE THE PUBLIC UTILITIES COMMISSION OF OHIO?

A. Yes, I submitted testimony in support of Duke Energy Ohio's application for recovery of program costs, lost distribution revenue and performance incentives related to its Energy Efficiency (EE) and Demand Response (DR) programs, Case Nos. 14-457-

EL-RDR, 15-534-EL-RDR, 16-0664-EL-RDR, 17-781-EL-RDR, 18-397-EL-RDR, 19-622-EL-RDR, and 20-613-EL-RDR.

Q. WHAT IS THE PURPOSE OF YOUR TESTIMONY IN THIS PROCEEDING?

A. The purpose of my testimony in this proceeding is to discuss the history of Rider Energy Efficiency-Peak Demand Response (EE-PDR), Duke Energy Ohio's energy efficiency programs, and the successful achievements Duke Energy Ohio has had with its current portfolio of programs. My testimony will also discuss how the Company determines program cost-effectiveness and explain the Company's evaluation, measurement and verification process (EM&V) used to verify the results of its portfolio of programs. The testimony of Duke Energy Ohio witness James E. Ziolkowski will explain Rider EE-PDR and how it is applied to the programs to determine cost recovery.

II. HISTORY OF RIDER EE-PDR

Q. PLEASE EXPLAIN THE HISTORY OF RIDER EE-PDR.

A. Duke Energy Ohio proposed the Rider EE-PDR energy efficiency and peak demand cost recovery mechanism in its application in Case No. 11-4393-EL-RDR that was filed on July 20, 2011. The Company's application requested approval to implement Rider EE-PDR to replace Rider DR-SAW, which was due to expire on December 31, 2011. The application also proposed a mechanism by which to recover the costs it incurs in achieving the energy efficiency and peak demand reduction targets set by S.B. 221, and to provide the Company with an incentive to exceed the targets. The Public Utilities Commission of Ohio (Commission) approved a Stipulation and Recommendation resolving intervening parties' concerns and establishing Rider EE-PDR on August 15, 2012. In compliance with the Order, Duke Energy Ohio submitted an updated portfolio filing, Case No. 13-0431-EL-POR, to align the cost recovery mechanism with the portfolio of programs on April 15, 2013. The application was approved on December 4, 2013. The Company also filed and received approval for a new non-residential program, Small Business Energy Saver.[1] The Company filed a new portfolio, Case No. 16-576-EL-POR, for years 2017 – 2019 in 2016. On February 26, 2020, the Commission approved the Company's request to extend its existing portfolio (for 2017 – 2019) through the end of 2020.[2]

Q. HAS DUKE ENERGY OHIO UPDATED ANY OF ITS PROGRAMS TO BE OFFERED TO CUSTOMERS IN 2017 - 2020?

A. Yes. Duke Energy Ohio filed a new portfolio in 2016 for program years 2017 – 2019. An amended stipulation with the majority of intervening parties was submitted on January 27, 2017. On September 27, 2017 the amended stipulation was approved by the Commission with modifications.[3] Because the Commission's Order was issued in September of 2017, the Commission recognized that the Company's spending for 2017 might exceed the cap imposed. Therefore, the Commission stated that it might permit the Company to exceed the cap but would

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[1] *In the Matter of the Application of Duke Energy Ohio, Inc., for Approval to Add a New Program to its Approved Energy Efficiency Portfolio*, Case No. 14-964-EL-POR, Finding and Order, (September 10, 2014).
[2] *In the Matter of the Application of Duke Energy Ohio, Inc. for Approval of its 2017-2019 Energy Efficiency and Peak Demand Reduction Program Portfolio Plan*, Case No. 16-576-EL-POR, Finding and Order, p. 17 (February 26, 2020) (2020 Finding and Order).
[3] *In the Matter of the Application of Duke Energy Ohio, Inc. for Approval of its 2017-2019 Energy Efficiency and Peak Demand Reduction Program Portfolio Plan*, Case No. 16-576-EL-POR, Opinion and Order, p. 1 (September 27, 2017) (2017 Opinion and Order).

not permit shared savings for 2017.[4] The Commission also stated that the Company should not exceed the Portfolio Plan budget for programs for calendar year 2017 absent obtaining a waiver from the Commission.[5] On October 12, 2017 Duke Energy Ohio requested a waiver to permit the Company to exceed the Portfolio Plan budget and the waiver was approved on November 21, 2017.[6] Consistent with the amended stipulation that the Commission had approved, until the Company received approval of the 2017 – 2019 portfolio programs, Duke Energy Ohio continued to operate under the 2016 portfolio guidelines. On February 26, 2020, the Commission approved the Company's request to extend its existing portfolio (for 2017 – 2019) through the end of 2020, with an increased budget of $46,895,800.[7] No additional programs were offered in 2020.

Q. PLEASE SUMMARIZE THE COST RECOVERY AND INCENTIVE MECHANISM UNDERLYING RIDER EE-PDR THAT WAS APPROVED IN CASE NO. 16-576-EL-POR.

A. Under Rider EE-PDR, the Company is entitled to recover the costs prudently incurred to deliver energy efficiency and peak demand reduction programs. Additionally, pursuant to the modified amended stipulation approved by the Commission on September 27, 2017, the Company was entitled to earn a shared savings incentive in an amount up to $8 million dollars a year on an after-tax basis based upon its ability to *exceed* its annual efficiency savings benchmark targets that

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[4] *Id.*, pp. 15-16.

[5] *Id.*, p. 16.

[6] *In the Matter of the Application of Duke Energy Ohio, Inc. for Approval of its 2017-2019 Energy Efficiency and Peak Demand Reduction Program Portfolio Plan*, Case No. 16-576-EL-POR, Entry on Rehearing, p. 1 (November 21, 2017).

[7] 2020 Finding and Order, pp. 3, 17.

are mandated by Ohio law.[8] In Case No. 16-576-EL-POR, the Commission approved recovery of lost distribution margins from all customer classes not included in the Company's pilot distribution decoupling rider (i.e., those customers receiving service under Rates DS, DP, and TS). In the 2017 Opinion and Order, the Commission also imposed a separate cap on the total amount of program costs and shared savings, with such cap (Cost Cap) set at four percent of the Company's annual operating revenues, as reported on the Company's 2015 FERC Form 1.[9] The Company challenged the imposition of the Cost Cap on rehearing, and the Commission ultimately decided "to remove the 4 percent cost cap" on the basis of an interim Ohio Supreme Court decision.[10]

In that same Third Entry on Rehearing, the Commission made two additional determinations. First, the Commission ordered that the Stipulation approved by the Commission on September 27, 2017, be modified to limit shared savings to no more than $7.8 million (pre-tax) (Shared Savings Cap). Second, the Commission held in the Third Entry on Rehearing that the "pla[i]n language" of R.C. 4928.66(G)(3) precluded the Company from "recover[ing] lost distribution revenue after December 31, 2020, even if the lost distribution revenue is attributed to energy savings achieved in 2018, 2019 or 2020."[11]

Also on November 18, 2018, the Commission issued a separate Finding and Order to all the utilities, seeking to implement the directives of R.C. 4928.66(G).

[8] 2017 Opinion and Order, p. 18.
[9] *Id.*, p. 15.
[10] *See In the Matter of the Application of Duke Energy Ohio, Inc. for Approval of its 2017-2019 Energy Efficiency and Peak Demand Reduction Program Portfolio Plan*, Case No. 16-576-EL-POR, Third Entry on Rehearing, pp. 22 (November 18, 2020) (Third Entry on Rehearing).
[11] *Id.*, p. 24.

The Commission directed each utility to "file proposed revised tariffs for their respective EE/PDR cost recovery riders, setting the riders to zero, effective January 1, 2021," and to "file an application for a final reconciliation of their EE/PDR cost recovery riders when the full information for such final reconciliation is available."[12]

On December 18, 2020, Duke Energy Ohio filed an application for rehearing challenging the inappropriate imposition of the $7.8 million pre-tax Shared Savings Cap, the inability to appropriately collect lost revenues incurred, and several other aspects of the Third Entry on Rehearing and accompanying Finding and Order.[13] This application for rehearing was granted for purposes of further consideration by the PUCO on January 13, 2021 and remains pending.[14]

Q. PLEASE DESCRIBE HOW THE COMPANY'S APPROVED SHARED SAVINGS MECHANISM WORKS.

A. The Company's shared savings incentive structure is designed to incentivize the Company for exceeding its energy efficiency benchmark in the most cost-effective manner possible. Under this incentive structure, the level of incentive, or the magnitude of the percentage of the net system benefits (avoided costs less the costs of delivering the efficiency) that the Company may earn, is tiered and can range

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[12] *In the Matter of the Application of Duke Energy Ohio, Inc. for Approval of its 2017-2019 Energy Efficiency and Peak Demand Reduction Program Portfolio Plan*, Case No. 16-576-EL-POR, Finding and Order, p. 3 (November 18, 2020).

[13] *In the Matter of the Application of Duke Energy Ohio, Inc. for Approval of its 2017-2019 Energy Efficiency and Peak Demand Reduction Program Portfolio Plan*, Case No. 16-576-EL-POR, Duke Energy Ohio Inc.'s Application for Rehearing (December 18, 2020).

[14] *In the Matter of the Application of Duke Energy Ohio, Inc. for Approval of its 2017-2019 Energy Efficiency and Peak Demand Reduction Program Portfolio Plan*, Case No. 16-576-EL-POR, Fourth Entry on Rehearing (January 13, 2021).

from 6.0% up to 12.0%, depending on the degree by which the actual efficiency savings exceeds its energy savings benchmark. Please see Table 1 below.

Table 1	
Achievement of Annual Target	After-Tax Shared Savings
≤ 100	0.0%
> 100 - 106	6.0%
> 106 - 112	9.0%
> 112	12.0%

This shared savings mechanism allows Duke Energy Ohio an opportunity to recover its costs and earn an incentive for exceeding the mandated benchmarks.

Q. IS THE SHARED SAVINGS INCENTIVE MECHANISM EFFECTIVE IN INCENTIVIZING DUKE ENERGY OHIO TO OVER COMPLY WITH ITS ENERGY EFFICIENCY BENCHMARKS IN 2020?

A. Yes. The fact that the shared savings mechanism only allows the Company to earn a shared savings incentive in a year that it meets or exceeds its energy efficiency benchmark will help to ensure that the Company will continue to strive to achieve as much energy efficiency as possible and even more importantly, it motivates the Company to maximize cost effectiveness.

Q. DOES THE SHARED SAVINGS CALCULATION INCLUDE COST INCURRED FOR MEASUREMENT AND VERIFICATION?

A. Yes, consistent with the Commission's Order in Case No. 13-753-EL-RDR, the net benefit used in the calculation of shared savings includes costs incurred for EM&V.

Q. IS THE COMPANY'S SHARED SAVINGS MECHANISM APPROVED FOR 2020?

A. On February 26, 2020, the Commission approved the Company's request to extend its existing portfolio (for 2017 – 2019) as approved in the stipulation for Case No. 16-576-EL-POR through the end of 2020, with an increased budget of $46,895,800.[15] No additional programs were offered in 2020. Then, as described earlier, the Commission imposed a Shared Savings Cap in its Third Entry on Rehearing, limiting shared savings to an annual amount no more than $7.8 million (pre-tax). The Company's application for rehearing on this point remains pending.

Q. PLEASE DESCRIBE THE LOST DISTRIBUTION REVENUE RECOVERY ELEMENT CONTAINED IN THE CALCULATION OF RIDER EE-PDR.

A. The calculation of Rider EE-PDR includes the recovery of lost distribution revenue for customers billed under schedules Rate DP, Rate DS, and Rate TS. Unlike all other customers being billed under Rider EE-PDR, the customers under these three rate schedules were excluded from the distribution revenue decoupling pilot being recovered through Rider DDR. To eliminate the disincentive created by the under-recovery of fixed costs from the customers who are not served under the decoupling pilot, the Commission's order in Case No. 11-5905-EL-RDR authorized the Company to collect thirty-six months of lost distribution margins associated with the impacts of its energy efficiency programs for these customers.

As described earlier, the Commission held in the Third Entry on Rehearing that the "pla[i]n language" of R.C. 4928.66(G)(3) precluded the Company from "recover[ing] lost distribution revenue after December 31, 2020, even if the lost

[15] 2020 Finding and Order, pp. 3, 17.

distribution revenue is attributed to energy savings achieved in 2018, 2019 or 2020."[16] The Company's application for rehearing on this point remains pending.

Q. DID THE COMMISSION'S ORDER INCLUDE A PROVISION FOR RECEIVING CARRYING COSTS FOR OVER- OR UNDER-COLLECTION OF LOST MARGINS?

A. No. Any over- or under-collection of lost margins is to be determined without including carrying costs.

III. OVERVIEW OF PORTFOLIO PERFORMANCE

Q. WHAT ENERGY EFFICIENCY AND DEMAND RESPONSE PROGRAMS WERE ULTIMATELY OFFERED TO DUKE ENERGY OHIO CUSTOMERS UNDER RIDER EE-PDR IN 2020?

A. The portfolio of programs approved for inclusion in Rider EE-PDR included the following programs:[17]

- Residential Energy Assessments
- Smart $aver® Residential
- Energy Efficiency Education Program for Schools
- Power Manager® for Residential Customers
- My Home Energy Report
- Smart $aver® Prescriptive
- Smart $aver® Custom
- PowerShare® for Nonresidential Customers

[16] Third Entry on Rehearing, p. 24.

[17] The implementation of certain programs had to be modified and/or curtailed during part of 2020 due to restrictions and constraints stemming from the COVID-19 pandemic.

- Power Manager® for Business
- Low Income Neighborhood Program
- Low Income Pay for Performance
- Small Business Energy Saver

Q. HAS DUKE ENERGY OHIO UPDATED ANY OF ITS PROGRAMS TO BE OFFERED TO CUSTOMERS IN 2020?

A. No. The 2020 portfolio is consistent with the programs offered in 2019.

Q. DID DUKE ENERGY OHIO OFFER ANY OTHER PROGRAMS DURING 2020 THAT WERE NOT INCLUDED IN CASE NO. 16-576-EL-POR?

A. Yes. Duke Energy Ohio has offered eligible customers the opportunity to participate in the Ohio Mercantile Self-Direct Rebate Program.

Q. DID DUKE ENERGY OHIO PARTICIPATE IN THE PJM INTERCONNECTION, INC. BASE RESIDUAL AUCTION?

A. Yes. All eligible[18] and cost effective[19], PJM approved MW resources were bid into the 2021/2022 Base Residual Auction (BRA). This resulted in 42.3 MWs from energy efficiency and 45.9 MWs from DR resulting in 88.2 MWs clearing in the 2021/2022 auction. When the clearing MW revenue is collected, it will be allocated back to programs after all administrative and EM&V costs are covered. Revenue offset is allocated back to the program based on percentage of MWs clearing each auction and customer class and the net offset will be shared with the

[18] "Eligible" is defined as existing and planned energy efficiency savings and demand response that comply with PJM Manuals 18 and 18b.

[19] "Cost effective" is defined as the projected auction revenues that are greater than the projected costs for existing and planned energy efficiency and demand response, where the phrase "projected auction revenues" is defined as the estimated kW multiplied by the previous BRA clearing price for the Duke Energy Ohio zone and "projected costs" are defined as the costs necessary to fully qualify and bid the resources into the PJM capacity auctions.

Company at its approved shared savings percentage as applicable. Due to the FERC ruling delaying the auctions, Duke Energy Ohio has not participated in an auction beyond the 2021/2022 Base Residual Auction. Additionally, due to the passing of House Bill 6 (H.B.6), the Company's EE and DR programs were discontinued at the end of 2020. While PJM is now prepared to restart the BRA auction process beginning in May 2021, the Company is not planning to participate in additional BRAs due to the loss of eligible resources resulting from H.B.6.

Duke Energy Ohio kept the Duke Energy Community Partnership (the Collaborative) updated throughout 2020 regarding the auction process.

Q. HAS DUKE ENERGY OHIO BEEN SUCCESSFUL IN MEETING ITS TARGETED MANDATES FOR ENERGY EFFICIENCY AND PEAK DEMAND REDUCTION?

A. Duke Energy Ohio successfully met the statutory mandates through 2020 for energy efficiency and peak demand of 2,108,493 MWh and its peak reduction mandate of 401.3 MW.

Q. WHAT PROGRAMS WERE THE PRIMARY CONTRIBUTORS TO THE COMPANY'S SUCCESS DURING 2020?

A. While the Company is pleased with the performance of its overall portfolio of programs that were deemed cost effective by the total resource cost test, the Smart Saver® Programs: Smart Saver® for Residential Customers and Smart Saver® Prescriptive and Custom for Nonresidential Customers continue to dominate the portfolio. Together these programs accounted for over 160,000 MWh, 60%, of the total impacts recognized in 2020.

Q. IS DUKE ENERGY OHIO'S ACHIEVEMENT LEVEL VERSUS ITS BENCHMARKS THE SAME ACHIEVEMENT THAT THE COMPANY IS USING TO CALCULATE ITS PERFORMANCE FOR THE PURPOSES OF CALCULATING ITS EARNED INCENTIVE LEVEL FOR 2020?

A. Yes, the Company's achievement level for benchmark achievement is the same as the achievement level to earn incentive.

Q. PLEASE DESCRIBE HOW THE COMPANY'S MERCANTILE SELF-DIRECT REBATE PROGRAM HAS BEEN FACTORED INTO THE CALCULATION OF RIDER EE-PDR.

A. While the impacts and associated net benefits from the Mercantile Self-Direct Rebate Program have been excluded from the calculation of the Company's shared savings incentive, the program costs associated with the Mercantile Self-Direct Rebate Program are included for recovery in the calculation of Rider EE-PDR. The Company did not perform EM&V on the impacts associated with the Mercantile Self-Direct Rebate Programs.

Q. HAS THE COMPANY INCLUDED ANY COSTS OR IMPACTS FROM TRANSMISSION AND DISTRIBUTION INVESTMENTS THAT REDUCE LINE LOSSES IN THE CALCULATION OF ITS SHARED SAVINGS INCENTIVE IN RIDER EE-PDR?

A. No, the Company has not counted any of the net benefits associated with the impacts from investments in transmission and distribution systems that reduce line losses in the calculation of its shared savings incentive.

Q. HAS THE COMPANY COMPLIED WITH ALL THE DIRECTIVES FROM THE COMMISSION IN ITS 2017 OPINION AND ORDER AND OTHER APPLICABLE ORDERS IN THE 16-0576-EL-POR CASE?

A. Yes, except insofar as the Company's Application in this case seeks cost recovery in accordance with the Company's December 18, 2020, Application for Rehearing, which remains pending before the Commission. The Company submits this Application to recover the full amounts to which it believes it is entitled in order to preserve its rights pending rehearing and/or appeal. Otherwise, Duke Energy Ohio has complied with applicable directives. For example, the Commission directed the Company to continue to work with its Collaborative and to file specific information in its status reports. The Company has held Collaborative meetings, with significant participation on 03/04/20, 06/10/20, 09/10/20, and 12/02/20. Additionally, the Company has filed full and complete status reports in Case Nos. 10-0317-EL-EEC, 11-1311-EL-EEC, 12-1477-EL-EEC, 13-1129-EL-EEC and 14-456-EL-EEC, 15-454-EL-EEC, 16-0513-EL-EEC, 17-689-EL-EEC, 18-396-EL-EEC, 19-621-EL-EEC, 20-612-EL-EEC and 21-481-EL-EEC[20]. And the Company is filing this Application for final reconciliation in accordance with the November 18, 2020, Finding and Order in Case No. 16-576-EL-POR, which directed utilities to "file an application for a final reconciliation of their EE/PDR cost recovery riders when the full information for such final reconciliation is available."[21]

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[20] To be filed by May 15, 2021

[21] *In the Matter of the Application of Duke Energy Ohio, Inc. for Approval of its 2017-2019 Energy Efficiency and Peak Demand Reduction Program Portfolio Plan*, Case No. 16-576-EL-POR, Finding and Order, p. 4 (November 18, 2020).

IV. OVERVIEW OF EVALUATION, MEASUREMENT, AND VERIFICATION

Q. WHAT IS THE PURPOSE OF YOUR TESTIMONY ON EVALUATION, MEASUREMENT AND VERIFICATION (EM&V)?

A. This section of my testimony (1) provides an overview of the programs on which Evaluation, Measurement and Verification (EM&V) activities were performed in 2020, (2) provides the current findings from the Company's EM&V work, and (3) demonstrates how the results from the EM&V process will be used in the true-up.

Q. WHICH PROGRAMS RECEIVED EVALUATION, MEASUREMENT & VERIFICATION IN 2020?

A. The table below provides the detailed EM&V reports completed in 2020:

Attachment	Program	Evaluation Type	Report Date
1	Power Manager®	Process and Impact	August 2020
2	Neighborhood Energy Saver Program	Process and Impact	May 2020
3	Retail Lighting Program	Process and Impact	June 2020
4	Save Energy and Water Kits Program	Process and Impact	April 2020
5	EE Post Installation EM&V Non-Residential Lighting Report	PJM Report	May 2020
6	EE Post Installation EM&V Residential Lighting Report	PJM Report	May 2020

Additionally, the Company will provide the reports presented here as Appendices B - G as appendices in its annual energy efficiency status report, Case No. 21-481-EL-EEC.[22]

[22] The EM&V reports were prepared before H.B. 6 took effect and may occasionally refer to Ohio statutory provisions that have since changed. This does not affect the substance of the reports' EM&V analysis.

Q. HAS THE COMPANY ADOPTED ANY OF THE IMPACT COUNTING PROVISIONS ESTABLISHED IN S.B. 310?

A. Yes, the Company is operating under the impact counting provisions established by S.B. 310.

Q. HOW WERE THE EVALUATION, MEASUREMENT, AND VERIFICATION RESULTS UTILIZED IN DEVELOPING ESTIMATES OR TRUE-UPS FOR THE EE RIDER?

A. The original projection of program cost-effectiveness utilized projected numbers for participants in the programs and estimates of the load impacts per participant, derived either from initial estimates, previous EM&V results or deemed savings as established by S.B. 310. The Company has measured actual participation and uses this actual participation information as the basis for annual true-ups of estimated incentives for the rider by multiplying the actual participation by the current estimates of load impact per participant.

For those programs on which EM&V has been performed since the filing, the higher of the evaluated estimates of energy efficiency and/or peak demand impacts and net-to-gross ratio or the deemed[23] values are applied prospectively to adjust subsequent impact assumptions until superseded by new EM&V results, if any. The evaluated impacts identified in the EM&V report for a program, if found to be higher than the deemed savings, are applied to the rider in the month[24] following the completion of the EM&V report. When applicable, these results will also be

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[23] *See* R.C. 4928.662(B).

[24] Impacts for demand response programs are applied at the beginning of the next program cycle.

used to estimate future target achievement levels for development of estimated incentives and in future cost-effectiveness evaluations[25].

Q. WHAT ANALYTICAL DATA WERE USED IN THE CALCULATION OF THE REVENUE REQUIREMENT PROVIDED BY DUKE ENERGY OHIO WITNESS JAMES E. ZIOLKOWSKI?

A. The revenue requirement was calculated using both data inputs and outputs from the DSMore™ model, including initial estimates or estimated energy savings, program costs and avoided costs. In addition, the costs of the independent measurement and verification activities, which are not used as an input to the DSMore™ model, are also included in the calculation of revenue requirements.

Q. WERE ATTACHMENTS 1 – 6 PREPARED BY YOU OR AT YOUR DIRECTION?

A. The EM&V reports were prepared by Nexant (Attachments 1 and 4) and Opinion Dynamics (Attachments 2, 3, 5, and 6), all of which are Duke Energy Ohio's independent third-party evaluators.

V. CONCLUSION

Q. PLEASE DESCRIBE THE COMPANY'S OVERALL ENERGY EFFICIENCY AND PEAK DEMAND REDUCTION PORTFOLIO PERFORMANCE IN 2020.

A. Duke Energy Ohio's portfolio of programs continued to perform exceptionally well considering the many challenges of 2020 and delivered cost effective energy savings. The actual achieved MWH impacts in 2020 are below the 2020 forecasted

[25] For demand response programs, the contracted amounts of kW reduction capability from participants are considered to be components of actual participation.

load impacts. This shortfall is due to the impact that the COVID-19 pandemic and related measures had on the programs, as well as the Commission's guidance regarding the implementation of the House Bill 6 order which required the wind down of programs prior to September 30, 2020. The forecasted impacts were filed in Case No. 20-0612-EL-EEC before the impacts of the pandemic could have been known.

The success of the Company's programs has allowed customers that participated in the Company's programs to take control of their energy usage and realize significant bill savings, as well as allowing all Duke Energy Ohio customers to realize the benefits of millions of dollars of avoided system costs. In fact, the net present value of the system avoided costs associated with the 2020 energy and capacity achievements from its portfolio of programs is over five times the program cost incurred to achieve the impacts.

Q. DOES THIS CONCLUDE YOUR TESTIMONY?

A. Yes, it does.

REPORT

Duke Ohio 2019 Power Manager Evaluation

Submitted to Duke Energy

August 31, 2020

Principal authors:
Eric Bell, Principal
Greg Sidorov, Consultant
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1 Executive Summary

This report presents the results of the 2019 Power Manager impact evaluation for the Duke Energy Ohio territory. Power Manager is a voluntary demand response program that offers incentives to residential customers who allow Duke Energy to reduce the use of their central air conditioner's outdoor compressor and fan during summer days with high energy usage. Through the program, events are called at times when extreme temperatures are expected and household cooling needs are highest. During normal shed events, a remote signal is sent to participating load control devices that reduce customers' air conditioner use. During emergency shed operations, all devices are initiated to instantaneously shed loads and deliver larger demand reductions.

1.1 Impact Evaluation Key Findings

The impact evaluation is based on a randomized control trial. All Power Manager program participants who had a load control device installed by the start of the summer were randomly assigned to one of six groups – a primary group made up of 75% of the population, and five research groups, each made up of 5% of the population. During each event, one or more of the smaller research groups (each comprising approximately 2,200 customers) is withheld as a control group in order to provide an estimate of energy load profiles absent a Power Manager event. During the summer of 2019, approximately 43,600 households were actively participating in Power Manager and had load control devices.

Table 1-1 summarizes the demand reductions attained during each event in 2019. With the exception of two PJM test events, impacts were estimated using an RCT approach. By design, the PJM test events called on August 1 and September 10 dispatched the full program population and did not withhold a control group. As a result, a RCT design could not be applied. Instead, impacts for these events were estimated using a within-subjects approach, summarized in Section 5. The event called on July 10 included a side-by-side test of emergency and normal operations in order to estimate the incremental demand reductions due to emergency operations.

A few key findings are worth highlighting:

- Demand reductions were -0.78 kW per household for the average general population event.
- On average, emergency shed produced impacts that were similar to normal shed events.
  - Excluding the emergency event on August 1, which was called early in the day and at lower temperatures, emergency shed impacts were 0.15 kW greater than normal shed impacts.
- In general, the magnitude of demand reductions grows larger when temperatures are higher and resources are needed most.

- The difference in impacts between customers who signed up for the moderate and high load control options was minimal and within the range of uncertainty.
- The time-temperature matrix predicts -1.04 kW load reduction per household for a 1-hour event beginning at 4:00PM.
- Duke Energy will claim the deemed value of -1.41 kW per device (-1.49 kW per customer) from 2016-2017 for Power Manager per SB 310.

Table 1-1: Demand Reductions for Individual Events

Event Date	Type	Event Period	Reference Load	Impact	90% Confidence		% Impact	90% Confidence		Daily Max Temp
					Lower Bound	Upper Bound		Lower Bound	Upper Bound	
7/10/2019	Normal	4 PM - 5 PM	3.26	-0.85	-0.79	-0.92	-28.8%	-26.8%	-30.7%	91°F
	Emergency	4 PM - 5 PM	3.26	-0.94	-0.88	-1.00	-26.3%	-24.3%	-28.3%	91°F
7/19/2019	Normal	4 PM - 6 PM	3.59	-0.86	-0.80	-0.92	-24.0%	-22.2%	-25.7%	92°F
8/1/2019	Emergency	12 PM - 1 PM	2.23	-0.49	-0.41	-0.57	-21.9%	-18.5%	-25.3%	89°F
8/19/2019	Normal	4 PM - 6 PM	3.66	-0.89	-0.83	-0.95	-24.4%	-22.8%	-26.1%	94°F
9/10/2019	Emergency	4 PM - 5 PM	3.33	-0.91	-0.70	-1.12	-27.2%	-20.8%	-33.6%	95°F
9/12/2019	Normal	4 PM - 6 PM	3.38	-0.65	-0.59	-0.71	-19.2%	-17.4%	-21.0%	93°F
9/30/2019	Normal	4 PM - 6 PM	3.39	-0.71	-0.60	-0.81	-20.9%	-17.8%	-24.0%	94°F
Average General Population Event			**3.50**	**-0.78**	**-0.71**	**-0.85**	**-22.1%**	**-20.0%**	**-24.4%**	**93°F**

1.2 Time-Temperature Matrix and Demand Reduction Capability

A key objective of the 2019 impact evaluation was to quantify the relationship between demand reductions, temperature, hour-of-day, and cycling levels. This was accomplished by estimating loads under historical weather conditions and applying observed percent load reductions from the 2018 and 2019 events.[1] The resulting tool, referred to as the time-temperature matrix, allows users to predict the program's load reduction capability under a wide range of temperature and event conditions.

In an ideal program year, a large number of events would be called under a variety of different weather conditions, dispatch windows and cycling strategies so that demand reduction capability could be estimated for a wide range of operating and planning scenarios. In actuality, opportunities for program events can be sporadic and based on uncertain weather projections, such that they occur infrequently and under fairly similar conditions. In order to expand the spectrum of observed event data with which to cultivate the time-temperature matrix, Nexant

[1] Consistency in DEO program design and evaluation approaches between the 2018 and 2019 program years allowed for a combined, two-year expansion of the time-temperature matrix, and a more robust estimation of program performance.

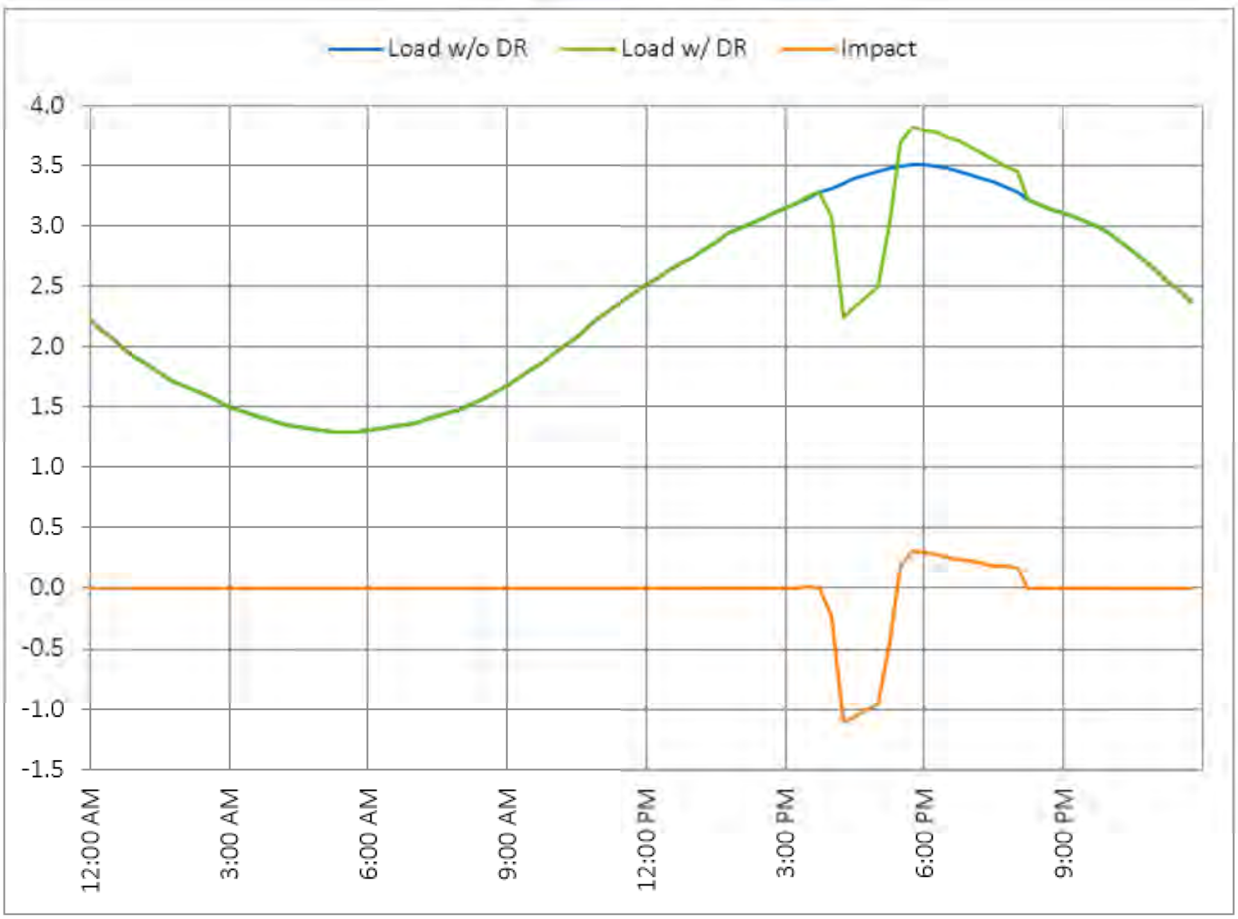
opted to incorporate impacts from the 2018 and 2019 program evaluations. The combined set of event impact data used to inform the time-temperature matrix included impacts from 15 distinct event dispatches. All events were either 1-hour or 2-hours in duration and occurred on days with daily maximum temperatures ranging from 89°F to 95°F.

Figure 1-1 shows the demand reduction capability of the program if emergency shed becomes necessary on a day with a maximum temperature of 94°F for a 1-hour event duration. Individual customers are expected to deliver -1.04 kW demand reduction. Because there are approximately 43,600 customers, the expected aggregate system load reduction is 45.2 MW.

Figure 1-1: Demand Reduction Capability - 94°F Maximum Temperature

Inputs	
Dispatch Type	Emergency Dispatch
Option	Overall
Event Start	4 PM
Event Duration (Hours)	1
Daily Max Temp (°F)	94
# Customers	43,600

Event Window Average Impacts	
Load without DR	3.40 kW per customer
Load with DR	2.36 kW per customer
Impact per customer	-1.04 kW per customer
Impact (MW)	-45.2 MW
% Impact	-30.5 %



2 Introduction

This report presents the results the 2019 Power Manager program impact evaluation for the Duke Energy Ohio (DEO) jurisdiction. Power Manager is a voluntary demand response program that provides incentives to residential customers who allow Duke Energy to reduce the use of their central air conditioner's outdoor compressor and fan on summer days with high energy usage.

Because Duke Energy has full deployment of smart meters in DEO territory, and has access to Power Manager customers' interval data, the impact evaluation is based on a randomized control trial that randomly assigned customers to six different groups. During each event, at least one of the groups is withheld to serve as a control group and provide an estimate of customer's load usage profiles absent a Power Manager event. The randomized control trial approach was applied during normal Power Manager operations, as well as during specific test events designed to address a set of specific research questions.

In addition to estimating load impacts during 2019 events, this study enables the estimation of the program's demand reduction capability under a range of weather and dispatch conditions. Average customer load reductions, as well as aggregate system capacity, is estimated as a function of event type, control option, event start time, event duration, and maximum daily temperature.

2.1 Key Research Questions

The study data collection and analysis activities were designed to address the following impact evaluation research questions:

- What demand reductions were achieved during each event called in 2019?
- Did impacts vary for customers who enrolled in the moderate vs. high load control options?
- Do impacts vary based on the hour(s) of dispatch?
- Do impacts vary based on temperature conditions?
- What is the magnitude of the program's aggregate load reduction capability during extreme conditions?

2.2 Program Description

Power Manager is a voluntary demand response program that provides incentives to residential customers who allow Duke Energy to reduce their central air conditioner's outdoor compressor and fans on summer days with high energy usage. All Power Manager participants have a load control device installed on at least one outdoor unit of qualifying air conditioners. The device enables the customer's air conditioner to be cycled off and on to reduce load when a Power Manager event is called. Duke Energy initiates events by sending a signal to participating devices through a corporate paging network, which instructs the devices to systematically cycle the air conditioning system on and off, reducing the aggregate runtime of the unit during events.

The program participates in the energy and capacity markets of the PJM market, but Duke Energy generally limits participation in the energy markets to days when the wholesale price exceeds $65/MWh. Duke Energy regularly bids Power Manager into the capacity market, which means that the program must be available for PJM emergency events. Absent a PJM emergency, Duke Energy's operations team schedules and calls events for local emergency, economic, or testing reasons.

Power Manager events typically occur from May through September in DEO territory, but are not limited to these months. Participants receive financial incentives for their participation based on the amount of load control they experience during an event. Upon program enrollment, Power Manager customers select either moderate or high load control. During the event season, customers receive financial incentives for their participation in the program based on the control option selected upon enrollment. The payments received by participants include a one-time installation credit – $25 for moderate load control and $35 for high load control – plus bill credits for cycling events. The minimum bill credit for 2019 participation was $12 for customers enrolled in the moderate option and $18 for customers enrolled in the high option.

In DEO territory, Duke Energy uses a cycling algorithm known as *true cycle*. The algorithm uses learning days to estimate air conditioners' runtime (or duty cycle) as a function of hour-of-day and temperature at each specific site, and aims to curtail load demand by a specified amount. In general, Power Manager events fall into two categories: regular shed events, during which customers are cycled at 60% and 75% for moderate and high control customers, respectively; and emergency shed events during which both moderate and high customers are cycled at 75%. At least once per program year, PJM requires a test event, where the full population of program participants are dispatched under emergency shed conditions. For purposes of regulatory reporting of program capability, emergency shed is used to estimate program impacts. Table 2-1 shows the device cycling levels for each event type and control option.

Table 2-1: DEO Regular and Emergency Shed Cycling Options

Event Type	Low Option	Moderate Option	High Option
Regular Shed	25%	60%	75%
Emergency Shed	66%	75%	75%
PJM Test Event	66%	75%	75%

2.3 Participant Characteristics

Duke Energy serves approximately 663,000 residential customers in DEO service territory, located in the southern portion of Ohio and centered in the Cincinnati area. By the start of summer 2019, over 46,000 devices were part of Power Manager.[2] Approximately 83% of Power Manager devices in DEO are enrolled in the moderate load control option and the remaining 17% are enrolled in the high load control option.[3]

Table 2-2: Device Count by Control Option

Control Option	Device Count	Percent
Low	59	0.1%
Moderate	38,395	83.4%
High	7,603	16.5%
Total	**46,057**	**100%**

To enroll in Power Manager, customers must own a single-family home located in DEO service territory and have a functional central air conditioning unit with an outdoor compressor. Figure 2-1 depicts program enrollment over time.

Figure 2-1: Power Manager Participation Over Time

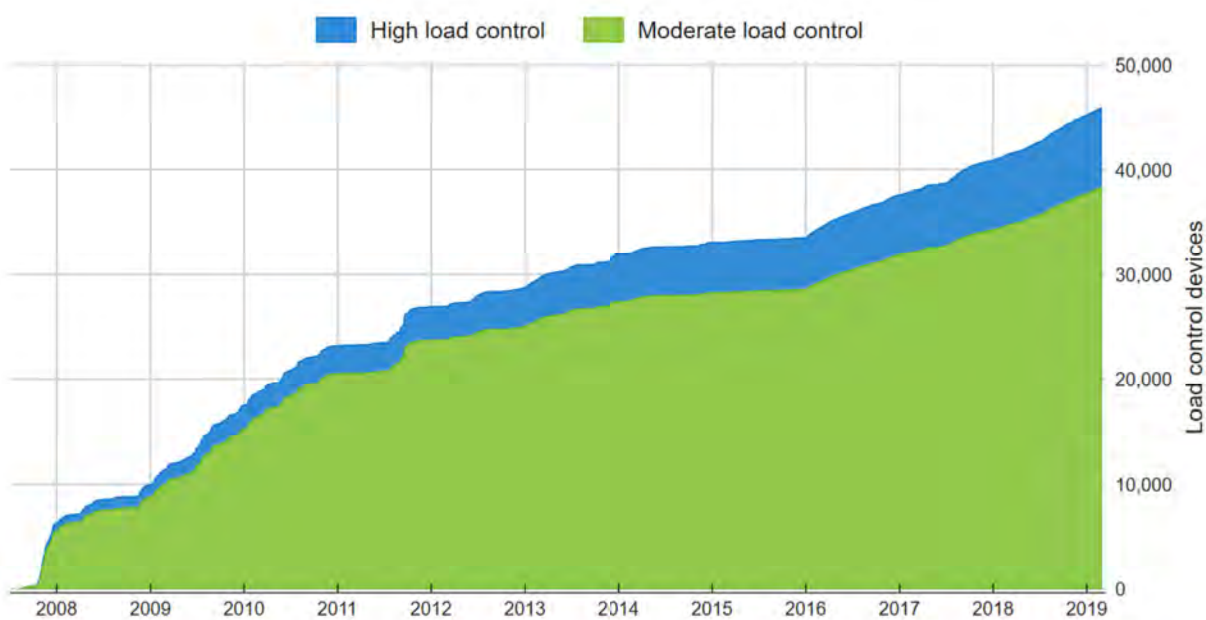


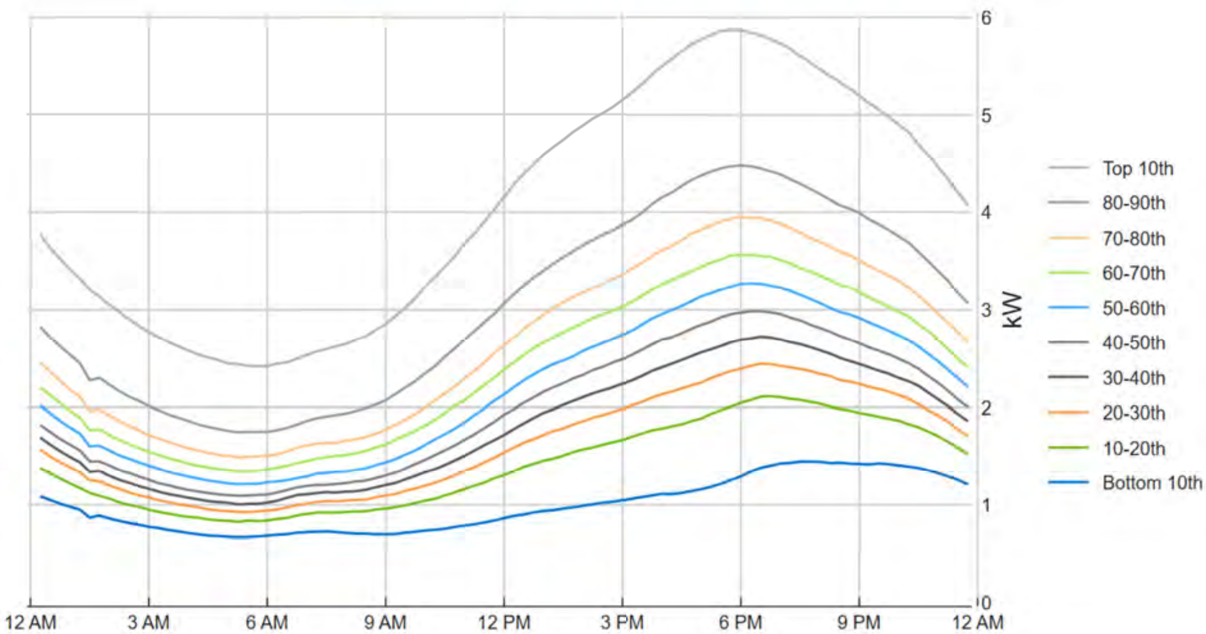
Figure 2-2 provides additional detail and shows the hourly household loads for different customer groups. The customers were classified into ten equally sized groups, known as

[2] 43,637 accounts were enrolled in the program, totaling approximately 46,057 air conditioner units.

3 A low load control option is offered to customers who request to be removed from the program as a way to minimize attrition; approximately 0.1% of devices are enrolled in the low load control option.

deciles, based on their household consumption during hot, non-event days. Each line represents the hourly loads for the average customer in each decile.

Figure 2-2: Household Loads by Size Decile



Household loads varied substantially, reflecting different occupancy schedules, comfort preferences, and thermostat settings.[4] As with any program, some enrollees use little or no air conditioning during late afternoon hours on hotter days. These customers are, in essence, free riders. The bulk of the costs for recruitment, equipment, and installation have already been sunk for these customers and, as a result, removing these customers may not improve cost effectiveness substantially. However, given the availability of smart meter data, we recommend assessing nonparticipant afternoon loads on hotter days prior to marketing in order to target customers who are cost effective to enroll.

2.4 2019 Event Characteristics

Duke Energy dispatched Power Manager events on seven days in 2019. All general population events occurred between 4:00 and 6:00pm. Emergency shed was dispatched three times: once as part of a side-by-side event designed for measurement & verification (M&V) purposes, and twice as a result of PJM required test events. The side-by-side dispatch framework on July 10 allowed for direct comparison of emergency shed performance compared to general dispatch. Table 2-3 summarizes 2019 event conditions.

[4] It is assumed that household-level demand on these days is predominantly due to AC use; however, other factors could contribute to the varying customer loads.

Table 2-3: 2019 Event Operations and Characteristics[5]

Event Date	Event Window	Event Type	# Customers	Control Group	Maximum Daily °F	Notes
7/10/2019	4PM - 5PM	M&V	1,955	35,009	91°F	Emergency shed Feeder 1 dispatched
		M&V	1,886	35,009		Normal shed Feeder 2 dispatched
7/19/2019	4PM - 6PM	General Population	37,131	1,890	92°F	Normal shed Feeder 2 withheld as control
8/1/2019	12PM - 1PM	PJM Test	39,233	–	89°F	Emergency shed Full population dispatched
8/19/2019	4PM - 6PM	General Population	37,819	2,012	94°F	Normal shed Feeder 1 withheld as control
9/10/2019	4PM - 5PM	PJM Test	39,637	–	95°F	Emergency shed Full population dispatched
9/12/2019	4PM - 6PM	General Population	37,874	1,922	93°F	Normal shed Feeder 3 withheld as control
9/30/2019	4PM - 6PM	General Population	16,599	756	94°F	Normal shed Feeder 4 withheld as control

5 Counts here represent the customers with complete data used in the analysis dataset.

3 Methodology and Data Sources

This section details the study design, data sources, sample sizes, and analysis protocols for the impact evaluation.

3.1 Data Sources

The impact analysis relied on four key datasets:

1) Participant data that identifies customer cycling options and feeder assignments;
2) Smart meter interval data for participants for the entire summer (May 1 through September 30);
3) Hourly weather data for the entire summer, which informs the selection of proxy days for the within-subjects analysis, as well as establishes the impact-weather relationship for the time-temperature matrix, and;
4) Event data for all DEO Power Manager events in 2019, which identify treatment and control feeders, event type, and start/end times for each event.

Most of the required data was provided by Duke Energy at the end of the 2019 Power Manager season. Weather data was sourced from the NOAA website using the Dayton Wright Brothers Airport weather station (KMGY). All subsequent datasets used in the analysis relied on a combination of these primary datasets.

3.1.1 Data Management and Cleaning

All datasets went through a thorough cleaning and validation process to ensure impacts were being estimated using only reliable observations from customers who were properly dispatched on event days. The analysis benefitted from a full population-based approach, allowing Nexant to logically exclude customers who were found to have incomplete or questionable load data, while still maintaining large enough sample sizes to produce highly precise estimates.

During the course of the data validation, Nexant discovered that, on certain event days, customers assigned to the control group actually showed signs of load control during the event hours, despite being correctly programmed. This small, but still detectable, portion of customers adversely affects the RCT analysis by falsely lowering the reference load, resulting in artificially low impacts that are attributable to the program's event. In order to remove the bias introduced by these accounts, customers from the affected control feeders were grouped into 20 clusters based on their event period load patterns. The clusters containing customers that exhibited clear load reduction during the first hour of the event were removed from the analysis. These accounts represent approximately 10% of each control group.

Table 3-1: 2019 Event Data Issues Summary

Affected Segment	Affected Events	Summary of Issue	Resolution
Control groups	7/19/2019 8/19/2019 9/30/2019	A portion of control groups showed signs of dispatch during events, resulting in biased reference loads.	Affected customers were excluded from the analysis for all affected event days.

Nexant was able to work around the issue described in Table 3-1 by excluding from the analysis customers whose systems exhibited suspicious load patterns during events. The result was a more certain and reliable reference load against which to compare treatment loads and calculate event impacts via RCT.

3.2 Randomized Control Trial Design and Analysis

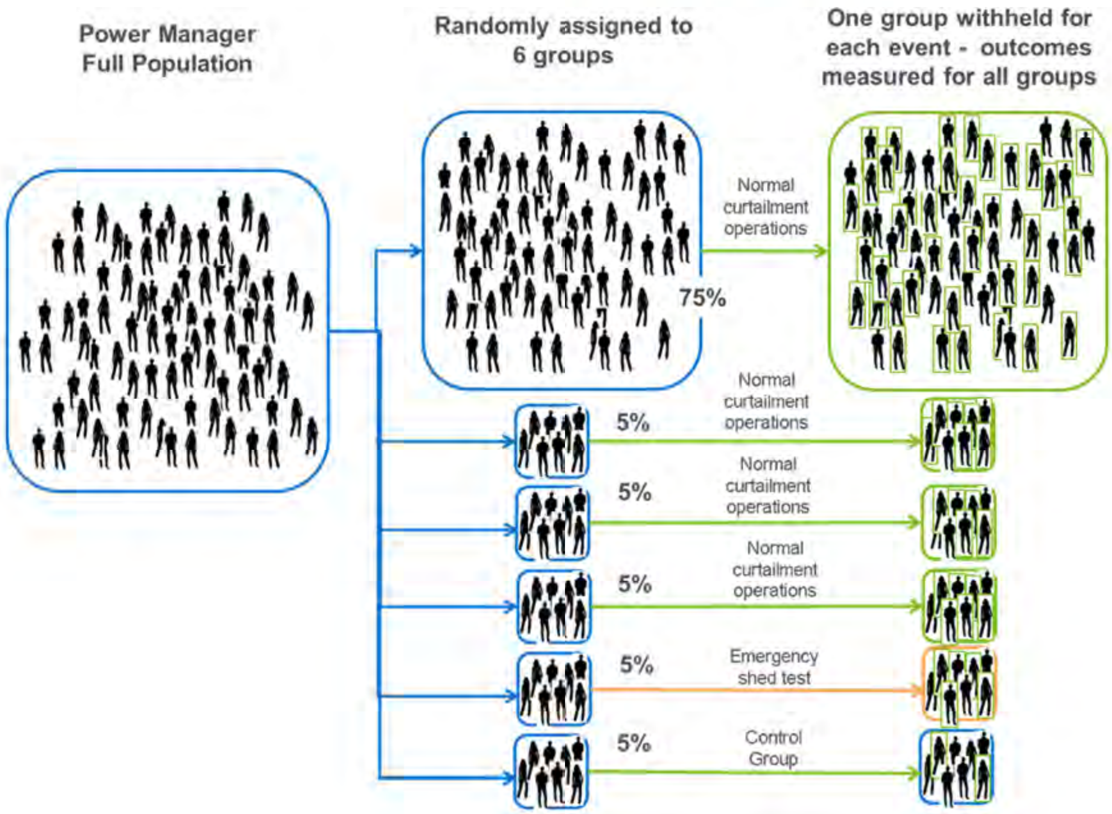
Randomized control trials are well-recognized as the gold standard for obtaining accurate impact estimates and have several advantages over other methods:

- They require fewer assumptions than engineering-based calculations;
- They allow for simpler modeling procedures that are effectively immune to model specification error; and
- They are guaranteed to produce accurate and precise impact estimates, provided proper randomization and large sample sizes.

The RCT design randomly assigns the Power Manager population into six groups – a primary group consisting of 75% of the population and five research groups, each consisting of 5% of the population. For each event, groups are assigned as either treatment or control according to Duke Energy's operational plan.[6] All devices assigned to the treatment group are controlled during the event window, while devices assigned to the control group are withheld and continue to operate normally throughout the event period. As a result of random group assignment, the only systematic difference between the treatment and control groups is that one set of customers is curtailed while the other group was not. Figure 3-1 shows the conceptual framework of the random assignment.

[6] The PJM test events called on August 1 and September 10 dispatched all program participants and therefore, no control group was withheld.

Figure 3-1: Randomized Control Trial Design



All customers who were enrolled in the program and had addressable load control devices installed by the start of the 2019 summer were randomly assigned into six distinct groups using the last two digits of the device serial number.[7] Table 3-2 summarizes the feeder assignment and number of devices in each group. By design, the primary general population group includes 75% of participants, approximately 35,000 devices. The remaining five research groups each include 5% of participants, or roughly 2,200 devices each.

[7] Some households have multiple load control devices. In these instances the homes were randomly assigned such that all devices in a given home were in the same group.

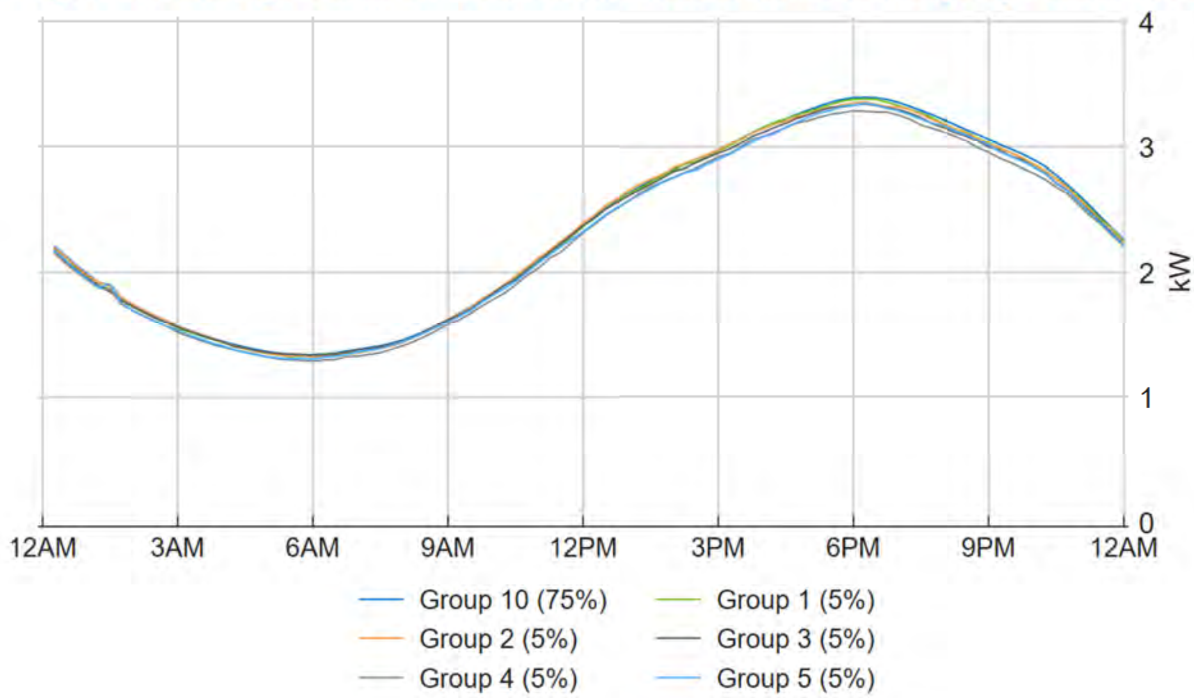
Table 3-2: Feeder Group Assignment

Feeder Group	Number of Devices
10	34,857
1	2,336
2	2,281
3	2,198
4	2,174
5	2,211
Total	**46,057**

The purpose of creating six distinctive, randomly assigned groups is twofold. First, it allows for side-by-side testing of cycling strategies, event start times, or other operational aspects to help optimize the program. Second, it allows Duke Energy to alternate the group being withheld as control for each event, increasing fairness and helping to avoid exhausting individual customers by dispatching them too often solely for research purposes.

To ensure that random group assignment was properly implemented, average loads for each of the six groups were compared to each other for all non-event days with temperatures reaching 90°F or higher. Figure 3-2 shows average loads for each feeder group on these hottest, non-event days. Feeder loads are nearly identical, which provides strong evidence that the random group assignment effective. It also emphasizes the high degree of precision provided by an effective RCT design for estimating the counterfactual.

Figure 3-2: Average Customer Loads on the Hottest Non-Event Days by Feeder Group



For each event, one of the five smaller research groups was withheld to serve as a control group and establish the electricity load patterns in the absence of curtailment, i.e. the baseline. Within the experimental framework of an RCT, the average usage for control group customers provides an unbiased estimate of what the average usage for treatment customers would have been if an event had not been called. Therefore, estimating event day load impacts requires simply calculating the difference in loads between the treatment and control groups during each interval of the event window, as well as for the hours immediately following the event when snapback can occur. Demand reductions calculated in this way reflect the net impacts and inherently account for offsetting factors, such as device failures, paging network communication issues, and customers' use of fans to compensate for curtailment of air conditioners.

Impacts are calculated simply by taking the difference in loads between the treatment and control groups. However, additional statistical metrics, such as standard error, are calculated in order to evaluate whether these differences are meaningful, as well as whether different cycling strategies could produce significantly different impacts. The standard error is then used to calculate 90% confidence bands, which are additional measures used to describe the statistical accuracy of the impact estimate. The standard error is calculated using the formula shown in Equation 1.

Equation 1: Standard Error Calculation for Randomized Control Trial

$$Std.Error\ of\ Difference\ between\ Means_i = \sqrt{\frac{sd_c^2}{n_c} + \frac{sd_t^2}{n_c}}$$

Where:

sd = standard deviation
n = sample size
t = indicator for treatment group
c = indicator for control group
i = individual time intervals

3.3 Within-Subjects Analysis Design

Although an RCT approach has many implicit advantages that make it the preferred method for estimating impacts, it is not applicable when no valid control group is available to establish the counterfactual. In these cases, when events were called absent a control group, a within-subjects approach was used, whereby customer loads observed on similar non-event days were used to establish the counterfactual against which to compare treatment loads. This approach works because the program intervention is introduced on some days, and withheld on other days that could otherwise be considered event-worthy, allowing for comparison of load patterns with and without load control.

A key consideration of the within-subjects design is how to select a model that generates the most precise and accurate counterfactual, and by extension impacts. In many cases, multiple counterfactuals may be plausible, but result in varying estimations of impacts. Using non-event days with similar temperature conditions, regression modeling was applied to estimate the demand reduction as the difference between the predicted baseline loads and the actual event day loads. In order to identify the regression model that best predicts the counterfactual, a rigorous model selection process is applied, whereby ten distinct model specifications were tested and ranked using various accuracy and precision metrics. The best performing model was selected and used to estimate the counterfactual for actual event days. Figure 3-3 summarizes the regression model selection process.

Figure 3-3: Within-Subjects Regression Model Selection

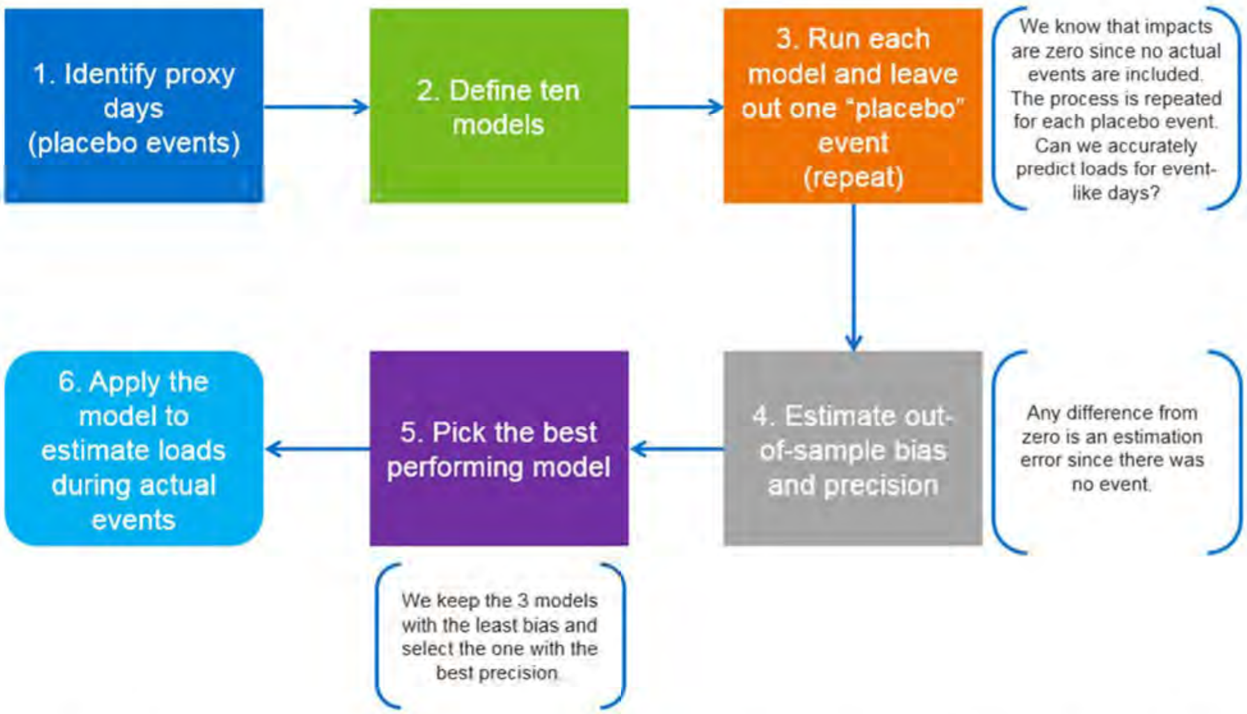


Table 3-3 summarizes metrics for bias and precision. Bias metrics measure the tendency of different approaches to over or under predict and are measured over multiple out-of-sample days. The mean percent error (MPE) describes the relative magnitude and direction of the bias. A negative value indicates a tendency to under predict and a positive value indicates a tendency to over predict. The precision metrics describe the magnitude of errors for individual event days and are always positive. The closer they are to zero, the more precise the model prediction. The absolute value of the mean percentage error is used to select the three model candidates with the lowest bias. The coefficient of variation of the root mean square error, or CV(RMSE), metric is used to identify the most precise model from the three models with the least bias.

Table 3-3: Measures of Bias and Precision

Type of Metric	Metric	Description	Mathematical Expression
Bias	Average Error	Absolute error, on average	$AE = \frac{1}{n}\sum_{i=1}^{n}(\hat{y}_i - y_i)$
	Mean Percentage Error (MPE)	Indicates the percentage by which the measurement, on average, over or underestimates the true demand reduction	$MPE = \frac{\frac{1}{n}\sum_{i=1}^{n}(\hat{y}_i - y_i)}{\bar{y}}$
Precision	Root Mean Squared Error	Measures how close the results are to the actual answer in absolute terms, penalizes large errors more heavily	$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(\hat{y}_i - y_i)^2}$
	CV(RMSE)	Measures the relative magnitude of errors across event days, regardless of positive or negative direction (typical error)	$CV(RMSE) = \frac{RMSE}{\bar{y}}$

4 Randomized Control Trial Results

One of the primary goals of the impact evaluation is to understand the load impacts associated with the Power Manager program under a variety of temperature and event conditions. General population events were targeted to understand the available load reduction capacity under varying temperature conditions during normal operations, while emergency shed events were used to demonstrate the program's capacity for short-duration events under more extreme conditions. In addition, the July 10 event was specifically designed to dispatch groups of customers under normal operations and emergency shed operations simultaneously, allowing for a side-by-side comparison of impacts under the two scenarios. Section 4.1 presents overall program results for all event days, including general population and emergency shed events. Section 4.2 details the results of the side-by-side comparison of normal operations vs. emergency shed on July 10. Section 4.3 presents impacts by control option (moderate vs. high) for 2019 events.

4.1 Overall Program Results

The load impact estimates resulting from the RCT analysis for the general population events, as well as the research events that occurred side-by-side with normal operation, are presented in Table 4-1. Impacts resulting from the normal shed and emergency shed dispatches called on July 10 are presented separately. The load impacts presented for each event, along with their confidence intervals, are the average changes in load during the indicated dispatch windows. Results for the PJM test events, called on August 1 and September 10, are presented separately in Section 5.

Table 4-1: Randomized Control Trial per Customer Impacts

Event Date	Shed Type	Event Period	Reference Load (kW)	Impact (kW)	90% Confidence		% Impact	90% Confidence		Daily Max
					Lower bound	Upper bound		Lower Bound	Upper Bound	
7/10/2019	Emergency	4PM - 5PM	3.26	-0.94	-0.88	-1.00	-28.8%	-26.8%	-30.7%	91°F
	Normal	4PM – 5PM	3.26	-0.85	-0.79	-0.92	-26.3%	-24.3%	-28.3%	91°F
7/19/2019	Normal	4PM – 6PM	3.59	-0.86	-0.80	-0.92	-24.0%	-22.2%	-25.7%	92°F
8/19/2019	Normal	4PM – 6PM	3.66	-0.89	-0.83	-0.95	-24.4%	-22.8%	-26.1%	94°F
9/12/2019	Normal	4PM – 6PM	3.38	-0.65	-0.59	-0.71	-19.2%	-17.4%	-21.0%	93°F
9/30/2019	Normal	4PM – 6PM	3.39	-0.71	-0.60	-0.81	-20.9%	-17.8%	-24.0%	94°F
Average General Population Event			**3.50**	**-0.78**	**-0.71**	**-0.85**	**-22.1%**	**-20.0%**	**-24.4%**	**93°F**

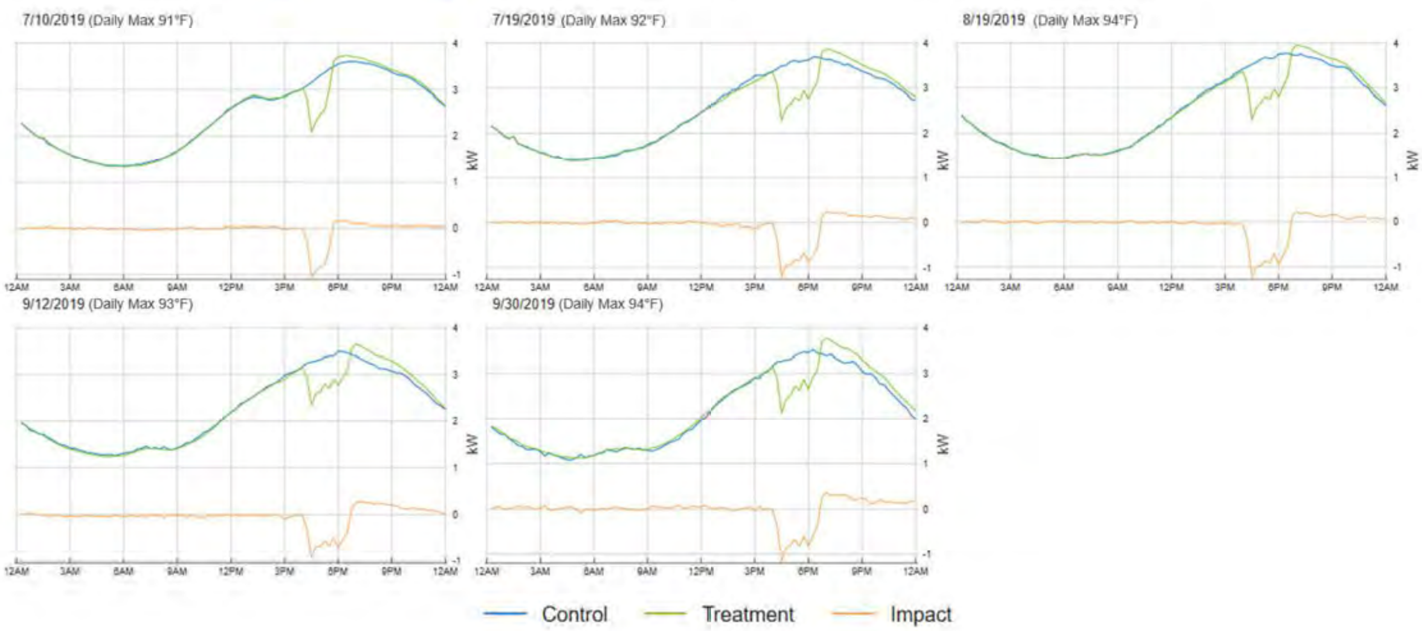
Overall load impacts for the average customer ranged between -0.65 kW and -0.89 kW during normal operations, with an average of -0.78 kW. These impacts are comparable to those observed in 2018, where the impacts for the general population ranged from -0.46 to -0.98 kW, with an average of -0.81 kW. The general population event days in 2019 all experienced similar daily maximum temperatures, ranging from 91°F to 94°F. As expected, the emergency shed event produced higher load impacts compared to general population events in 2019. The average per household load reduction under emergency conditions was -0.94 kW.

At least 5% of the population was held back as a control group during each event (excluding the PJM test events) in order to establish the baseline. While withholding a control group is an essential component of the RCT research design, it adversely affects the aggregate performance of the program, since customers being withheld do not contribute load reduction to the total impact. For example, the aggregate impacts on August 19 totaled approximately -33.7 MW, accounting for the total number of customers dispatched on that day. Had all program customers been dispatched under normal operation on August 19, including those from the control group, the program would have delivered approximately -35.4 MW.

The RCT results implicitly take device inoperability (and other offsetting factors) into account. Because randomized group assignment was utilized effectively, each of the individual test groups accurately represents the overall percentage of customers with inoperable devices from among the entire population. As such, the estimated load impacts are appropriately de-rated by the non-working devices included in the test groups, and do not require any independent adjustment to account for device inoperability.

Event impacts are displayed graphically in Figure 4-1, with the average customer load profiles shown for the treatment and control groups. In Figure 4-1, the blue line represents the average load from control group customers, the green line reflects average load of the customers participating in the event, and the orange line shows the average load impact (the difference between the control group and participant customer loads). All of the events show a clear drop in treatment group loads during the event dispatch period, as well as a measureable snapback in energy usage during the hours immediately following the events. Furthermore, most events show an instantaneous and prominent load drop during the first 15-minute interval of the dispatch period, underpinning the immediate, collective response of the load control devices once the event signal is received.

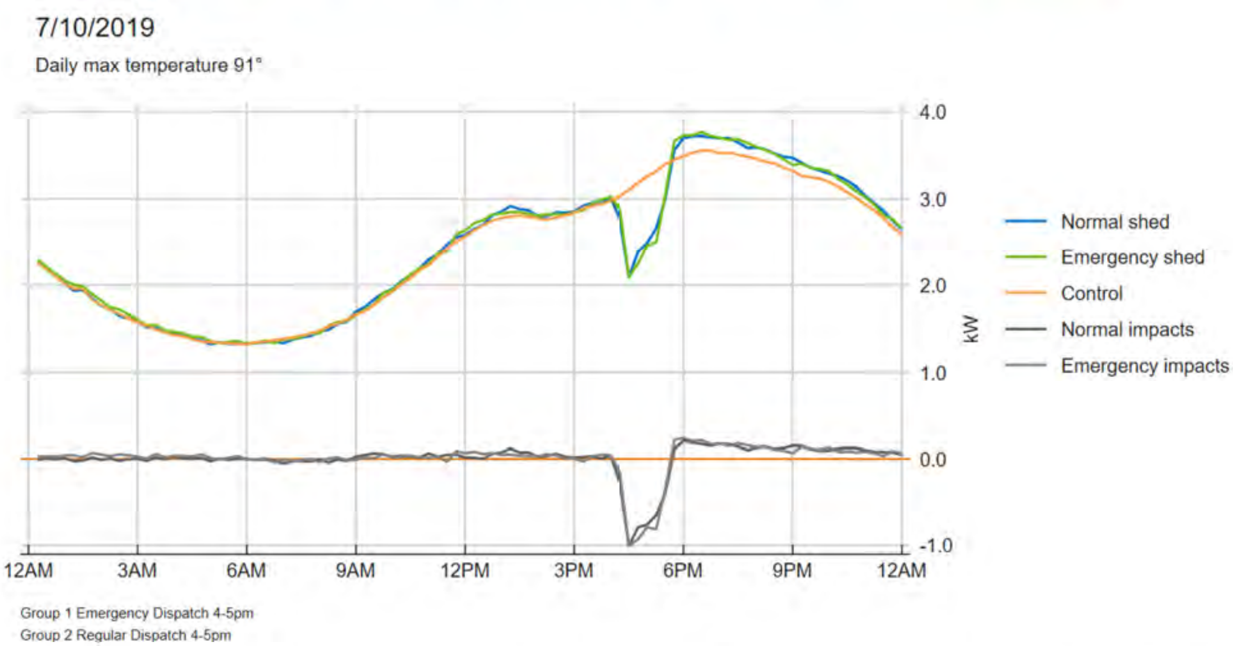
Figure 4-1: Average Customer Loads and Impacts for General Population Event Days



4.2 Side-by-Side Comparison of Normal and Emergency Conditions

The event called on July 10 dispatched feeder group 1 under normal conditions while simultaneously dispatching feeder group 2 under emergency conditions. This allows for a direct side-by-side comparison of emergency shed to normal event operations. Impacts for these events for both normal and emergency operations are presented together in Figure 4-2.

Figure 4-2: Load Profiles for Emergency and Normal Operations on July 10



A key takeaway from the side-by-side comparisons is that the customers dispatched under emergency shed options appear to have produced load impacts that are nearly equivalent to the customers dispatched under normal operations on the same day. Nonetheless, emergency operations typically produced slightly larger impacts than normal operations (-0.94 kW compared to -0.85 kW). This result is comparable with the results from the two side-by-side normal/emergency events in 2018, which also found only minor differences in impacts between simultaneous emergency and normal shed.[8]

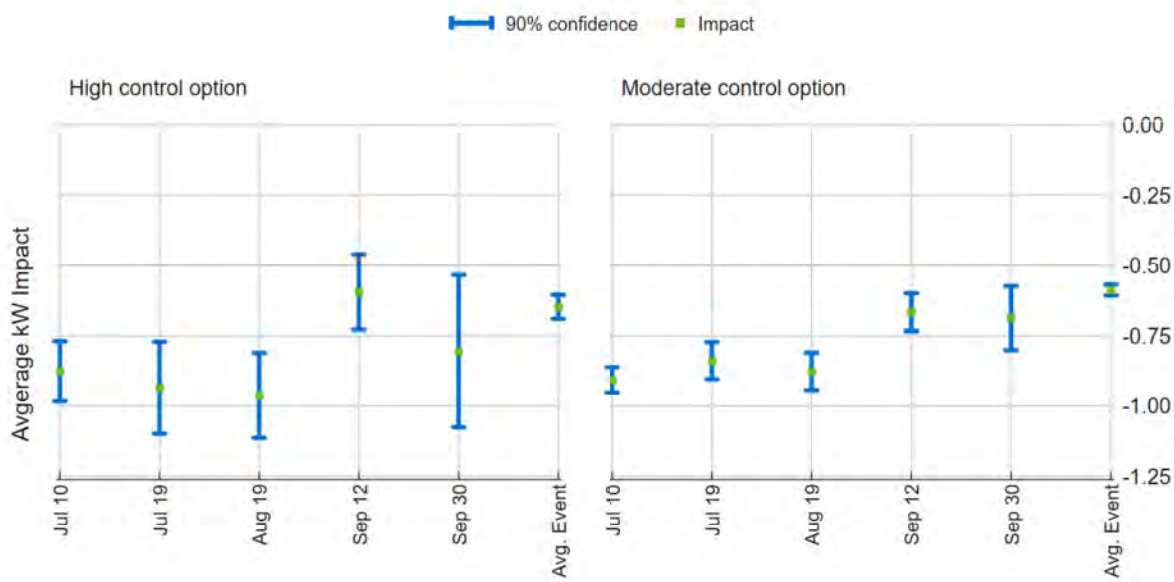
4.3 Impacts by Load Control Option

Figure 4-3 compares the load impact estimates for customers enrolled in the moderate vs. high load control options, as well as 90% confidence intervals, for each general population event called in 2019. In general, load impacts are larger for customers enrolled in the high load control option compared to the moderate option. However, differences in average per household

[8] Side-by-side events in 2018 yielded an average difference between normal and emergency 1 shed dispatches of approximately 0.11 kW compared to 0.09 kW in 2019.

impacts were never more than 0.12 kW, indicating a prevailing equivalence in performance between the two groups. On average, customers enrolled in the high load control option produced impacts of -0.82 kW, compared to -0.77 kW among those enrolled in the moderate control option. In addition, because there were significantly fewer customers in the high load control option subgroup, the confidence intervals for these point estimates are considerably wider. As a result, any differences in point estimates that do exist are statistically insignificant due to uncertainty. This is also reflected in the average event load impact for each group.

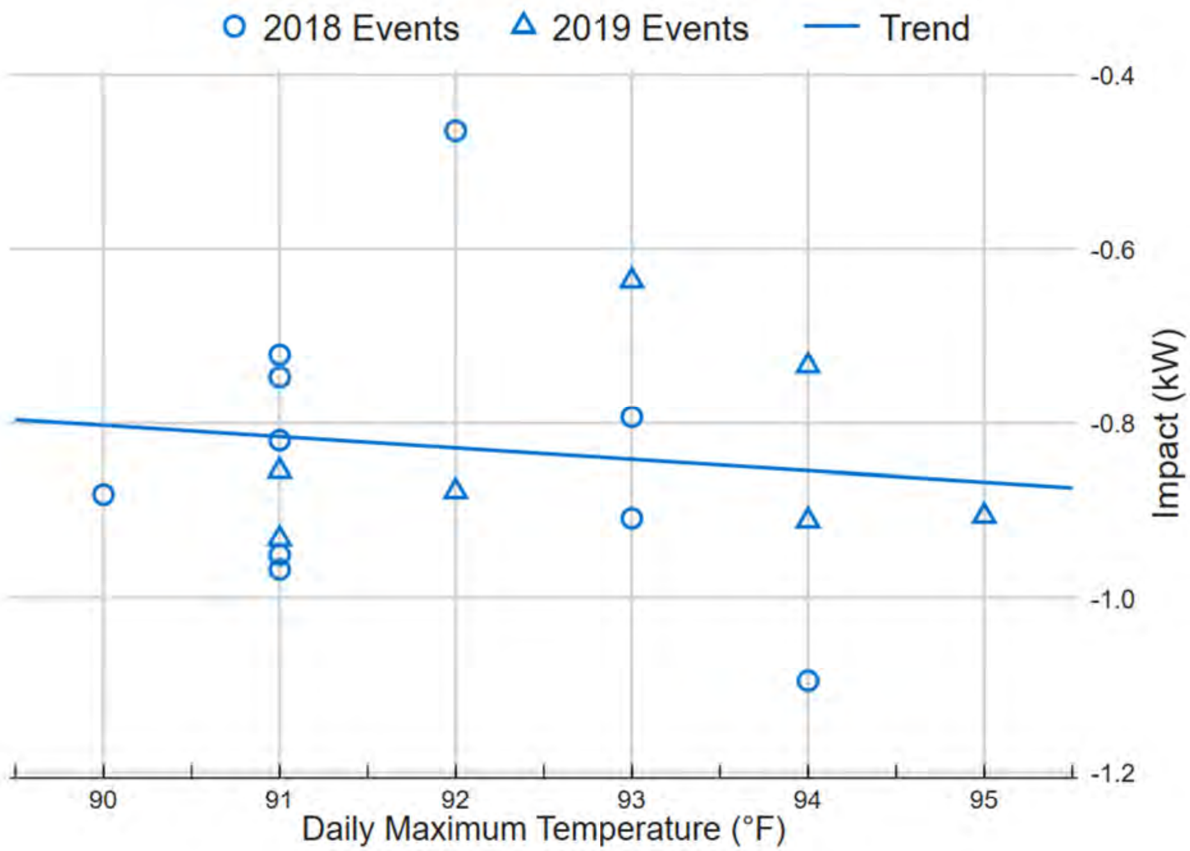
Figure 4-3: Comparison of Load Impact Results by Control Option



4.4 Weather Sensitivity of AC Load and Demand Reductions

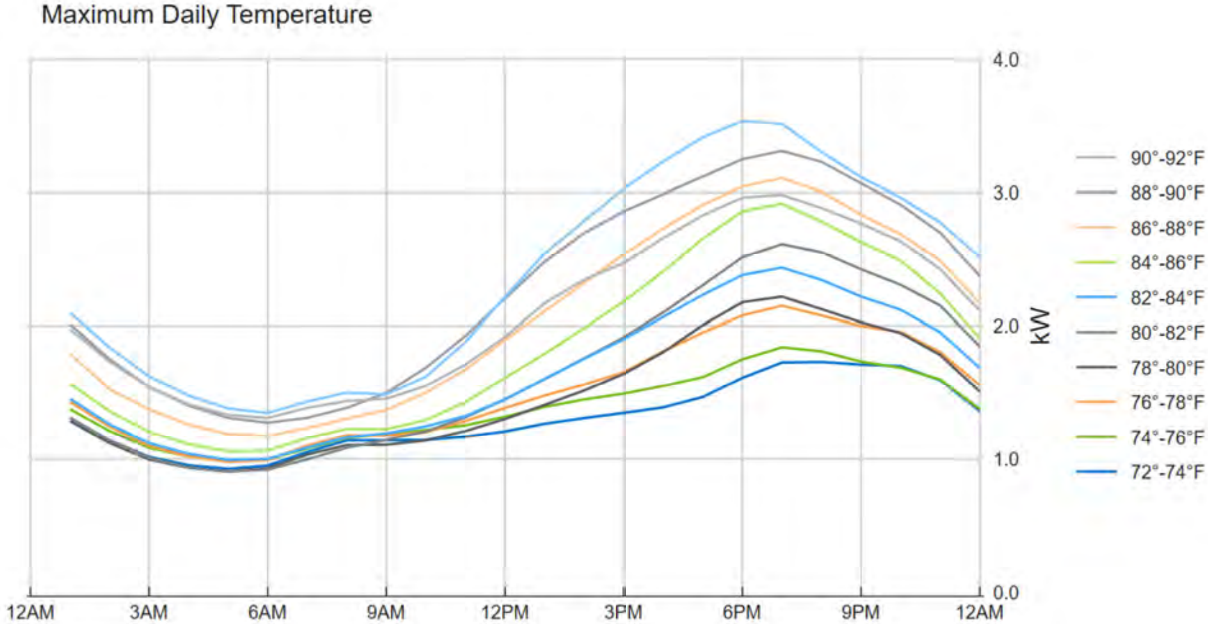
Load reduction capacity of Power Manager is largely dependent on weather conditions, as shown in Figure 4-4. The graph shows the estimated average customer impact for each event as a function of daily maximum temperature. The downward-sloping trendline indicates a correlation between higher temperatures and greater load reduction capacity.

Figure 4-4: Weather-Sensitivity of Overall Impacts



Both demand reductions and air conditioning loads grow with hotter temperatures. Figure 4-5 shows the weather sensitivity of whole-house loads for the average customer in Power Manager. All non-event weekdays where temperatures reached at least 75°F were classified into two-degree bins. The plot shows how the loads vary by hour as temperatures grow hotter.

Figure 4-5: Whole-House Loads by Maximum Daily Temperature



The key finding is simple: demand reductions grow larger in magnitude when temperatures are hotter and resources are needed most. Because peak loads are driven by central air conditioner use, the magnitude of air conditioning loads available for curtailment grows in parallel with the need for resources. Not only are air conditioning loads higher, but the program performs at its best when temperatures are hotter.

4.5 Key Findings

A few key findings regarding the RCT results are worth highlighting:

- Demand reductions were -0.78 kW per household for the average general population event.
- The emergency shed event on July 10 produced the highest load impacts of -0.94 kW.
- Emergency operations on July 10 produced only slightly higher impacts (-0.94 kW) than the normal operations (-0.85 kW).
- In general, the magnitude of demand reductions grows larger when temperatures are higher and resources are needed most.
- The difference in impacts between customers enrolled under the moderate and high load control options was minimal and within the range of uncertainty.

5 Within-Subjects Results

In addition to the regular and emergency shed events described in Section 4, Duke Energy dispatched two PJM test events on August 1 and September 10. The purpose of the PJM test events was to assess the full extent of program capability for demand reduction under emergency conditions. Under this scenario, the full program population is dispatched for the event and no customers are withheld as a control group. Absent a control group for these events, Nexant employed a within-subjects analysis approach in order to quantify impacts. The analysis approach used for within-subjects is described in detail in Section 3.3.

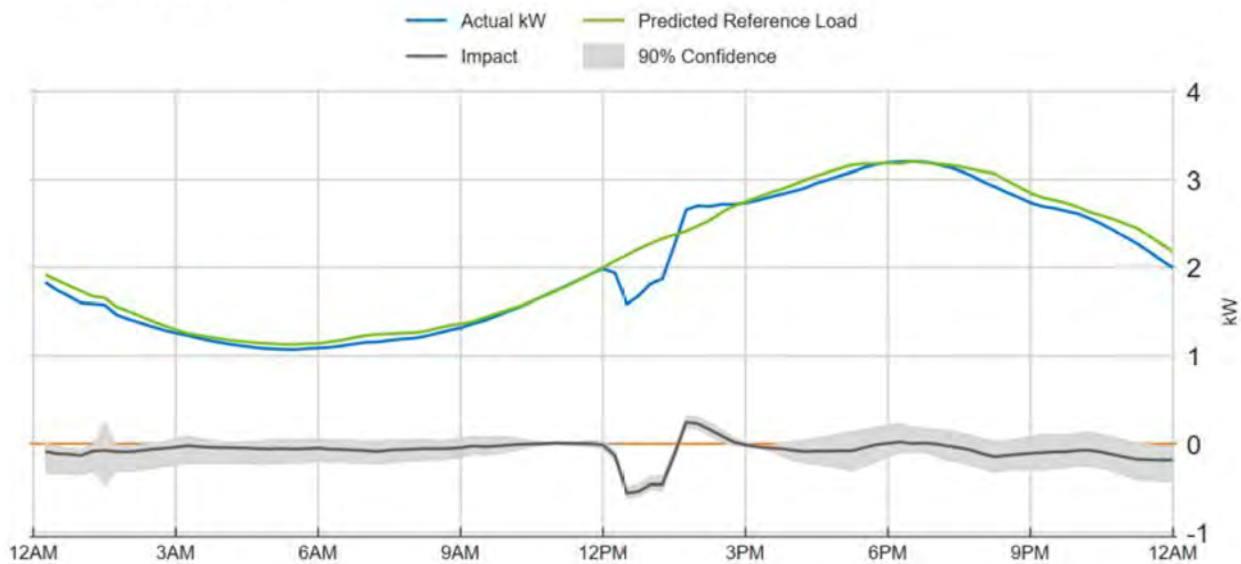
5.1 PJM Test Event Impacts

For each of these two events, a different set of proxy days was selected and used to generate the baseline loads through the process summarized in Figure 3-3. In this way, baselines were found that closely resembled the load patterns of the treatment groups during non-event hours, and accurately simulate the event period loads absent curtailment, i.e. the counterfactual

Load impacts for both the August 1 and September 10 PJM test event are shown in Figure 5-1 and Figure 5-2, respectively. The average per household load impact on August 1 was estimated to be -0.49 kW. The relatively low average impact resulting from this event is likely due to a combination two factors: first, the daily maximum temperature of 89°F is markedly lower than the other event days in 2019; and second, the unique timing of this event from 12:00 PM to 1:00 PM corresponds to substantially lower household loads that are available for curtailment.

Figure 5-1: Load Impacts for PJM Test Event on August 1

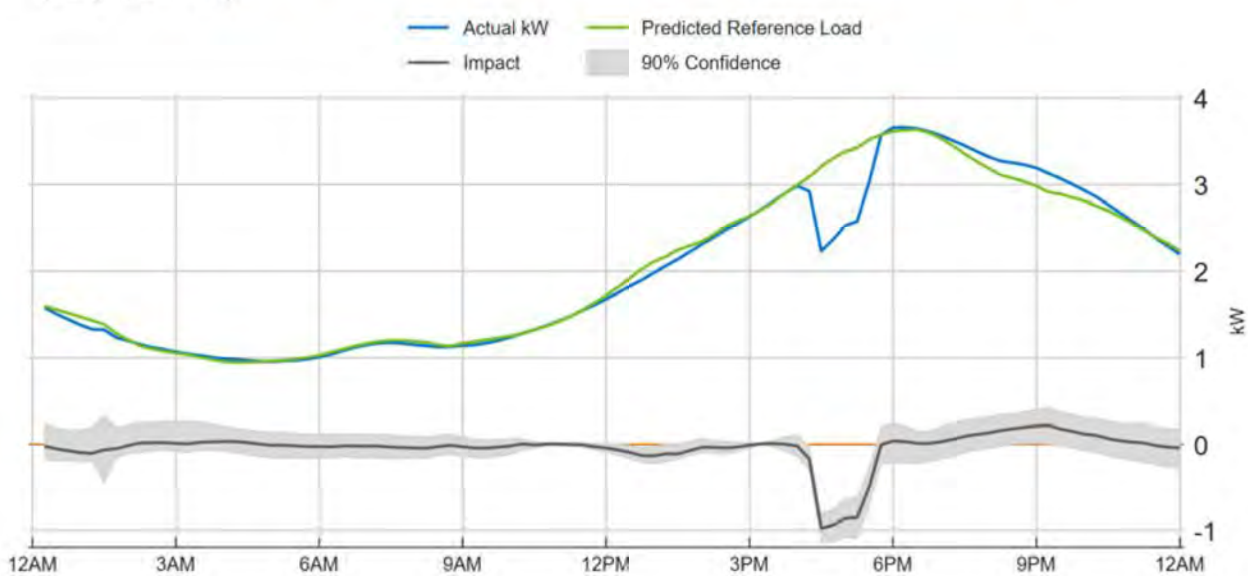
(Daily Max 89°F)



The average per household load impact found for the PJM test event called on the September 10 was estimated to be -0.91 kW. Contrary to the August 1 test event, the test event on September 10 had a daily maximum temperature of 95°F - the highest observed among all event days in 2019 - and occurred closer to system peak hours, resulting in significantly larger per household impacts that were consistent with the emergency shed impacts found via RCT.

Figure 5-2: Load Impacts for PJM Test Event on September 10

(Daily max 95°F)



5.2 Key Findings

- The within-subjects methodology produced accurate reference loads against which to compare treatment loads, leading to highly reliable impact estimates.
- The PJM-required emergency shed event on August 1 produced impacts of -0.5 kW per household.
  - The August 1 event impacts were likely affected by lower temperatures and early event timing.
- The PJM-required emergency shed event on September 10 produced impacts of -0.91 kW per household and were comparable to the emergency shed impacts found via RCT on July 10 (-0.94 kW).

6 Demand Reduction Capability

A key objective of the 2019 impact evaluation was to quantify the relationship between demand reductions, temperature, hour of day, and cycling strategy. This was accomplished by estimating loads under historical weather conditions and applying observed percent load reductions from the both 2018 and 2019 events. The resulting tool, referred to as the time-temperature matrix, allows users to predict the program's load reduction capability under a wide range of temperature and event conditions. For purposes of reporting program capability, emergency conditions are used, where both moderate and high customers are cycled at 75% shed.

In an ideal program year, a large number of events would be called under a variety of different weather conditions, dispatch windows and cycling strategies so that demand reduction capability could be estimated for a wide range of operating and planning scenarios. In actuality, opportunities for program events can be sporadic, and based on uncertain weather projections, such that they occur infrequently and under fairly similar conditions. In 2018 and 2019, events were called under a rather narrow range of temperature conditions, with daily maximum temperatures on event days ranging from 89°F to 95°F. As a result, the ability to predict demand reduction capability across a broader range of conditions was somewhat inhibited.

6.1 Methodology

In previous evaluations, only the current year's results was used to develop the time-temperature matrix. However, only using the 2019 data proved to be ineffective for this evaluation – the resultant reference loads were too low, and did not accurately reflect the full capability of the program. Therefore, 2018 evaluation results were combined with those from 2019 to form a comprehensive dataset that showed greater consistency in program design and evaluation approach between the two years. The resultant dataset more broadly reflects program performance over a longer time period and should result in more accurate estimates.

Figure 6-1 illustrates the weather sensitivity trends of event load impacts and peak household demand on hot, non-event days. The figure, based on actual 2018/2019 customer load data, shows that Power Manager demand reductions grow as temperatures increase, and with deeper cycling. At the same time, peak household loads available for curtailment also increase with temperature. The implication is that larger percent reductions are attainable from larger loads, when temperatures are hotter.

Figure 6-1: Weather Sensitivity of Load Impacts and Household Loads

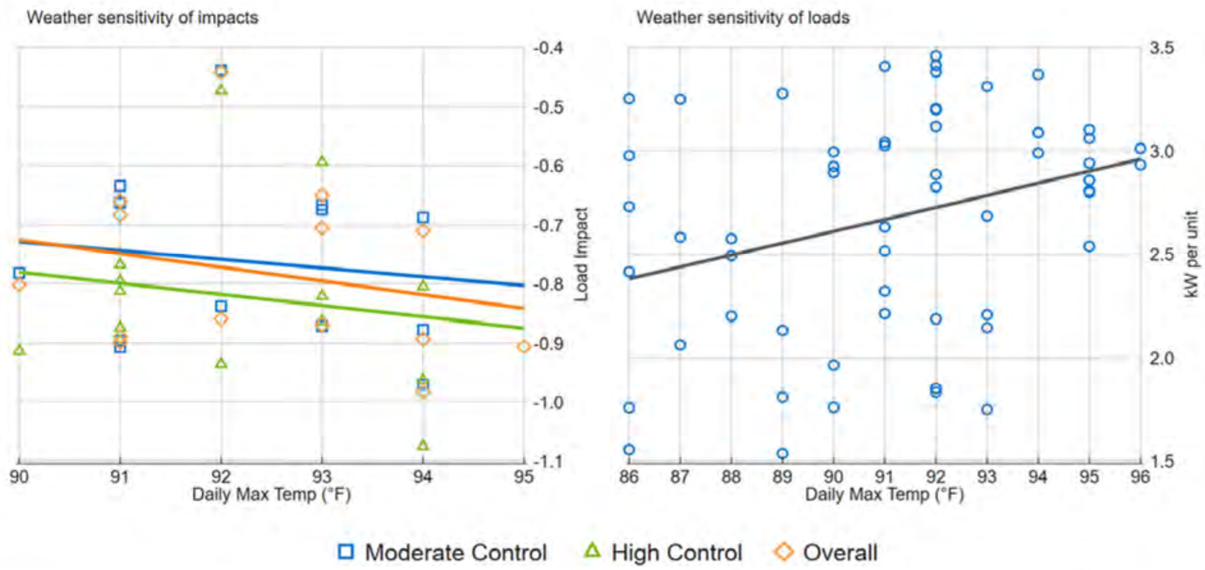
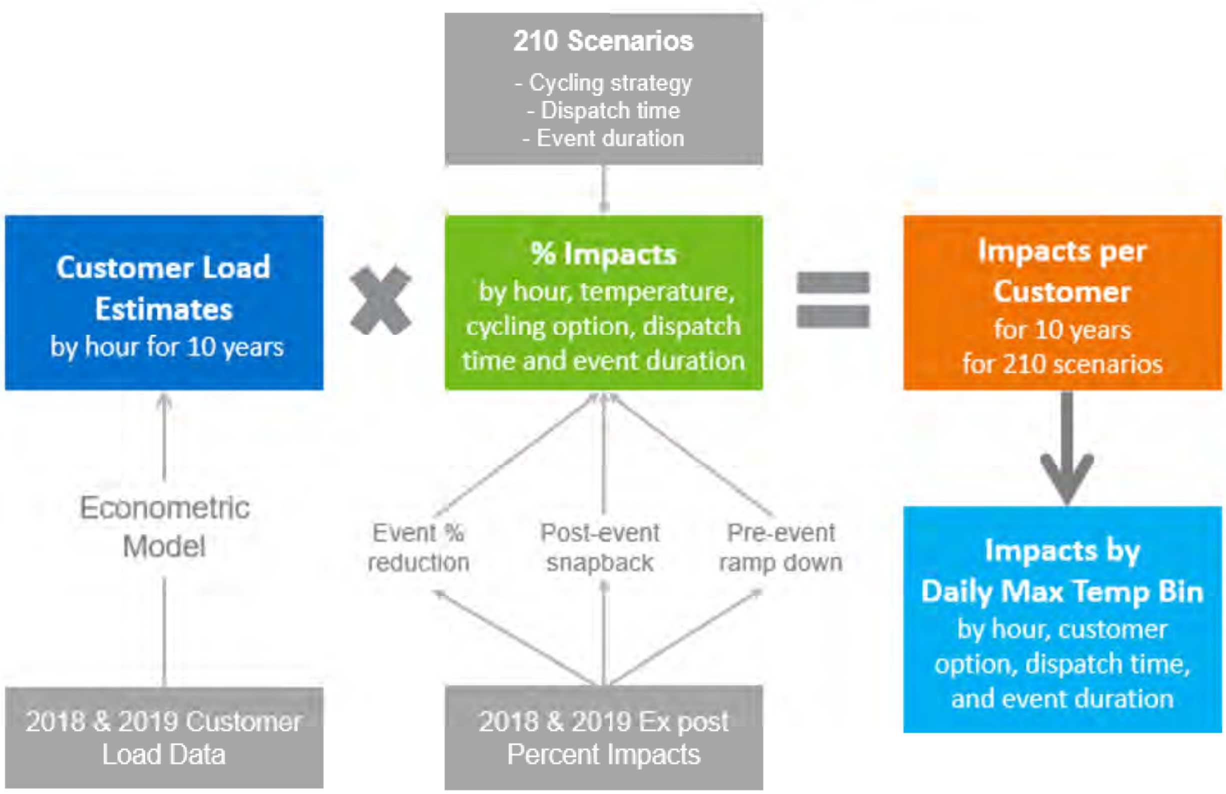


Figure 6-2 summarizes the process used to develop the time-temperature matrix for estimating demand reduction capability under various scenarios.

Figure 6-2: Time Temperature Matrix Development Process



The process used to produce the time-temperature matrix involved the following primary components:

- Estimates of customer loads were developed by applying 2018 and 2019 AMI data to the same regression models used to estimate impacts. All weekdays with daily average temperatures above 70˚F were included in the models. The 2018 and 2019 usage patterns were applied to actual weather patterns experienced over the past ten years rather than hypothetical weather patterns.
- Estimates of the percent reductions were based on three distinct econometric models: load control phase-in, percent reductions during the event, and post-event snapback. The models were based on the percent impacts and temperatures experienced during 2018 and 2019 events.
- A total of 210 scenarios were developed to reflect various cycling/control strategies, event dispatch times, and event lengths.
- Estimated impacts per customer were produced by combining the estimated household loads, estimated percent reductions, and dispatch scenarios. The process produced estimated hourly impacts for each hot weekday during 2009-2018 under 210 scenarios.
- Multiple days were placed into 2-degree temperature bins and were averaged to produce an expected load reduction profile for each temperature bin.

6.2 Demand Reduction Capability for Emergency Conditions

While Power Manager is typically dispatched for economic or research reasons, its primary function is to deliver demand relief during extreme conditions, when demand is high and capacity is constrained. Extreme temperature conditions can trigger emergency operations, which are designated to deliver larger demand reductions than normal event cycling. During emergency conditions, all program devices are instructed to instantaneously shed loads. While emergency operations are rare and ideally avoided, they represent the full demand reduction capability of Power Manager.

Figure 6-3 shows the demand reduction capability of the program if emergency shed becomes necessary on a day with 94˚F maximum temperature. Individual customers are expected to deliver -1.04 kW of demand reduction over a one-hour event window. Because there are approximately 43,600 customers enrolled in Power Manager, the expected aggregate reduction is -45.2 MW.

Figure 6-3: Demand Reduction Capability – Emergency 1 Dispatch with 94°F Maximum Temperature

Inputs	
Dispatch Type	Emergency Dispatch
Option	Overall
Event Start	4 PM
Event Duration (Hours)	1
Daily Max Temp (°F)	94
# Customers	43,600

Event Window Average Impacts	
Load without DR	3.40 kW per customer
Load with DR	2.36 kW per customer
Impact per customer	-1.04 kW per customer
Impact (MW)	-45.2 MW
% Impact	-30.5 %

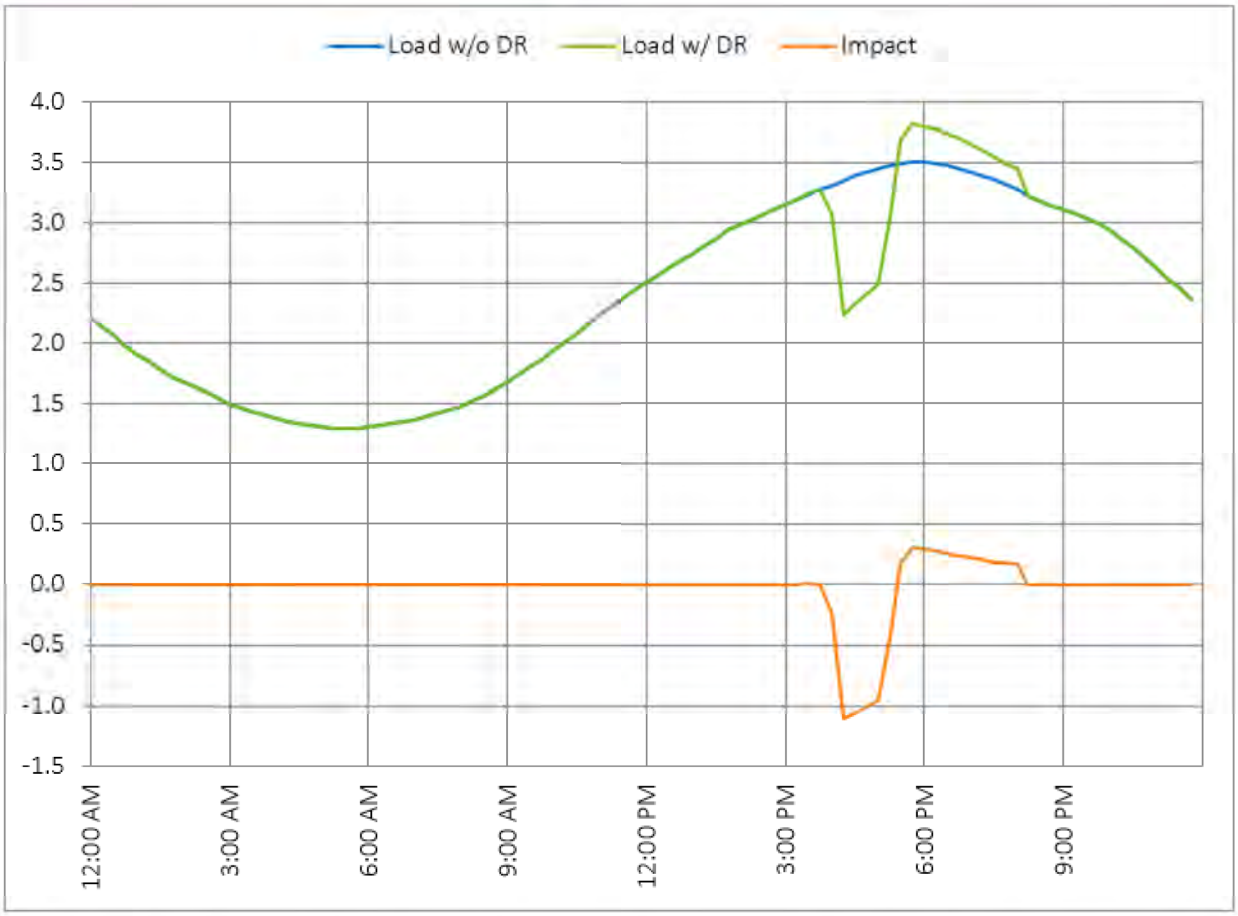


Table 6-1 shows the predicted impacts for 1-hour events across the range of temperatures of 86°F to 100°F and event start times between 1 PM and 5 PM. Impacts increase as temperatures increase and as the event starts later in the day. Impacts increase with a later event start time because reference loads are generally increasing from 1:00 PM to 5:00 PM during the summer. In practice, event day impacts may vary due to unique weather patterns or day characteristics.

Table 6-1: Average Predicted Impacts by Maximum Daily Temperature and Event Start

Daily Maximum Temperature	Event Start Time				
	1:00 PM	2:00 PM	3:00 PM	4:00 PM	5:00 PM
86°F	-0.68	-0.74	-0.79	-0.85	-0.89
88°F	-0.76	-0.82	-0.87	-0.92	-0.95
90°F	-0.81	-0.86	-0.91	-0.96	-0.99
92°F	-0.83	-0.88	-0.93	-0.97	-1.00
94°F	-0.89	-0.94	-0.99	-1.04	-1.06
96°F	-0.92	-0.98	-1.03	-1.06	-1.09
98°F	-0.98	-1.04	-1.09	-1.13	-1.15
100°F	-1.04	-1.10	-1.13	-1.16	-1.17

6.3 State Bill 310 Compliance

In the state of Ohio, electric distribution utilities (EDUs), including Duke Energy, are required to achieve a cumulative annual energy savings of more than 22% by 2027, in addition to achieving 0.75% peak demand reductions (PDR) in 2017-2020, per Ohio Senate Bill (SB) 310. Under current law, EDUs must implement PDR programs designed to achieve a 1% PDR and an additional 0.75% PDR each year through 2018. SB 310 also introduced new mechanisms that adjust how EDUs may estimate their energy savings or PDR achieved through demand side management (DSM) programs. Specifically, SB 310 requires the Ohio Public Utilities Commission (PUC) to permit EDUs to account for energy-efficiency or PDR savings estimated on whichever value is higher between an "as-found" or a deemed basis. In the case of the 2019 Power Manager evaluation, the "deemed" savings approach will be applied using the claimed results from the previous year, which were based on the results from the 2016-2017 impact evaluations. The relevant language for SB310 is provided in Appendix B.

Table 6-2 compares the deemed peak demand reductions from 2016-2017 to the as-found demand reductions from the 2018 and 2019 impact evaluations. Per SB310, Duke Energy will again claim the deemed values from 2016-2017 for Power Manager.

Table 6-2: SB 310 Compliance Peak Demand Reductions

Event Conditions	Number of Customers	Average Impact per Device	Average Impact per Customer	Aggregate Impact	Source
Emergency Shed	45,000	-1.41 kW	-1.49 kW	-67.0 MW	Time-Temperature Matrix based on 2016 and 2017 impacts
Emergency Shed	43,600	-0.98 kW	-1.04 kW	-45.2 MW	Time-Temperature Matrix based on 2018 and 2019 impacts

6.4 Key Findings

Key findings from the development of the time temperature matrix include:

- While emergency operations are rare and ideally avoided, they represent the full demand reduction capability of Power Manager.
- Power Manager demand reductions grow as temperatures increase, and with deeper cycling. At the same time, peak household loads available for curtailment also increase with temperature.
- If emergency shed becomes necessary on a 94˚F maximum temperature day, Power Manager can deliver -1.04 kW of demand reductions per household during a 1-hour event.
- Because there are approximately 43,600 Power Manager customers, the expected aggregate reductions total -45.2 MW.
- The event start time also influences the magnitude of reductions which, generally, are larger during hours when customer loads are highest.
- Duke Energy will claim the deemed value of -1.41 kW per device (-1.49 kW per customer) from 2016-2017 for Power Manager per SB 310.

Appendix A Senate Bill Legislation on Energy Efficiency Accounting

130th General Assembly Senate Bill Number 310

Sec. 4928.662. For the purpose of measuring and determining compliance with the energy efficiency and peak demand reduction requirements under section 4928.66 of the Revised Code, the public utilities commission shall count and recognize compliance as follows:

(A) Energy efficiency savings and peak demand reduction achieved through actions taken by customers or through electric distribution utility programs that comply with federal standards for either or both energy efficiency and peak demand reduction requirements, including resources associated with such savings or reduction that are recognized as capacity resources by the regional transmission organization operating in Ohio in compliance with section 4928.12 of the Revised Code, shall count toward compliance with the energy efficiency and peak demand reduction requirements.

(B) Energy efficiency savings and peak demand reduction achieved on and after the effective date of S.B. 310 of the 130th general assembly shall be measured on the higher of an as found or deemed basis, except that, solely at the option of the electric distribution utility, such savings and reduction achieved since 2006 may also be measured using this method. For new construction, the energy efficiency savings and peak demand reduction shall be counted based on 2008 federal standards, provided that when new construction replaces an existing facility, the difference in energy consumed, energy intensity, and peak demand between the new and replaced facility shall be counted toward meeting the energy efficiency and peak demand reduction requirements.

(C) The commission shall count both the energy efficiency savings and peak demand reduction on an annualized basis.

(D) The commission shall count both the energy efficiency savings and peak demand reduction on a gross savings basis.

(E) The commission shall count energy efficiency savings and peak demand reductions associated with transmission and distribution infrastructure improvements that reduce line losses. No energy efficiency or peak demand reduction achieved under division (E) of this section shall qualify for shared savings.

(F) Energy efficiency savings and peak demand reduction amounts approved by the commission shall continue to be counted toward achieving the energy efficiency and peak demand reduction requirements as long as the requirements remain in effect.

(G) Any energy efficiency savings or peak demand reduction amount achieved in excess of the requirements may, at the discretion of the electric distribution utility, be banked and applied toward achieving the energy efficiency or peak demand reduction requirements in future years.

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Duke Energy Ohio (DEO)

2017-2018 Neighborhood Energy Saver Program Evaluation Report – Final

May 13, 2020

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1. Evaluation Summary

1.1 Program Summary

The Duke Energy Ohio (DEO) Neighborhood Energy Saver Program (NES) provides one-on-one energy education, on-site energy assessments, and energy conservation measures to customers in selected low-income neighborhoods. Duke Energy offers these services free of charge to all active DEO account holders that are individually metered homeowners and tenants living in predetermined income-qualified communities. Qualifying neighborhoods have at least 50% of households with incomes equal to or less than 200% of the federal poverty level.

The program employs a neighborhood canvas approach to drive participation, while working with existing organizations in each community to maximize the number of customers benefitting from the program. Per implementation period, program teams aim to reach 1,339 DEO customers. Program staff aim to serve at least 70% of the households in each of the neighborhoods they engage. The program period under evaluation is July 1st, 2017 through May 31st, 2018. The evaluation team selected this period to capture the Woodlawn neighborhood only. The program launched in the Woodlawn neighborhood in July of 2017 and concluded in November of 2017 due to the program reaching recovery caps and subsequently being asked to cease operations prior to serving 70% of the neighborhood. Implementation in the next Ohio neighborhood (Evanston; not covered in this evaluation) started on May 31at, 2018.

1.2 Evaluation Objectives

The objectives of the 2017-2018 DEO NES Program evaluation are to:

- Review and update, as necessary, deemed savings estimates through a review of measure assumptions and calculations.
- Verify measure installation and persistence.
- Estimate program energy (kWh), summer and winter peak demand (kW) savings, and realization rates.
- Determine participant satisfaction with and effectiveness of the NES Program.

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

1.3 High Level Findings

Overall, NES Program teams in DEO territories implemented the program effectively. Despite the shortened implementation period, the program team served 1,085 participants (81% of program goal) and had a 64% penetration rate. In addition, the evaluation found high levels of program satisfaction, with 93% of participants somewhat or very satisfied with the program overall and 91% somewhat or very satisfied with the equipment they received through the program.

Impact Evaluation

As part of the impact evaluation, we conducted an engineering analysis to provide insight into how each measure contributes to overall program savings. The engineering analysis also allows us to develop a ratio of overall kW to kWh savings, which we then apply to the net energy savings from the billing analysis to determine evaluated net demand savings for the program. Table 1-1 presents the total gross impacts for each measure installed through the program and the estimated individual measure contribution to the overall energy (kWh) savings from the engineering analysis.

Table 1-1 Measure-Level Gross Impact Results from Engineering Analysis

Measure	Energy (kWh)	% of kWh	Summer Coincident Demand (kW)	Winter Coincident Demand (kW)
LEDs	259,944	72%	20.43	17.98
Low Flow Showerhead	32,862	9%	1.17	2.34
Infiltration Reduction	30,273	8%	17.50	4.90
Pipe Insulation	12,031	3%	1.37	1.37
Faucet Aerator	10,103	2%	0.55	1.11
Water Heater Insulation Wrap	7,230	2%	0.82	0.82
HVAC Filters	8,066	1%	5.23	0.24
Total Database Savings	**360,510**	**100%**	**47.08**	**28.76**

Overall program net savings for the DEO NES Program are primarily derived from the results of our billing analysis. The billing analysis provides average per-household net energy savings, including savings from equipment installed by program representatives, as well as savings from any additional behavioral changes and participant spillover attributable to the program (see Table 1-2). Demand savings are calculated from the ratios of engineering analysis kW to kWh savings, which are applied to the billing analysis net energy savings.

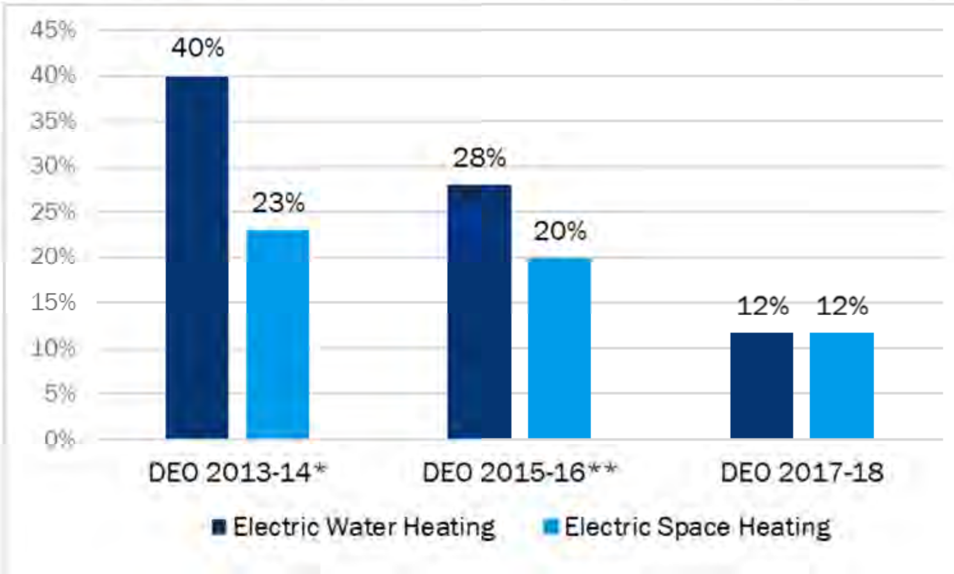
Table 1-2 Net Annual Impact Results from Billing Analysis

	Energy (kWh)	Summer Coincident Demand (kW)	Winter Coincident Demand (kW)
Participant-Level Savings	216	0.02	0.01
Program-Level Savings	234,475	30.6	19.2

Based on the billing analysis, participants in the DEO NES Program saved 2.3% of their baseline energy usage after participating in the program. Per-participant annual net energy savings from the billing analysis (216 kWh) decreased 29% from the estimated savings from the 2016 evaluation (303 kWh). Ex-ante annual savings were 420 kWh, resulting in a 52% realization rate.

Per household energy savings for the 2017-18 evaluation period were lower than estimates from previous evaluations. Lower savings were driven, in part, by a smaller share of participants with electric space and water heating (Figure 1-1). Given the mix of measures offered through the NES Program, energy savings from domestic hot water and infiltration measures represent a large portion of potential program savings. To realize electric savings from these measures, participants need to heat their homes or hot water with electricity. As such, a lower share of participants that heat with electric fuel will yield lower energy savings per household.

Figure 1-1 Share of DEO Participants with Electric Space and Water Heating



* Source: Process and Impact Evaluation of the 2013–2014 Residential Neighborhood Program in Ohio. Prepared for Duke Energy by TecMarket Works, February 2015.
**Source: 2015-16 Duke Energy Ohio 2015-2016 Neighborhood Energy Saver Program Evaluation Report. Prepared for Duke Energy by Opinion Dynamics, November 2017.

Senate Bill 310 Compliance

To support compliance with Ohio Senate Bill 310 (SB 310), Table 1-3 provides the energy and peak demand savings claimable under SB 310. Per SB 310, DEO will claim 420 kWh of energy savings and 0.13 kW and 0.14 kW of peak summer and winter demand savings, respectively, per household for the 2017-2018 program evaluation period. These values are the higher of the ex- ante and ex-post savings values, based on analyses conducted for the current and the previous evaluations.

Table 1-3. Summary of Impacts for SB 310 Compliance

Per Household Impacts (2017-2018)	
Energy Savings (kWh) per Household	420
Summer Coincident Savings (kW)	0.13
Winter Coincident Savings (kW)	0.14

Process Evaluation

Opinion Dynamics conducted a limited process evaluation; therefore, the research team focused on several questions related to NES participant satisfaction and the overall effectiveness of the program. We present the full results Section 5 and summarize the key findings below.

- Participants were highly satisfied with the NES Program:

- Ninety-three percent of survey respondents said that they were satisfied with the program overall and 91% of said they were satisfied with the equipment they received through the program.

- Ninety-seven percent of survey respondents reported being somewhat or very motivated to reduce their energy use after participating in the program.

1.4 Evaluation Recommendations

Opinion Dynamics has the following recommendations for maintaining and improving program performance and overall savings. More details on these recommendations are included in Section 6 and throughout this report.

- **NES Program teams should consider including additional criteria (e.g., energy use intensity (EUI) or number of number of disconnect notices) when identifying and selecting neighborhoods for future program years.** The NES Program offers, by design, a relatively limited set of easy-to-install measures. Beyond lighting measures, domestic hot water and air infiltration measures will continue to be key to increasing the average electric energy savings for participating households. As such, program staff should consider analyzing supplemental data to maximize energy savings from the program and ensure that the NES treatments reach those customers with the highest need**.** When selecting neighborhoods to canvass in future program years, program staff should review EUI, the number of disconnect notices, the share of households with electric space heating, and other criteria that may identify neighborhoods with higher energy burdens.

2. Program Description

2.1 Program Design

The DEO NES Program offers direct-install measures and employs a neighborhood canvassing approach to drive participation. The goal is to offer persistent energy savings to income-qualified customers through the direct installation of energy-saving measures. NES implementation teams provide energy saving measures at no cost to participants, information on the measures that they received, and additional suggestions on ways to lower energy use in their homes. The NES Program teams also partner with neighborhood organizations to promote the program and maximize the number of customers benefitting from the receipt of energy conservation measures.

Neighborhoods can be selected to participate in the program if at least 50% of households in the neighborhood have incomes equal to or less than 200% of the federal poverty level. Implementation teams aim to reach 1,339 DEO customers per implementation period in one or more preselected communities throughout Ohio. The 2017-2018 evaluation captures the Woodlawn neighborhood only; the subsequent Ohio neighborhood (Evanston) will be evaluated in the next DEO evaluation. Participating households are limited to a one-time receipt of energy efficiency measures through the program.

2.2 Program Implementation

Honeywell Building Solutions (Honeywell) implemented the 2017-2018 DEO NES Program in partnership with Duke Energy program staff. The implementer performs all assessments and installations. DEO program staff are heavily involved in selecting specific neighborhoods based on program eligibility criteria.

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

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

2.3 Program Performance

The evaluation period is set from the start of program implementation in the Woodlawn neighborhood (July 1st, 2017) until the start of the implementation in Evanston, the next Ohio neighborhood (May 31st, 2018). The program launched in the Woodlawn neighborhood in July 2017 and concluded in November of 2017 due to the NES Program team reaching recovery caps and subsequently being asked to cease operations prior to serving 70% of the neighborhood. Over the evaluation period, the program team served 1,085 households in the Woodlawn neighborhood and had a 64% penetration rate. Based on our billing analysis, NES participants saved an average of 216 kWh per household per year and reduced their demand by 0.028 kW in the summer and 0.017 kW in the winter per household.

3. Overview of Evaluation Activities

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

- Interviews with DEO program staff;
- A review of program materials and program tracking data;
- A participant telephone survey;
- An engineering analysis of deemed savings; and
- A billing analysis of savings.

Sections 4 and 5, respectively, provide more details on the methods and results of the impact and process analyses. Below, we summarize the scope and approach for the staff interviews, the program materials and data review, the engineering analysis, the billing analysis and the participant survey. Each of these components supported either the impact or the limited process evaluations.

3.1 Program Staff Interviews

Opinion Dynamics conducted an in-depth interview with program staff responsible for program administration in the 2017-2018 evaluation period. The in-depth interview allowed us to discuss implementation of the NES Program in DEO territory including differences between the DEO program and program implementation in other Duke Energy territories. We also used this interview to identify program successes, to discuss any difficulties in administering the program, and to determine any risks for the program achieving its goals.

3.2 Program Materials and Data Review

DEO program administration staff provided Opinion Dynamics with information on the program. These data included the program marketing materials, program tracking databases, and other program documents—such as the NES Program manual, educational materials, and implementers' on-site auditing and direct installation procedures. Review of these materials informed development of the participant survey instrument and the engineering analysis.

Each of these materials is further described below.

- **Marketing Materials.** Opinion Dynamics reviewed the leave-behind brochure, the customer survey booklet, the pre-participation program informational brochure, the leave-behind door hanger, the energy efficiency brochure about other Duke Energy programs, the introduction letter to the NES Program and the informational session, examples of the presentation shown at the informational sessions, and postcards sent to participants with information about how to participate.
- **Program Database.** The program staff provided Opinion Dynamics with program tracking data from July 1st, 2017 to November 30th, 2017; the period of time that implementation teams served DEO neighborhoods during the evaluation period. The database provided us with information on the quantities, location (in some cases), and types of measures installed in each treated household.

- **Program Documents.** The program documents that we reviewed included statements of work between Duke Energy and Honeywell as well as the NES Program guide. The guide explained the program implementation process, including homeowner eligibility, communication, scheduling, and assessment and installation, as well as a description of installed measures.

3.3 Participant Survey

The purpose of the participant survey was to collect information to support the process evaluation and development of in-service rates (ISRs). Opinion Dynamics implemented the survey as a computer-assisted telephone interviewing (CATI) survey between January 7th and January 21st, 2019. We completed a total of 89 interviews and achieved a response rate of 16.2%. The average length of the interviews was 11 minutes.

The sample frame for the survey was based on the 1,085 NES participants that enrolled between July 1st, 2017 and May 31st, 2018. Our team removed 36 records that were missing phone numbers and 312 records that were on Duke Energy's "Do Not Call" list. We then attempted to contact all the remaining 737 program participants, i.e., a census attempt. Therefore, the concept of relative sampling precision does not apply to this effort.

3.4 Engineering Analysis

The objectives of the engineering analysis were to (1) better understand the relative contribution of each measure to overall energy savings and (2) develop the ratio of demand to energy savings, which is applied to billing analysis results (see Section 3.5) to estimate evaluated demand savings.

Opinion Dynamics first conducted a review of the deemed savings values and assumptions for each of the NES Program measures (described below). We then adjusted the ex post deemed per-unit savings for each measure using the ISRs developed through the participant survey. We estimated total program savings (energy and demand) by applying the adjusted per unit savings to each participant based on the package of measures they received, their heating fuel, and the presence or absence of different types of heating and cooling equipment.

Appendix A provides more detail on the methods used in the engineering analysis.

3.4.1 Deemed Savings Review

The primary goal of the deemed savings review was to develop updated savings algorithms and input assumptions that are consistent with standard industry practice and comparable with applicable Technical Reference Manuals (TRMs).

To conduct our deemed savings review, we performed the following steps:

- Reviewed the prior evaluation report, for the 2015-2016 NES Program years;
- Analyzed program tracking data to compile household characteristics (e.g., primary heating fuel type) to be used in estimating deemed savings for individual measures;
- Reviewed other secondary information, including the program manual and the technical specifics of efficient equipment offered through the program; and
- Reviewed the latest Ohio (OH), Illinois (IL), and Indiana (IN) TRMs, along with other recently published studies where relevant, to determine if there was a need for additional updates.

3.5 Billing Analysis

Opinion Dynamics conducted a billing analysis to determine the net savings attributable to the NES Program for the 2017-2018 evaluation period. We used a linear fixed effect regression (LFER) model to estimate the overall net ex-post program savings. For previous NES evaluations, we have used participants from the current evaluation period as the treatment group and customers that participated after the evaluation period as the comparison group. However, because the treatment and comparison group did not have equivalent usage patterns, we chose a pre-post model to estimate savings. The pre-post model functions similarly to models using a comparison group and allows us to correct for household factors that do not vary over time. However, pre-post models may not capture variances in non-program factors that could affect energy usage. A summary of the billing analysis approach is provided in Section 4.3; a detailed description of the billing analysis methodology is presented in Appendix B.

4. Impact Evaluation

This section describes the process by which the evaluation team calculated NES Program impacts through the engineering analysis and billing analysis.

4.1 Engineering Analysis

As part of the impact evaluation, Opinion Dynamics conducted an engineering analysis for each NES Program measure installed in 2017-2018. Note that the billing analysis determines the net evaluated energy (kWh) impacts for the program. The engineering analysis supplements the billing analysis by:

- Providing a ratio of demand savings (kW) to energy savings (kWh), which is then applied to the billing analysis net energy savings to calculate net evaluated demand savings; and
- Providing insight into the individual measure contributions to the overall program savings.

4.1.1 Engineering Analysis Methodology

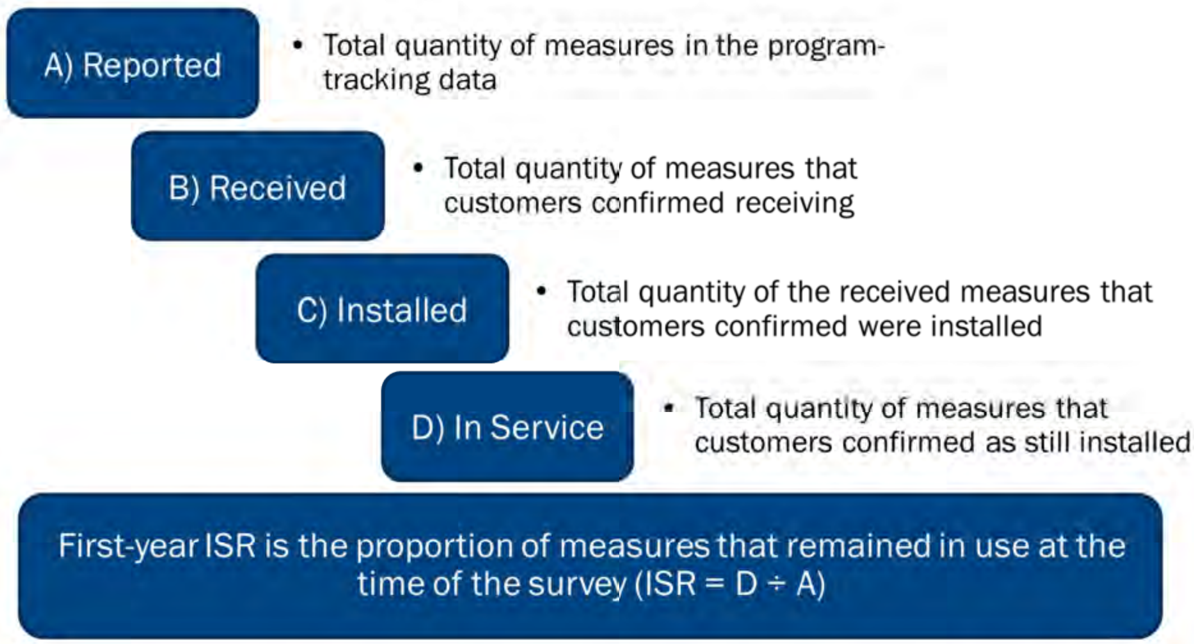
The engineering analysis consisted of two distinct steps: (1) measure verification and development of measure-specific ISRs and (2) a deemed savings review of all program measures. Both are described below.

Measure Verification

The participant survey included questions designed to verify that participants received and installed program measures and that those measures remained in place and operational. The ISR for each measure represents the share of measures in the program tracking data that was still in service at the time of the survey, based on 89 completed telephone interviews. Our engineering analysis applies the ISRs to ex post deemed savings to develop total engineering savings.

Figure 4-1 outlines the method for deriving the ISR for each measure. During the survey, we asked participants to confirm that they received the quantity of measures recorded in Duke Energy's program tracking data and, when necessary, to provide the correct quantity. We also asked participants to confirm the quantity of measures that were installed and remained in service at the time of the survey.

Figure 4-1 In-service Rate Components



Based on the survey responses, we calculated the verification, installation, and persistence rates, as well as the resulting ISR – using the equations shown below – for each participant and each measure they received. We then developed averages of all four rates for each measure group (see Table 4-1).

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

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

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

4) $First\ Year\ In - Service\ Rate = \frac{(D) In\ Service\ Measures}{(A) Reported\ Measures}$

In previous evaluations of the NES Program, Opinion Dynamics found that participants were unable to verify certain measures (e.g., water heater tank wrap, and pipe wrap). For these measures, we assumed 100% for all four rates. Additionally, for air infiltration measures, such as caulking or glass patch tape, participants are unable to verify installation and persistence of individual measures. As such, we asked participants to verify receipt of the entire package of air infiltration measures and assumed that implementation crews installed 100% of those treatments and that they remained installed. As all NES measures are installed directly by program staff and these measures specifically are difficult to remove, we feel that these assumptions are reasonable for this type of program. Finally, the ISR for HVAC filters is based on verifying that participants both receive and install program filters at least once during the first year.

Ex-Post Deemed Savings

We used several resources and assumptions to conduct our deemed savings review, including previous DEO NES evaluations and relevant TRMs (OH, IL, and IN) to examine algorithms and assumptions. Where possible, we used DEO-specific assumptions to estimate measure-specific deemed savings. For more information on the algorithms and inputs that our engineering team used to develop deemed savings estimates for each measure, see Appendix A.

Total Program Savings

When developing total program savings, we adjusted the ex post deemed per-unit savings for each measure using the ISRs developed through the participant survey. We then applied the adjusted per-unit savings to each participant. Where savings for certain measures relied on households having specific heating/cooling equipment or fuel types, our engineering team only applied savings for those measures to participants that received them and had the appropriate mix of fuel and equipment. For example, NES implementation teams provide domestic hot water measures to all participants, regardless of the fuel they use to heat water in their homes. However, as Duke Energy only provides electricity to DEO customers, when developing total program savings, our team only applied savings for domestic hot water measures to participants who (1) received them and (2) heat their water with electricity. In some cases, program tracking data did not have information related to heating/hot water fuel type or heating/cooling equipment. In these instances, we applied per-unit savings for appropriate measures, weighted according to the participating population's fuel type and heating/cooling equipment as necessary.

We then calculated per household savings by dividing total program savings by the total number of participants.

4.1.2 Engineering Analysis Results

This section provides the results of the engineering analysis, including ISRs and ex post deemed energy and demand savings estimates for each measure offered by the NES Program, as well as total program savings and per household savings estimates for the 2017-2018 evaluation period.

Measure Verification Results

The results of this analysis showed high ISRs for all measures, as shown in Table 4-1. NES participants reported that 82% of LEDs and 88% of efficient showerheads remained in service at the time of the survey. However, 22% of participants did not recall receiving HVAC filters and 14% did not recall receiving air infiltration measures. Additionally, while 13% of participants did not recall receiving faucet aerators, 95% of those that did recall having them installed reported that they were still installed at the time of the survey.

Table 4-1. First Year Measure In-Service Rates

Measure Category	Verification Rate	Installation Rate	Persistence Rate	ISR
LEDs	91%	97%	93%	82%
Showerheads	97%	97%	94%	88%
Faucet Aerator	87%	93%	95%	79%
Pipe Insulation*	N/A	N/A	N/A	100%
Water Heater Insulation Wrap*	N/A	N/A	N/A	100%
Air Infiltration	86%	N/A	N/A	86%
HVAC Filters	78%	93%	N/A	72%

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

Ex-Post Deemed Savings Results

Table 4-2 provides the estimated gross per-unit energy and demand savings for all measures installed through the NES Program. As described in Section 3.3, we based the measure-level savings on secondary research and applied NES Program-specific assumptions on household characteristics, where applicable. The estimates shown below are for households with the relevant heating and cooling equipment, and with electric heat and hot water. For example, savings from kitchen faucet aerators would only be realized by households with an electric water heater.

Table 4-2 Ex- Post Per-Unit Deemed Savings Estimates

Measure	Per-Unit Energy Savings (kWh)	Per-Unit Summer peak demand (kW)	Per-Unit Winter peak demand (kW)
Lighting			
LEDs (75W equivalent)	38.5	0.0030	0.0027
LEDs (60W equivalent)	31.0	0.0024	0.0021
LEDs (40W equivalent)	22.1	0.0017	0.0015
LEDs 5 W or similar - Candelabra Bulbs	19.7	0.0016	0.0014
LED 5 W or similar - Globes	19.3	0.0015	0.0013
Domestic Hot Water			
Low Flow Showerhead	346.4	0.0123	0.0247
Kitchen Faucet Aerator	111.3	0.0053	0.0107
Water Heater Insulation Wrap	104.8	0.0120	0.0120
Pipe Insulation (5 feet sections)	90.2	0.0103	0.0103
Bathroom Faucet Aerator	17.8	0.0017	0.0033
Air Sealing			
Infiltration Reduction*	123.7	0.0256	0.0443
HVAC			
HVAC Filters (central AC and elec. heat)	52.8	0.0089	0.0200
HVAC Filters (central AC and gas heat)	10.1	0.0089	0.0000

Note: Per-unit savings for domestic hot water measure reflect electric savings only (i.e., attributable to households with electric water heating)

* Weighted based on mix of 2017-18 DEO participants with different heating fuel and cooling equipment

Total Program and Per Household Savings

Our team calculated total program savings by applying the ISRs shown in Table 4-1 to the per-unit estimates shown in Table 4-2. We then applied the adjusted per-unit estimates to each participant that received the corresponding measure.[1] and, where applicable, multiplied the per-unit estimate by the measure quantity installed in each participating household.

Table 4-3 below summarizes total gross program energy and demand savings for the 2017-2018 evaluation period. It also shows average energy and demand savings per participating household.

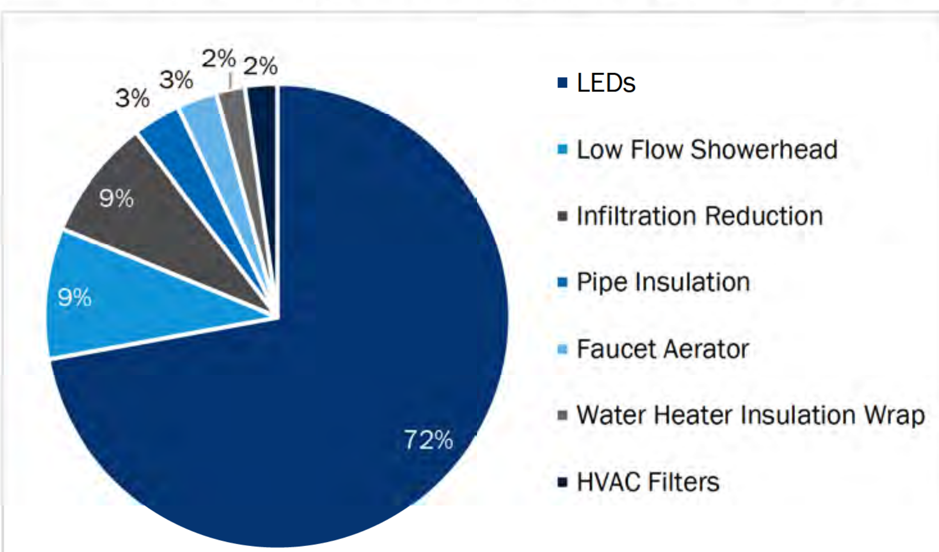
[1] Certain measures only generate electric savings in households with electric space or water heating, or central cooling (i.e., domestic hot water, infiltration reduction, and HVAC filters). For these measures, we only applied savings to those households with the relevant mix of electric heating, hot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

Table 4-3. Engineering Analysis Total Gross Program Savings

Measure	Energy Savings (kWh)	Summer Peak Demand (kW)	Winter Peak Demand (kW)
Lighting			
LEDs (60W equivalent)	186,953	14.69	12.93
LED 5 W or similar - Globes	28,811	2.26	1.99
LEDs (75W equivalent)	22,307	1.75	1.54
LEDs 5 W or similar - Candelabra Bulbs	18,056	1.42	1.25
LEDs (40W equivalent)	3,818	0.30	0.26
Domestic Hot Water			
Low Flow Showerhead	32,862	1.17	2.34
Pipe Insulation (5 feet sections)	12,031	1.37	1.37
Kitchen Faucet Aerator	8,610	0.41	0.83
Water Heater Insulation Wrap	7,230	0.82	0.82
Bathroom Faucet Aerator	1,493	0.14	0.28
Air Sealing			
Infiltration Reduction	30,273	17.50	4.90
HVAC			
HVAC Filters	8,066	5.23	0.24
Total Program Savings	**360,510**	**47.08**	**28.76**
Savings Per Household	**332**	**0.043**	**0.027**

The estimated energy savings of 332 kWh per household is 20% lower than the engineering estimate for the 2016 program (417 kWh). The majority of 2017-2018 savings, 72%, are attributable to lighting installations (see Figure 4-2). This is significantly higher than the contribution of lighting to overall savings in the prior evaluation (47% and 43% for 2015 and 2016, respectively).

Figure 4-2 Measure Contribution to Total Energy (kWh) Savings



The higher contribution of lighting to overall savings is likely due to two main factors. First, the share of 2017-2018 participants with electric hot water and home heating was lower than in previous years. Because many of the program offerings require electric hot water or home heating to realize savings, overall savings are lower, meaning that lighting savings represent a larger proportion of total savings. Second, 2017-2018 participants received two more bulbs per household than in 2016 (Table 4-4).

Table 4-4 Comparison of Household Characteristics and Savings

Territory and Year	Annual kWh Savings per Household (Engineering)	Percent Electric Heat	Percent Electric Hot Water	Lighting % of Savings	Number of Bulbs per Household *
DEO 2015	422	20%	28%	47%	9
DEO 2016	417	20%	28%	43%	8
DEO 2017-18	**332**	**12%**	**12%**	**72%**	**10**

Note: Percent electric heat and percent electric hot water for 2015 and 2016 came from the participant survey for the 2015/16 evaluation.

* 2015 and 2016 participants received CFLs, whereas 2017-18 participants received LEDs.

Measure Penetration and Average Quantities

To evaluate the success of the NES Program in providing energy-saving measures to participants, and to determine if there were missed savings, Opinion Dynamics examined the number of measures provided to each home. Most participants received all the measure groups offered by the program. Table 4-5 shows the percent of homes that received at least one of each measure and the average quantity installed per home[2]. The table also shows the percent of homes that received measures from each of five main categories: lighting, infiltration reduction, HVAC, domestic hot water, and educational/other.

[2] Average measure quantities tracked in the program tracking database prior to applying researched ISRs.

Table 4-5 Percent of Households with Measure and Average Quantities Per Household

Measure Category	Measure	Percent of Households with Measure Category	Percent of Households with Measure	Average Qty Per Household
Lighting	LEDs (60W equivalent)	92%	87%	6.8
	LED 5 W or similar – Globes		45%	1.7
	LEDs 5 W or similar – Candelabra Bulbs		25%	1.0
	LEDs (75W equivalent)		22%	0.7
	LEDs (40W equivalent)		5%	0.2
Infiltration Reduction	Door Sweep	77%	61%	1
	Caulking		56%	0.6
	Weather-stripping per door		53%	0.9
	Foam Insulation		44%	0.4
	Cover for A/C		25%	0.4
	Poly Tape		0.5%	0.0
HVAC	HVAC Filters	87%	87%	10.4
Hot Water	Kitchen Faucet Aerator	97%	74%	0.7
	Bathroom Faucet Aerator		68%	0.8
	Low Flow Showerhead		68%	0.7
	Pipe Insulation (5 feet sections)		36%	0.7
	Water Heater Insulation Wrap		7%	0.1
Education /Other	Refrigerator thermometer	100%	91%	2.0
	Water Heater Temp Check		91%	0.9
	Switch Plate Wall Thermometer		90%	0.9

Demand-to-Energy Ratios

We calculated overall kW per kWh savings ratios from the engineering analysis, as shown in Table 4-6, which we used to estimate net demand savings from the billing analysis results for both summer and winter peak savings.

Table 4-6. Engineering Demand-to-Energy Ratios

	Summer Coincident Peak	Winter Coincident Peak
Average energy (kWh) savings	360,510	360,510
Average demand (kW) savings	47.08	29.53
Ratio multiplier (kW/kWh)	0.0001306	0.0000819

4.2 Billing Analysis

4.2.1 Billing Analysis Methodology

Opinion Dynamics conducted a billing analysis to determine the overall evaluated savings of the 2017-2018 DEO NES Program. Our method requires that participants in the treatment group have electricity usage data for at least 9 months both before and after participating in the program. We used monthly billing data for all participants.

The billing analysis employed a pre-post LFER model. While it is preferable to use a comparison group in billing analyses because members of the group can improve the counterfactual and provide more robust results, we were unable to establish an equivalent comparison group and chose to use a pre-post model to estimate program savings. For more detail, see Appendix C.

Our model takes into account changes in weather (heating and cooling degree-days) on a monthly basis and before and after participation to model differences in the impact that weather had on energy savings after participation. The model also has an interaction term of electric water heater incidence with the post period. The fixed-effect for the model is set at the account level, which allows us to control for all household factors that do not vary over time. In the process of determining the appropriate model for the analysis, we tested thirteen different models before selecting the best one. The savings provided through the pre-post analysis are very near to net despite not incorporating a comparison group, because free ridership is assumed to be zero in this income-qualified program. The model reflects savings associated with installed measures, participant spillover, and potential behavioral changes from energy efficiency knowledge gained during the assessment.

Table 4-7 shows the number of 2017-2018 participants that we included in the final model versus those who were not included primarily because they had inadequate pre or post-participation billing data or because they participated in other Duke Energy energy-efficiency programs.

Table 4-7 Accounts Included in Final Billing Analysis Model

	Participant Accounts Included in Model	Participant Accounts Not Included in Model	Total
Total Accounts	687	395	1,082*

* Although there were 1,085 participants in the program tracking data, we received billing data for 1,082 participants.

We provide the final model specification in Equation 1 below.

Equation 1. Final Model Specification

$$Usage_{it} = \alpha + \alpha_i + B_{post}Post_{it} + B_{HDD}HDD_{it} + B_{CDD}CDD_{it} + B_{post\ ew}Post_{it} \cdot EW_i + \varepsilon_{it}$$

Where:

$Usage$ = Monthly consumption (in kWh) for the billing period
α = Overall intercept
$\boldsymbol{\alpha_i}$ = Household-specific intercept (absorbed)
$Post_{it}$ = Indicator for treatment group in the post-program period for household i at time t
HDD_{it} = Monthly Heating Degree Days from NOAA for household i at time t
CDD_{it} = Monthly Cooling Degree Days from NOAA for household i at time t
EW_i = Indicator for electric hot water heater usage by household i
B_{post} = Difference in usage associated with any differences in the pre and the post-program period, unadjusted by weather, day of week and month
B_{HDD} = Difference in usage associated with one-unit increase in HDD
B_{CDD} = Difference in usage associated with one-unit increase in CDD
$B_{post\ ew}$ = Difference in usage associated with using an electric hot water heater in the pre and post-program period
ε_{it} = Error term

For a more detailed discussion of the billing analysis methodology, including data-cleaning steps, comparative statistics, and the final model, see Appendix C.

4.2.2 Billing Analysis Results

This section presents the billing analysis results and savings estimates for the 2017-2018 evaluation period. Appendix C contains a detailed description of the methodology used for data cleaning and regression modeling, and complete results of the models. Table 4-8 summarizes the results of the billing model. The variable "Post (NES Program participation)" represents the main effect of the treatment, i.e., the change in average daily consumption (ADC) attributable to participation in the NES Program, controlling for weather and the presence of electric hot water.

Table 4-8. Results of Billing Analysis Models

Variable	Coefficient
Post (NES Program participation)	-13.08*
Heating Degree Days (HDD)	0.381*
Cooling Degree Days (CDD)	5.04*
Post-participation electric hot water (interaction of Post x presence of electric hot water)	42.37*
Constant	462.78
Observations	27,185
R-squared	0.62

* p<0.01.

Because the model contains a post-period electric hot water heater interaction term, we calculated the treatment effect by multiplying the proportion of customers with electric hot water heaters with the coefficient for the interaction term. We then added the product to the coefficient for the main effect term (Post) in the final model (see Equation 2 below) to estimate the average change in energy usage for participants.

Equation 2. Model Evaluation

$$\Delta Usage = B_1 Post + ProportionEW_i \cdot (B_2 Post \cdot EW_i)$$

$\Delta Usage$ = Change in monthly electricity usage
$ProportionEW_i$ = Proportion of customers with electric hot water heaters

Table 4-9 Adjusted Estimate of Monthly Program Savings Per Household

Savings Estimate (kWh/Month)	Standard Error	90% Confidence Interval	
		Lower	Upper
18.01	5.87	8.4	27.7

Table 4-10 shows the net per-home and program-level savings for NES participants. The annual baseline usage of DEO NES participants prior to participation was 9,409 kwh. On average, participants saved 2.3% of this baseline usage as a result of participating in the NES Program, or 216 kWh per home. This equates to 234,475 kWh for the program overall. As mentioned in Section 4.2, only 12% of households have electric hot water heating and 12 % have electric space heating. Therefore, most participants did not realize savings from measures associated with electric hot water or space heating.

Table 4-10. Net Annual Savings from Billing Analysis

Participants	Annual Baseline Usage (kWh)	Savings (%)	Net Annual Energy Savings (kWh)	
			Per-Home Savings	2017-18 NES Program Savings
1,085	9,409	2.30	216	234,475

4.3 Program Savings

The billing analysis results show that the NES Program saved an average of 216 kWh per home in 2017-2018. Table 4-11 compares the program's achieved savings to the savings assumptions used for planning purposes. Ex-ante savings were 420 kWh per home, producing a realization rate of 51%.

Table 4-11. Program Savings and Realization Rates

	Savings Assumption	2017-2018 Evaluated Net Savings	Realization Rate
Energy savings (kWh/home)	420	216	51%
Summer peak demand savings (kW/home)	0.13	0.028	21%
Winter peak demand savings (kW/home)	0.14	0.017	12%

Per household savings are also lower than in previous evaluations, as shown in Table 4-12. Similarly, savings as a share baseline energy consumption also fell during the 2017-2018 evaluation period when compared to previous years. This decrease is likely driven by a lower share of participating households with electric space and water heating (see Section 4.2).

Table 4-12. Percent and Per-Household Energy Savings

	DEO 2013-14*	DEO 2015**	DEO 2016**	DEO 2017-18
Baseline Energy Use	----	9,381		9,409
Percent Savings from Baseline Energy Use	----	3.2%		2.3%
Average Annual Per-Household kWh Savings (Billing)	412	303		216
Average Annual Per-Household kWh Savings (Engineering)	771	422	417	332

* Source: Process and Impact Evaluation of the 2013–2014 Residential Neighborhood Program in Ohio. Prepared for Duke Energy by TecMarket Works, February 2015.

**Source: 2015-16 Duke Energy Ohio 2015-2016 Neighborhood Energy Saver Program Evaluation Report. Prepared for Duke Energy by Opinion Dynamics, November 2017.

4.3.1 Program-Level Impacts for Regulatory Compliance

In the state of Ohio, electric distribution utilities (EDUs), including DEO, are required to achieve a cumulative annual energy savings of more than 22% by 2027 per Ohio Senate Bill (SB) 310. SB 310 also introduced new mechanisms that adjust how EDUs may estimate their energy savings achieved through demand side management programs. Specifically, SB 310 requires the Public Utilities Commission of Ohio (PUCO) to permit EDUs to account for energy-efficiency savings estimated on an "as-found" or a deemed basis. That is, an EDU may claim savings based on the baseline operating conditions found at the location where the energy-efficiency measure was installed, or the EDU may claim a deemed savings estimate.

To support compliance with SB 310, Table 4-13 below summarizes ex-ante and ex-post per household energy and demand savings. Per SB 310, DEO will claim 420 kWh of energy savings and 0.130 kW and 0.140 kW of peak summer and winter demand savings, respectively, per household for the 2017-2018 evaluation period. These values are the higher of the ex-ante and ex-post savings values, based on the billing analyses conducted for the current and the previous evaluations.

Table 4-13. Per Household Savings for SB 310 Compliance

Savings Estimate	kWh	kW (Summer)	kW (Winter)
Ex Ante	420	0.130	0.140
Ex Post	216	0.028	0.017
Claimable under SB 310	420	0.130	0.140

5. Process Evaluation

5.1 Researchable Questions

Opinion Dynamics conducted a limited (or focused) process evaluation for the 2017-2018 DEO NES Program. Based on experience evaluating this program in previous years and discussions with DEO program staff, Opinion Dynamics developed the following process-related research questions:

- What are the major strengths of the program? Are there specific ways that the program could be improved to be more effective in the future?
- How satisfied are participants with the program and the measures they received?
- What are the barriers to implementing this program—that is, are there limiting factors to achieving greater participation?

5.2 Methodology

The process evaluation relied on the following tasks:

- In-depth interview with DEO program staff;
- A review of secondary materials (i.e., Honeywell Scope of Work, NES marketing materials, NES Program guide, and program evaluations from previous years);
- Telephone survey of program participants; and
- An analysis of program tracking data.

5.3 Key Findings

5.3.1 Program Participation

The 2017 and 2018 evaluation years were the fifth and sixth year of the NES Program in Duke Energy's Ohio territory. Between July 1st, 2017 and May 31st, 2018, the NES Program teams served 1,085 participants in the Woodlawn neighborhood. Overall, staff reached 64% of customers in the neighborhood served during the 2017-2018 evaluation period (Table 5-1). Although the program goal was a 70% penetration rate, the program concluded early due to the program reaching recovery caps and subsequently being asked to cease operations prior to serving 70% of the neighborhood.

Table 5-1 DEO NES Program Participation and Penetration

	2015	2016	2017-18
Neighborhood Population	4,540	1,825	1,695
Participants	1,362	1,314	1,085
Penetration Rate	30%	72%	64%

Note: The 2015 implementer was Goodcents; Duke switched to Honeywell for the 2016 and 2017-18 program years.

Cross Participation

As part of the billing analysis, Opinion Dynamics also identified cross-participation of NES participants in other Duke Energy programs. Seventy-nine percent of NES participants also participated in at least one other Duke Energy program. Figure 5-2 below shows the breakdown of 2017-2018 NES participants for each of these programs.

Table 5-2 Cross Participation among 2017-2018 DEO NES Participants

Program Name	Count of Participants	Percent of Total Participants
Smart $aver Residential	754	88%
My Home Energy Report (Multifamily)	49	5.7%
Electric Weatherization pay per kwh program	15	1.8%
Residential DR	9	1.0%
Weatherization Gas	8	0.9%
Residential EE Products & Services	7	0.8%
Residential Energy Assessments	7	0.8%
Energy Maintenance Service	2	0.2%
Home Energy Solutions	1	0.1%
Refrigerator Replacement	1	0.1%
Total Unique Cross-Participants	***853***	***78.84%***
Total Participants	***1,082***	-

The majority of NES participants that enrolled in other Duke Energy programs also signed up for the Smart $aver Program. As shown in Table 5-3, these participants largely received home energy reports (85%) or lighting measures (73%), such as LEDs, CFLs, or other specialty lamps.

Table 5-3 Measures Received by Smart $aver Participants

Measure	Count of Participants	Percent of all Smart $aver Cross Participants
My Home Energy Report	643	85%
Lighting (CFLs, Specialty, LEDs)	549	73%
Energy Education Program for Schools	52	7%
My Home Energy Report – Online	17	2%
Home Energy House Call – Kit	5	0.7%
SAW Smartsaver – CAC	3	0.4%
Air Conditioner Tier 2 -Non-Referred	2	0.3%
Marketplace Smart Thermostats	1	0.1%

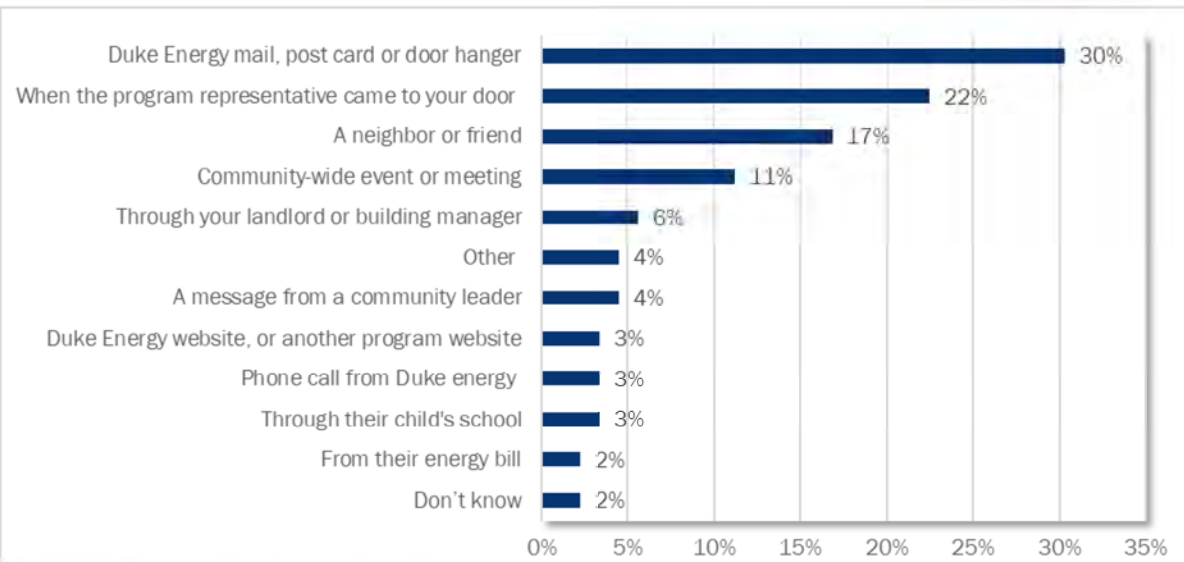
Note: Columns do not add up to total unique Smart $aver cross participants as NES participants may have received multiple measures.

5.3.2 Marketing and Outreach

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

The most common way that NES participants learned about the program was though a direct mail or door hanger (30%). The second most common method was when the program representative came to their door (22%). These responses indicate that the initial contacts made by program teams are an effective form of outreach. Figure 5-1 shows all the ways that participants indicated that they first learned about the NES Program.

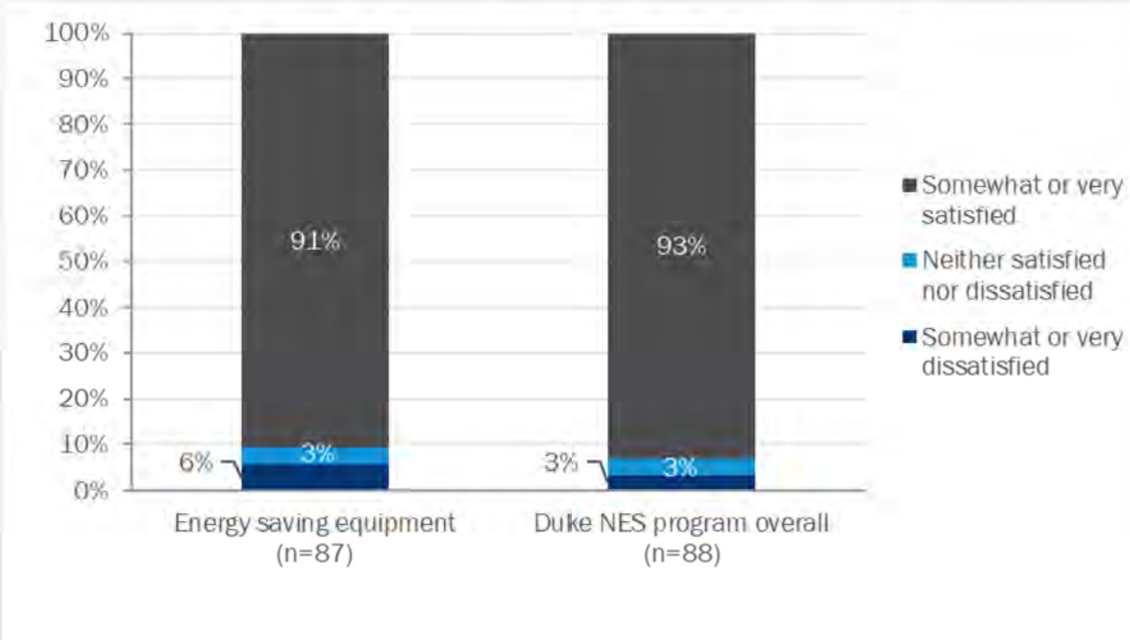
Figure 5-1 How Participants First Heard About the NES Program



5.3.3 Program Satisfaction

Participants are highly satisfied with all components of the program. As shown in Figure 5-2, 93% of survey respondents reported that they were somewhat or very satisfied with the program overall, and 91% reported that they were somewhat or very satisfied with the equipment they received through the program. Additionally, of 14 survey respondents that contacted Duke Energy staff during or after their participation, 10 indicated that they were very satisfied with the follow-up communication they had with the program team.

Figure 5-2 Satisfaction with NES Program and Equipment



In addition, on average survey respondents rated their experience with the NES Program overall a 9.1 (on a scale of 0 to 10, where 0 is not at all satisfied and 10 is very satisfied) and were also highly satisfied with the program representatives and equipment they received, providing an average rating of 9.8 out of 10. Participants also reported that they are motivated to reduce energy use: 97% of survey respondents said they were somewhat or very motivated to reduce energy use after participating in the NES Program.

6. Conclusions and Recommendations

Opinion Dynamics conducted a billing analysis of NES Program participants to determine overall ex-post program savings. Table 6-1 presents the per household ex-post energy savings from the billing analysis and the per household energy savings claimable under SB 310.

Table 6-1. 2017-2018 Participant-Level Impacts

Estimate	Per Household Participant-Level Savings		
	Energy (kWh)	Summer Coincident Demand (kW)	Winter Coincident Demand (kW)
Ex-post Savings (billing analysis)	216	0.028	0.017
Claimable savings (SB 310)	420	1.130	0.140

Key findings, which we discuss below, include:

- Estimated Per-household energy savings, based on the billing analysis, decreased 29% from the 2015/16 evaluation, from 303 kWh to 216 kWh;
- NES implementation teams served 1,085 homes in the Woodlawn neighborhood, 81% of the participation target; and
- Program participants are highly satisfied with the NES Program.

Per Household Savings

During this evaluation period, DEO participants saved 216 kWh per household, as determined by the billing analysis. Per household energy savings for this evaluation period were lower than billing analysis estimates from previous DEO impact evaluations. Lower savings were driven, in part, by a smaller share of participants with electric space and water heating. Given the mix of measures offered through the NES Program, energy savings from domestic hot water and infiltration measures represent a large portion of potential program savings. To realize electric savings from these measures at the household-level, participants need to heat their homes or hot water with electricity. As such, a lower share of participants that heat with electric fuel will yield less energy savings per household.

Program Participation

The program teams achieved strong participation during the 2017-2018 evaluation period. NES implementation crews launched the DEO Program in the Woodlawn neighborhood in July 2017. Due to reaching predetermined cost recovery caps early, program teams ceased operation in the Woodlawn neighborhood in November of 2017. Despite the abbreviated implementation period, implementation crews served 1,085 households, 81% of the participation target.

Program Satisfaction

Satisfaction with the DEO NES Program is also very high amongst participants. Ninety-three percent of those surveyed as part of the participant survey (see Section 3.3) were somewhat or very satisfied with the NES Program, and 91% were somewhat or very satisfied with the equipment they received. Additionally, survey respondents rated their overall experience with the NES program a 9.1 (on a scale of 0 to 10, where 0 is not at all satisfied and 10 is very satisfied) and were also very satisfied with the equipment they received, providing an average rating of 9.8 out of 10.

6.1 Recommendations

- **NES Program teams should consider including additional criteria (e.g., energy use intensity (EUI) or number of number of disconnect notices) when identifying and selecting neighborhoods for future program years.** The NES Program offers, by design, a relatively limited set of easy-to-install measures. Beyond lighting measures, domestic hot water and air infiltration measures will continue to be key to increasing the average electric energy savings for participating households. As such, program staff should consider analyzing supplemental data to maximize energy savings from the program and ensure that the NES treatments reach those customers with the highest need. When selecting neighborhoods to canvass in future program years, program staff should review EUI, the number of disconnect notices, the share of households with electric space heating, and other criteria that may identify neighborhoods with higher energy burdens.

7. Summary Form

Duke Energy Ohio

Neighborhood Energy Saver (NES) Program

Completed EM&V Fact Sheet

Program Description

The Neighborhood Energy Saver (NES) program provides a home energy assessment free of cost and installs energy-saving measures in the homes of income-qualified customers living in DEO service territory. During the assessment, program representatives discuss what was installed and provide additional recommendations on ways participants can save energy in their homes.

Date	May 13, 2020
Region	Duke Energy Ohio
Evaluation Period	July 1st, 2017- May 31st, 2018
Claimed Savings Per SB 310	
Per Participant kWh	420
Per Participant Coincident kW	0.140 (Summer) 0.130 (Winter)
Savings From Billing Analysis	
KWh Savings	234,475
Coincident MW Impact	0.0282 (Summer) 0.0177 (Winter)
Per Participant kWh Savings	216
Measure Life	Not evaluated
Net-to-Gross Ratio	N/A
Process Evaluation	Yes (limited)
Previous Evaluation(s)	2013-2014 and 2015-2016 evaluations

Evaluation Methodology

Opinion Dynamics conducted a billing analysis to estimate energy savings and a combination of billing analysis results and engineering analysis to estimate peak demand savings.

In addition, Opinion Dynamics verified deemed savings estimates using an engineering analysis of savings assumptions and calculations. This consisted of (1) a review of savings assumptions and calculations and (2) verification of measure installation and persistence through a participant survey. To determine deemed program savings, the evaluation team applied (1) measure-specific ISRs to per-unit estimates and (2) applied adjusted per-unit savings estimates to participants who both received each measure and had the appropriate mix of fuel and equipment

Impact Evaluation Details

- Neighborhoods in DEO service territory where at least 50% of residential customers are at or below 200% of the federal poverty guidelines are eligible to participate in the NES Program.
- To comply with SB 310, claimed savings will consist of estimates of gross impacts based on the larger of the ex- ante and ex-post savings.
- Results from the billing analysis reflect savings associated with installed measures, participant spillover, and potential behavioral changes from energy efficiency knowledge gained during the assessment.

8. DSMore Table

The embedded Excel spreadsheet below contains inputs for Duke Energy Analytics. Per-household savings values in the spreadsheet are based on the savings claimable under SB 310 reported above.

Appendix A. Engineering Algorithms and Assumptions Overview of Deemed Savings Review

As outlined in the evaluation plan for the Duke Energy Ohio (DEO) Neighborhood Energy Saver (NES) program, Opinion Dynamics conducted a review of the deemed savings values and assumptions for the NES program measures. The goal of the deemed savings review is to assess whether the savings algorithms and inputs used for the prior DEO NES program evaluations are still applicable and whether we can leverage any more recent data or published studies to update any of the current assumptions.

To conduct the deemed savings review, Opinion Dynamics performed the following steps:

- Reviewed the unit savings estimates developed under Opinion Dynamics's previous evaluation of the NES program and the assumptions behind them.
- Reviewed all information received to date to decide if any of the current savings estimates or assumptions required updates.
- Reviewed latest Technical Reference Manuals (TRMs) and other recently published studies to determine if there is a need for additional updates.

LEDs

LED Results

Table A-1 documents the inputs and methodology for estimating savings from LEDs installed by the DEO NES program.

Table A-1. Algorithms and Inputs for LEDs

Algorithms Used		
kWh Savings	= (Baseline Watts – LED Watts) / 1,000 * Hours * (1+WHFe)	
kW Savings (summer)	= (Baseline Watts – LED Watts) / 1,000 * CFs * (1+WHFds)	
kW Savings (winter)	= (Baseline Watts – LED Watts) / 1,000 * CFw * (1+WHFdw)	
Parameter	**Value**	**Source/Notes**
Δ Watts	see Table A-2	Baseline watts from the EISA adjusted Wattage equivalents. Installed LED wattage from distributed bulb specification.
Hours	1,001	2017 DEO Residential LED Hours of Use Study (Free LED).
Summer Coincidence Factor (CFs)	0.07	
Winter Coincidence Factor (CFw)	0.13	
Energy Waste Heat Factor (WHFe)	-0.061	IN TRM V2.2 Indianapolis.
Summer Demand Waste Heat Factor (WHFds)	0.055	
Winter Demand Waste Heat Factor (WHFdw)	-0.500	2012 DEP Energy Efficient Lighting Program Evaluation.

Table A-2 shows the EISA adjusted baseline wattage and installed LED wattage for each lighting measure offered through the program. The incandescent equivalent wattage was taken from the ENERGY STAR website and adjusted to account for EISA requirements[3]. We use the reduced EISA baseline to derive our engineering savings estimates.

Table A-2. Baseline and Efficient Wattages by Lighting Type

LED Measure	Baseline Watts[a]	LED Watts[b]	Δ Watts
LED 5W (or similar) - Globe	25.0	4.5	20.5
LEDs 5W (or similar) - Candelabra	25.0	4.0	21.0
LEDs (40W equivalent)	29.0	5.5	23.5
LEDs (60W equivalent)	43.0	10.0	33.0
LEDs (75W equivalent)	53.0	12.0	41.0

[a] EISA adjusted baselines. http://goo.gl/XjRoUk.
[b] LED efficient wattages provided by Oscar Toledo (Duke Energy) January 8, 2019 email (RE: DEC/DEP NES Data...)

Table A-3 displays the deemed savings values for LEDs installed by the DEO program.

Table A-3. Per-Measure Savings for LEDs

Measure (per Bulb)	Deemed Savings		
	Energy (kWh)	Summer Demand (kW)	Winter Demand (kW)
5-Watt LED Globe	19.3	0.0015	0.0013
5-Watt LED Candelabra	19.7	0.0016	0.0014
LEDs (40W equivalent)	22.1	0.0017	0.0015
LEDs (60W equivalent)	31.0	0.0024	0.0021
LEDs (75W equivalent)	38.5	0.0030	0.0027

Efficient Shower Heads

Efficient Shower Head Results

Table A-4 documents the inputs and methodology for estimating efficient shower head savings for the 2017-2018 NES program participants. Note that we provide separate deemed savings values for those with electric water heaters and for those with unknown water heating fuel.

Table A-4. Algorithms and Inputs for Efficient Shower Heads

Algorithms Used	
kWh Savings	= (((Baseline GPM - Efficient GPM) * (Minutes/Shower)) * (Showers/Person/Day) * (People/Household) * 365.25 / (Showerheads/Household)) * (8.33 * (Tmix - Tinlet)) / (3,412 * RE)) * %Elec
kW Savings (summer)	= (Baseline GPM - Efficient GPM) * 60 * 8.33 * (Tmix - Tinlet) / RE / 3,412 * CFs * %Elec

[3] EISA set in place standards for general service light bulbs, with the first phase going into effect in January 2012. The standard essentially eliminates the manufacture and sale of 40W, 60W, 75W, and 100W incandescent light bulbs and sets new standards as shown in Table A-3.

Algorithms Used		
kW Savings (winter)	= (Baseline GPM - Efficient GPM) * 60 * 8.33 * (Tmix - Tinlet) / RE / 3,412 * CFw * %Elec	
Parameter	**DEO Value**	**Source/Notes**
Baseline GPM	2.63	IN TRM V2.2, based on Residential Core Plus Evaluation, Multifamily Direct Install Program. 2012.
Efficient GPM	1.75	Duke provided measure specifications. Email from Casey Fields on Nov. 21, 2018 (RE: DEC/DEP NES Data...)
Minutes/Shower	7.80	IN TRM V2.2, based on 2013 Michigan Showerhead/Faucet Aerator Study.
Showers/Person/Day	0.69	2018 DEO Participant Survey Data.
People/Household	2.51	
Showerheads/Household	1.28	
Specific heat of water (Btu/gallon °F)	8.33	Standard conversion.
Shower water temperature (Tmix)	101°F	2013 Michigan Showerhead/Faucet Aerator Study.
Inlet water temperature (Tinlet)	60.2°F	NREL Domestic Hot Water Event Generator – Cincinnati, OH.
kWh/Btu conversion (Btu/kWh)	3,412	Standard conversion.
Recovery efficiency (RE) of water heater	0.98	Typical recovery efficiency for electric water heaters (IL TRM, IN TRM, ARK TRM).
%Elec (Electric WH)	100%	Applied only to those with electric water heating fuel.
Weighted %Elec (Unknown WH Fuel)	11.6%	DEO Program Tracking Data. Applied only to those with unknown water heating fuel.
Summer Coincidence Factor (CFs)	0.0023	IN TRM V2.2
Winter Coincidence Factor (CFw)	0.0046	According to Duke, the winter peak hour is from 7-8 am. It is expected that showers are used more frequently in the morning (winter peak is 7-8 am) than late afternoon (summer peak is 4-5pm). The evaluation team assumes the frequency is approximately double, and therefore doubled the summer CF to get the winter CF.

Table A-5 displays the deemed savings for efficient showerheads.

Table A-5. Per-measure Savings Comparison for Efficient Showerheads

Measure (per Shower Head)	Deemed Savings		
	Energy (kWh)	Summer Demand (kW)	Winter Demand (kW)
Efficient Shower Head (Electric WH)	346.38	0.0123	0.0247
Efficient Shower Head (Unknown WH Fuel)	40.23	0.0014	0.0029

Efficient Shower Head Recommendations

In past evaluations, a weighted savings value was applied to all participants regardless of water heating fuel type. Given the tracking database provides this information at the participant level, we recommend applying savings based on the actual water heater fuel type. For cases where the fuel type is unknown, we then suggest applying a weighted deemed savings based on weights using program tracking data.

Efficient Faucet Aerators

Efficient Faucet Aerator Results

Table A-6 documents the inputs and methodology for estimating efficient aerator savings for the NES program. We estimate savings for bathroom faucet aerators and kitchen faucet aerators separately as the two measures are operated differently and perform differently. For example, kitchen faucets have a higher flow rate and have a higher daily use compared to bathroom faucets. Note that we provide separate deemed savings values for those with electric water heaters and for those with unknown water heating fuel.

Table A-6. Algorithms and Inputs for Efficient Faucet Aerators

Algorithms Used		
kWh Savings	= (Baseline GPM - Efficient GPM) * (Minutes/Person/Day) * (People/Household) / (Faucets/Household) * (Tmix - Tinlet) * 365.25 * 8.33 / 3,412 / RE * DF * %Elec	
kW Savings (summer)	= (Baseline GPM - Efficient GPM) * 60 * 8.33 * (Tmix - Tinlet) / RE / 3,412 * CFs * DF * %Elec	
kW Savings (winter)	= (Baseline GPM - Efficient GPM) * 60 * 8.33 * (Tmix - Tinlet) / RE / 3,412 * CFw * DF * %Elec	
Bathroom Aerators		
Parameter	**DEO Value**	**Source/ Notes**
Baseline GPM	1.90	IN TRM V2.2. Original source: Residential Core Plus Evaluation, Multifamily Direct Install Program. 2012.
Efficient GPM	1.50	Duke provided measure specifications. Email from Casey Fields on Nov. 21, 2018 (RE: DEC/DEP NES Data...)
Minutes/ Person/Day	1.60	Cadmus and Opinion Dynamics Showerhead and Faucet Aerator Meter Study Memorandum dated June 2013, directed to Michigan Evaluation Working Group.
People/Household	2.51	2018 DEO Participant Survey Data.
Faucets/Household	1.91	IN TRM V2.2, based on 2013 Michigan Showerhead/Faucet Aerator Study.
Faucet water temperature (Tmix)	86 °F	IL TRM for bathroom faucets. Cadmus and Opinion Dynamics Showerhead and Faucet Aerator Meter Study Memorandum dated June 2013, directed to Michigan Evaluation Working Group.
Inlet water temperature (Tinlet)	60.2 °F	NREL Domestic Hot Water Event Generator - Cincinnati, OH.
Specific heat of water (Btu/gallon °F)	8.33	Standard conversion.
kWh/Btu conversion (Btu/kWh)	3,412	Standard conversion.

Algorithms Used		
Recovery efficiency (RE) of water heater	0.98	Typical recovery efficiency for electric water heaters (IL TRM, IN TRM, ARK TRM).
Drain Factor (DF)	90%	IL TRM V6.0.
%Elec (Electric WH)	100%	Applied only to those with electric water heating fuel.
Weighted %Elec (Unknown WH Fuel)	11.6%	2018 DEO Program Tracking Data. Applied only to those with unknown water heating fuel.
Summer Coincidence Factor (CFs)	0.0012	IN TRM V2.2.
Winter Coincidence Factor (CFw)	0.0024	According to Duke, the winter peak hour is from 7-8 am. There is no good data on winter coincidence factors for aerators during the 7am to 8 am peak hour. It is expected that aerators are used more frequently in the morning (winter peak is 7-8 am) than late afternoon (summer peak is 4-5pm). Assume the frequency is approximately double, and therefore doubled the summer CF to get the winter CF.
Kitchen Aerators		
Parameter	**DEO Value**	**Source/Notes**
Baseline GPM	2.44	IN TRM V2.2. Original source: Residential Core Plus Evaluation, Multifamily Direct Install Program. 2012.
Efficient GPM	2.00	Duke provided measure specifications. Email from Casey Fields on Nov. 21, 2018 (RE: DEC/DEP NES Data...)
Minutes/Person /Day	4.50	Cadmus and Opinion Dynamics Showerhead and Faucet Aerator Meter Study Memorandum dated June 2013, directed to Michigan Evaluation Working Group.
People/Household	2.51	2018 DEO Participant Survey Data.
Faucets/Household	1.00	IN TRM V2.2, based on 2013 Michigan Showerhead/Faucet Aerator Study.
Faucet water temperature (Tmix)	93 °F	IL TRM for kitchen faucets. Cadmus and Opinion Dynamics Showerhead and Faucet Aerator Meter Study Memorandum dated June 2013, directed to Michigan Evaluation Working Group.
Inlet water temperature (Tinlet)	60.2 °F	NREL Domestic Hot Water Event Generator - Cincinnati, OH.
Specific heat of water (Btu/gallon °F)	8.33	Standard conversion.
kWh/Btu conversion (Btu/kWh)	3,412	Standard conversion.
Recovery efficiency (RE) of water heater	0.98	Typical recovery efficiency for electric water heaters (IL TRM, IN TRM, ARK TRM).
Drain Factor (DF)	75%	IL TRM V6.0.
%Elec (Electric WH)	100%	Applied only to those with electric water heating fuel.
Weighted %Elec (Unknown WH Fuel)	11.6%	2018 DEO Program Tracking Data. Applied only to those with unknown water heating fuel.
Summer Coincidence Factor (CFs)	0.0033	IN TRM V2.2.
Winter Coincidence Factor (CFw)	0.0066	According to Duke, the winter peak hour is from 7-8 am. There is no good data on winter coincidence factors for aerators during the 7am to 8 am peak hour. It is expected that aerators are used more frequently in the morning (winter peak is 7-8 am) than late afternoon (summer peak is 4-5pm). We assume the frequency is approximately double, and therefore doubled the summer CF to get the winter CF.

Table A-7 displays the deemed savings for the 2017-2018 evaluation.

Table A-7. Per-Measure Savings for Efficient Faucet Aerators

Measure (per aerator)	Deemed Savings		
	Energy (kWh)	Summer Demand (kW)	Winter Demand (kW)
Bathroom Faucet Aerator (Electric WH)	17.78	0.0017	0.0033
Bathroom Faucet Aerator (Unknown WH Fuel)	2.07	0.0002	0.0004
Kitchen Faucet Aerator (Electric WH)	111.32	0.0053	0.0107
Kitchen Faucet Aerator (Unknown WH Fuel)	12.93	0.0006	0.0012
Bathroom & Kitchen Faucet Aerator Weighted Average (Electric WH)	64.55	0.0035	0.0070
Bathroom & Kitchen Faucet Aerator Weighted Average (Unknown WH Fuel)	7.50	0.0004	0.0008

Efficient Faucet Aerator Recommendations

In past evaluations, a weighted savings value was applied to all participants regardless of water heating fuel type. Given the tracking database provides this information at the participant level, we recommend applying savings based on the actual water heater fuel type. For cases where the fuel type is unknown, we then suggest applying a weighted deemed savings based on weights using program tracking data.

Infiltration Reduction

Infiltration Reduction Results

Table A-8 documents the inputs and methodology for estimating infiltration reduction savings for the 2017-2018 NES program participants. This measure includes savings for all infiltration reduction measures associated with the NES program, including door sweeps, caulk, foam spray, glass patch tape, weather stripping, and winterization kits.

Table A-8. Algorithms and Inputs for Infiltration Reduction

Algorithms Used		
Cooling kWh Savings	= ((ACH50base * (CFA * ceiling height) / 60) - (ACH50imp * (CFA * ceiling height) / 60)) / N-factor * 60 * 24 * CDD * DUA * 0.018 / 1000 / nCool * LM * %AC	
Heating kWh Savings	= ((ACH50base * (CFA * ceiling height) / 60) - (ACH50imp * (CFA * ceiling height) / 60))/ N-factor * 60 * 24 * HDD * 0.018 / nHeat / 3412 * %Electric_heat	
kW Savings (summer)	= Cooling kWh savings / FLHcool * CFs * %AC	
kW Savings (winter)	= Heating kWh savings / FLHheat * CFw * %Electric_heat	
Parameter	**DEO Value**	**Source/ Notes**
Baseline Infiltration Rate (ACH50base)	17.40	ENERGY STAR savings analysis assumptions for southern Ohio (DEO territory). We assume air sealing for "Windows, Doors and Walls" only based on measures

Algorithms Used		
Improved Infiltration Rate (ACH50imp)	17.00	available in the program. https://www.energystar.gov/ia/home_improvement/home_sealing/Measure_Upgrade_Assumptions.pdf?945a-eddc
Conditioned Floor Area (CFA)	1,006	DEO Program Tracking Data.
Ceiling Height (ft)	8.0	Engineering judgement.
N-factor	20	Mid-Atlantic TRM. Normal exposure. From LBL study.
Cooling degree days (CDD)	1,123	ASHRAE Fundamentals 2017. Cincinnati, Ohio.
Heating degree days (HDD)	4,755	
DUA	0.75	Discretionary Use Adjustment. Common to most TRMs.
nCool (SEER)	13	Assume 13 SEER based on several TRMs. Assume equipment installed after 2006.
Latent multiplier (LM)	7.7	Harriman et al "Dehumidification and Cooling Loads from Ventilation Air", ASHRAE Journal, November 1997. Indianapolis, IN as the city to represent DEO territory.
%AC (Central Cooling Present)	100%	Applied only to those with central cooling equipment (e.g., CAC, ASHP)
Weighted %AC (Unknown if Central Cooling Present)	78.1%	DEO Program tracking Data. Applied only to those where it is unknown if central cooling is present.
%Electric heat	100%	Applied only to those with electric heating equipment (e.g., electric furnace, ASHP).
Weighted %Electric heat (Unknown heating fuel)	11.6%	DEO Program Tracking Data. Applied only to those with unknown space heating fuel.
nHeat (Electric Resistance)	1.00	Weighted average based on type of heating in Ohio from DEO program tracking data.
nHeat (ASHP)	2.26	COP for ASHP. Indiana TRM V2.2.
COP heat pump	2.26	Indiana TRM V2.2.
COP electric resistance	1.00	Indiana TRM V2.2.
FLHcool	996	EPA (2002) for Cincinnati, OH.
Summer Coincidence Factor CFs	0.88	IN TRM V2.2. Duke Energy data for residential air conditioning loads.
Winter Coincidence Factor (CFw)	1.00	According to Duke, the winter peak hour is from 7-8 am. There is no good data on winter coincidence factors for heating equipment during the 7am to 8am peak hour.
FLHheat	2,134	EPA (2002) for Cincinnati, OH.

Table A-9 displays the deemed infiltration reduction savings for the DEO NES program participants. We group all infiltration reduction measures together to calculate savings, as they all relate to air sealing and calculating savings for the individual measures can be imprecise.

Table A-9. Per-Measure Savings for Infiltration Reduction

Measure	HVAC Type	Deemed Savings		
		Energy (kWh)	Summer Demand (kW)	Winter Demand (kW)
Infiltration Reduction	CAC w/ Electric Heating	134.13	0.0329	0.0454
	CAC w/ Gas Heating	37.18	0.0329	N/A
	Air Source Heat Pump	80.08	0.0329	0.0201
	Central Cooling w/ Unknown Heating Fuel	131.82	0.0329	0.0443
	No Central Cooling w/ Electric Heating	96.95	N/A	0.0454
	No Central Cooling w/ Unknown Heating Fuel	94.64	N/A	0.0443
	Unknown Cooling Type w/ Electric Heating	125.98	0.0256	0.0454
	Unknown Cooling Type w/ Gas Heating	29.03	0.0256	N/A
	Unknown Cooling Type w/ Unknown Heating Fuel	123.67	0.0256	0.0443

Infiltration Reduction Recommendations

In past evaluations, a weighted savings value was applied to all participants regardless of whether central cooling was present in the home and space heating fuel type. Given the tracking database provides this information at the participant level, we recommend applying savings based on the actual space cooling and heating types. For cases where this information is unknown, we then suggest relying on the weighted deemed savings based on weights from program tracking data.

HVAC Filters

HVAC Filter Results

Table A-10 documents the inputs and methodology for estimating HVAC filter savings for the DEO NES program participants. We based savings on RECS 2009 data and a study performed by LBNL that measures the effects of HVAC filters in residential homes.[4] The LBNL study states that regularly[5] replacing air filters reduces the energy consumption of HVAC equipment by 1%. We applied the 1% reduction to the average annual energy consumption for different types of HVAC equipment to arrive at average annual filter energy savings per home. The average annual energy consumption was determined using RECS 2009 data for Ohio.

Table A-10. Algorithms and Inputs for HVAC Filters

	Algorithms Used	
Cooling kWh Savings	= kWh consumption (cooling) * %Savings * %AC	
Heating kWh Savings	= kWh Consumption (heating) * %Savings * %Electric_heat	
kW Savings (summer)	= Cooling kWh savings / FLHcool * CFs * %AC	
kW Savings (winter)	= Heating kWh savings / FLHheat * %Electric_heat * CFw	
Parameter	**DEO Value**	**Source/Notes**

[4] LBNL. "System Effects of High Efficiency Filters in Homes." March 2013. http://eetd.lbl.gov/sites/all/files/lbnl-6144e.pdf.

[5] Air filters should be replaced monthly or bimonthly (depending on frequency of use and the levels of dust or contaminants within the home) according to the U.S. Department of Energy. http://energy.gov/energysaver/articles/maintaining-your-air-conditioner.

	Algorithms Used	
kWh Consumption (Cooling)	1,012	RECS 2009 Microdata for Ohio and Indiana region. Average for all central cooling types.
kWh Consumption (Heating)	4,269	RECS 2009 Microdata for Ohio and Indiana region. Average for all electric forced air heating types.
% Savings	1.0%	LBNL Study "System Effects of High Efficiency Filters in Homes" indicates about 1% change. This value is an average using data from the current study, and data from 2 other similar studies. http://eetd.lbl.gov/sites/all/files/lbnl-6144e.pdf
%AC (Central Cooling Present)	100%	Applied only to those with central cooling equipment (e.g., CAC, ASHP).
Weighted %AC (Unknown if Central Cooling Present)	78.1%	2018 DEO Program tracking Data. Applied only to those where it is unknown if central cooling is present.
%Electric heat	100%	Applied only to those with electric heating equipment (e.g., electric furnace, ASHP).
Weighted %Electric heat (Unknown heating fuel)	11.6%	2018 DEO Program Tracking Data. Applied only to those with unknown space heating fuel.
FLHcool	996	EPA (2002) for Cincinnati, Ohio.
FLHheat	2,134	EPA (2002) for Cincinnati, Ohio.
Summer Coincidence Factor (CFs)	0.88	IN TRM V2.2. Duke Energy data for residential air conditioning loads.
Winter Coincidence Factor (CFw)	1.00	According to Duke, the winter peak hour is from 7-8 am. There is no good data on winter coincidence factors for heating equipment during the 7am to 8am peak hour.
Cooling kWh Savings/system	10.12	Calculated using the following formula: kWh Consumption (Cooling) * %Savings
Heating kWh Savings/system	42.69	Calculated using the following formula: kWh Consumption (Heating) * %Savings

Table A-11 displays the deemed savings values for the DEO NES program participants.

Table A-11. Per-Measure Savings for HVAC Filters

Measure	HVAC Type	Deemed Savings		
		Energy (kWh)	Summer Demand (kW)	Winter Demand (kW)
HVAC Filters	Central Cooling w/ Electric Heating	52.81	0.0089	0.0200
	Central Cooling w/ Gas Heating	10.12	0.0089	N/A
	Central Cooling w/ Unknown Heating Fuel	15.08	0.0089	0.0023
	No Central Cooling w/ Electric Heating	42.69	N/A	0.0200
	No Central Cooling w/ Unknown Heating Fuel	4.96	N/A	0.0023
	Unknown Cooling Type w/ Electric Heating	50.59	0.0070	0.0200
	Unknown Cooling Type w/ Gas Heating	7.90	0.0070	N/A
	Unknown Cooling Type w/ Unknown Heating Fuel	12.86	0.00070	0.0023

HVAC Filter Recommendations

In past evaluations, a weighted savings value was applied to all participants regardless of whether central cooling was present in the home and space heating fuel type. Given the tracking database provides this information at the participant level, we recommend applying savings based on the actual space cooling and heating types. For cases where this information is unknown, we then suggest relying on the weighted deemed savings based on weights from program tracking data.

Hot Water Pipe Insulation

Hot Water Pipe Insulation Results

Table A-12 documents the inputs and methodology for estimating hot water pipe insulation savings for the DEO NES program participants.

Table A-12. Algorithms and Inputs for Hot Water Pipe Insulation

Algorithms Used		
kWh Savings	= (1/Rexist - 1/Rnew) * (L * C) * ΔT * 8,766 / RE / 3412 * %Elec	
kW Savings (summer)	= kWh Savings / 8,766 * CFs * %Elec	
kW Savings (winter)	= kWh Savings / 8,766 * CFw * %Elec	
Parameter	**DEO Value**	**Source/Notes**
Existing R-value (Rexist)	1.00	IL TRM V6.0. Original study was from Navigant Consulting Inc., April 2009; "Measures and Assumptions for Demand Side Management (DSM) Planning; Appendix C Substantiation Sheets", p77.
Installed R-value (Rnew)	3.35	Average of Duke provided insulation R-values for 1/2" and 3/4" pipe wrap. Email from Casey Fields on Nov. 21, 2018 (RE: DEC/DEP NES Data...)
Length of pipe insulation in feet (L)	5.0	Database labels indicate 5ft sections.
Circumference of pipe in feet (C)	0.164	Assume average of 1/2" and 3/4" diameter pipe mix. Per email from Casey Fields on Nov. 21, 2018 (RE: DEC/DEP NES Data...)
Recovery efficiency (RE) of water heater	0.98	Typical recovery efficiency for electric resistance heaters (IL TRM, IN TRM, ARK TRM).
%Elec (Electric WH)	100%	Applied only to those with electric water heating fuel.
%Elec (Unknown WH Fuel)	11.6%	2018 DEO Program Tracking Data. Applied only to those with unknown water heating fuel.
ΔT (°F)	60.0 °F	IL TRM V6.0. Assumes 125°F water leaving the hot water tank and average temperature of basement of 65 °F.
Summer Coincidence Factor (CFs)	1.00	IL TRM V6.0. Savings are realized 8,766 hours per year and through the full peak hours.
Winter Coincidence Factor (CFw)	1.00	IL TRM V6.0. Savings are realized 8,766 hours per year and through the full peak hours.

Table A-13 displays the deemed savings for the DEO NES program participants.

Table A-13. Per-Measure Savings for Hot Water Pipe Insulation

Measure (per 5 foot of pipe wrap)	Deemed Savings		
	Energy (kWh)	Summer Demand (kW)	Winter Demand (kW)
Hot Water Pipe Insulation (Electric WH)	90.15	0.0103	0.0103
Hot Water Pipe Insulation (Unknown WH Fuel)	10.47	0.0012	0.0012

Hot Water Pipe Wrap Recommendations

In past evaluations, a weighted savings value was applied to all participants regardless of water heating fuel type. Given the tracking database provides this information at the participant level, we recommend applying savings based on the actual water heater fuel type. For cases where the fuel type is unknown, we then suggest applying a weighted deemed savings based on weights using program tracking data.

Water Heater Blankets

Water Heater Blanket Results

Table A-14 documents the inputs and methodology for estimating water heater blanket savings for the DEO NES program participants.

Table A-14. Algorithms and Inputs for Water Heater Blankets

Algorithms Used		
kWh Savings	= (Abase / Rbase - Ainsul / Rinsul) * ΔT * 8,766 / RE / 3412 * %Elec	
kW Savings (summer)	= kWh saved / 8,766 *CFs * %Elec	
kW Savings (winter)	= kWh saved / 8,766 * CFw * %Elec	
Parameter	**DEO Value**	**Source/Notes**
Surface Area in ft2 prior to installing blanket (Abase)	23.18	IL TRM V6.0. Assumes 40-gallon capacity tank and R-12 prior to installing blanket, resulting in Abase of 23.18.
R-value prior to installing blanket (Rbase)	12.00	IL TRM V6.0. Assumes R-12 for baseline insulation.
Surface area in sf2 after installing blanket (Ainsul)	25.31	IL TRM V6.0. Assumes 40-gallon capacity tank and R-20 after installing blanket, resulting in Ainsul of 25.31.
R-value after installing blankt (Rinsul)	20.00	IL TRM V6.0. Assumes R-20 after installing blanket.
ΔT (°F)	60°F	IL TRM V6.0. Assumes 125°F water leaving the hot water tank and average temperature of basement of 60°F.
Recovery efficiency (RE) of water heater	0.98	Typical recovery efficiency for electric water heaters (IL TRM, IN TRM, ARK TRM).
kWh/Btu conversion (Btu/kWh)	3,412	Standard conversion.
%Elec (Electric WH)	100%	Applied only to those with electric water heating fuel.

Algorithms Used		
%Elec (Unknown WH Fuel)	11.6%	DEO Program Tracking Data. Applied only to those with unknown water heating fuel.
Summer Coincidence Factor (CFs)	1.00	IL TRM V6.0. Savings are realized 8,766 hours/year and through the full peak hours.
Winter Coincidence Factor (CFw)	1.00	IL TRM V6.0. Savings are realized 8,766 hours/year and through the full peak hours.

Table A-15 displays the deemed savings for the DEO NES program participants.

Table A-15. Per-Measure Savings for Water Heater Blankets

Measure (per water heater)	Deemed Savings		
	Energy (kWh)	Summer Demand (kW)	Winter Demand (kW)
Water Heater Blanket (Electric WH)	104.79	0.0120	0.0120
Water Heater Blanket (Unknown WH Fuel)	12.17	0.0014	0.0014

Water Heater Blanket Recommendations

In past evaluations, a weighted savings value was applied to all participants regardless of water heating fuel type. Given the tracking database provides this information at the participant level, we recommend applying savings based on the actual water heater fuel type. For cases where the fuel type is unknown, we then suggest applying a weighted deemed savings based on weights using program tracking data.

Key References

Reference	Source
2017-2018 DEO Participant Survey	Opinion Dynamics survey completed in January 2019 with 2017-2018 DEO Neighborhood Energy Saver participants.
2017 DEO Lighting Logger Study	Opinion Dynamics Corporation. Duke Energy Ohio (DEO) Energy Efficient Appliances and Devices Program. Prepared for Duke Energy. September 11, 2018.
DEO Program Tracking Data	Duke Energy – provided program tracking for the evaluation period (July 1st, 2017 through May 31st, 2018).
ASHRAE 2017	American Society of Heating, Refrigerating and Air-Conditioning Engineers: 2017 Fundamentals.
Arkansas TRM	Arkansas Technical Reference Manual. Version 7.0.
ENERGY STAR	ENERGY STAR Savings Analysis Measure Upgrade Assumptions. https://www.energystar.gov/ia/home_improvement/home_sealing/Measure_Upgrade_Assumptions.pdf?945a-eddc
EPA Study	EPA Study for HVAC hours of use. 2002.
Illinois TRM	Illinois Statewide Technical Reference Manual. Version 6.0. February 8, 2017.
Indiana TRM	Indiana Technical Reference Manual. Version 2.2. July 28, 2015.
LBNL	Lawrence Berkeley National Laboratory. "System Effects of High Efficiency Filters in Homes". http://eetd.lbl.gov/sites/all/files/lbnl-6144e.pdf

Reference	Source
2013 Michigan Showerhead/Faucet Aerator Study	Michigan Evaluation Working Group Showerhead and Faucet Aerator Meter Study Memorandum. June 2013.
Mid-Atlantic TRM	Mid-Atlantic Technical Reference Manual. Version 7.0. May 2017.
NREL Domestic Hot Water Event generator	National Renewable Energy Laboratory (NREL) Domestic Hot Water Event generator. 2013.
RECS Data	U.S. Energy Information Administration, 2015 Residential Energy Consumption Survey (RECS), Midwest Region.

Appendix B. Impact Calculation Tables

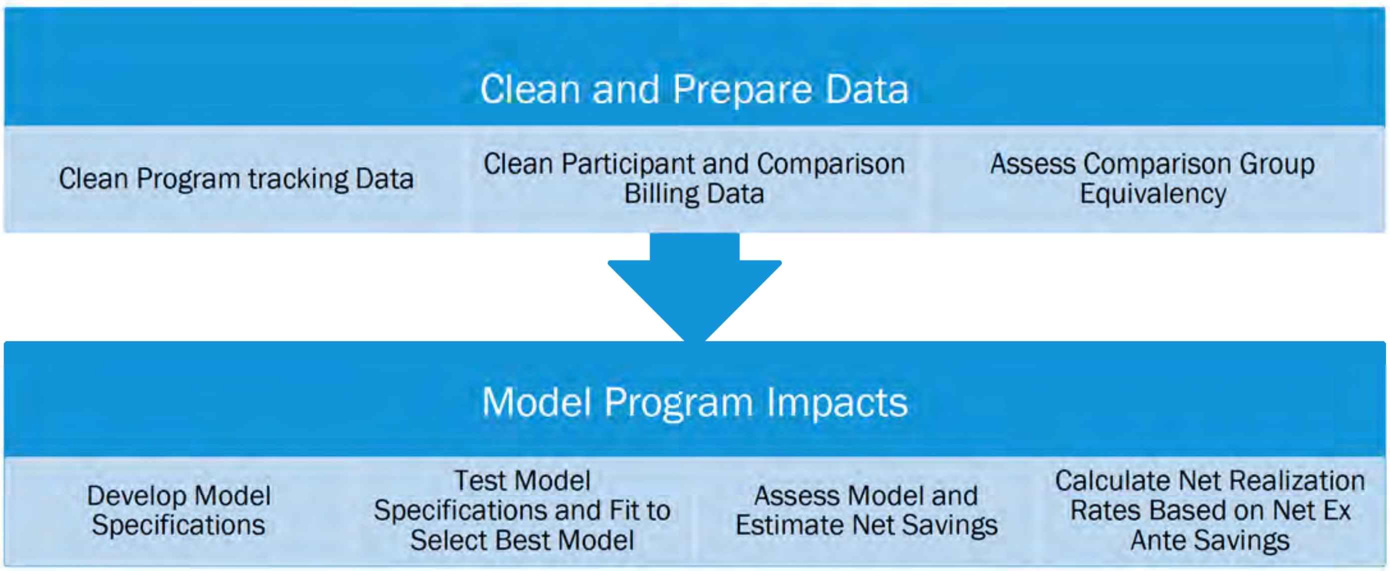
Appendix C. Detailed Methodology: Billing Analysis

The evaluation team conducted a billing analysis using a linear fixed-effects regression (LFER) model, with the goal of determining the overall ex post net program savings of the DEO NES Program. The fixed effect in the model is at the individual account level, which allows all household factors that do not vary over time to be controlled for in the model.

Data Cleaning and Preparation

As part of the billing analysis of NES Program participants, the evaluation team followed a standard series of steps for data collection, model specification, and analysis. Figure C-1 provides a summary of our billing analysis approach.

Figure C-1. Billing Analysis Approach



Clean Program tracking Data

As a first step in preparing the necessary data, the evaluation team prepared a master participant dataset that combined the program tracking data for the NES Program with dates of participation in other Duke Energy energy-efficiency programs. This master dataset is composed of customer information that includes:

- **Participation date:** The date of participation determines the program for each account and differentiates pre and post periods in our model.
- **Participation in other programs:** Customers who participated in multiple energy efficiency programs during the time period were identified and excluded as they would likely skew the observed effect of the NES, or double-count savings from other programs, if they are not accounted for or removed. There is one exception to this, the Smart $aver program, which had a very high rate of cross-participation.
- **Location:** We used the address and zip code of each customer to incorporate regional weather data.

Clean Participant Billing Data

We used billing data to conduct the billing analysis. These data were provided by DEO on a monthly basis, from December 2015 to July 2019. To develop the final dataset used for statistical analysis, we used a multi-step approach to combining and cleaning the data. We describe each billing data-cleaning step below.

- **Clean individual billing periods:**
  - **Removed all duplicate billing records:** There were no perfectly duplicated observations in the billing data.
  - **Combined participant data with billing records:** We merged monthly billing data with the customer-specific (account-level) data, including measure installation dates. We then assigned pre- and post-participation treatment billing periods based on those dates. We assigned billing periods before the first measure installation date to the pre-participation period, all bills following the last measure installation date as the post-participation period, and any bills occurring between installation dates (or in the month of the audit and measure installations) to a "dead-band" period that was not included in the analysis.

After individual billing records are cleaned and all data are combined, we remove accounts that do not meet certain criteria. We use these criteria to ensure that all accounts in the final analysis file have sufficient data to allow for robust analysis. Customers who do not meet the criteria necessary for accurate modeling are dropped from the analysis, but later included when calculating total results.

- **Extremely high or low ADC:** We removed customers with very high or very low average daily usage. We dropped households with energy use at or below 0 kWh/day on average (across their billing history in both the pre- and post-participation periods). We also dropped customers with extremely high usage (over 300 kWh/day). These households with odd usage patterns are likely the result of factors that cannot easily be controlled for and could bias the results of the model.
- **Inadequate billing history before or after program participation:** The primary savings measures are expected to generate energy savings throughout the year. To be able to fully assess changes in consumption due to program measures before and after installation, we included participants with a billing history covering, at a minimum, 9 months of records before and after the first day of program participation. We dropped customers if they had less than 75% of heating season (November through February) days in the pre- and post-participation period. Finally, we dropped customers if they had less than 45 days of data in summer before they participated or 60 days of data in the summer after they participated.
- **Participated in other Duke Energy program:** We removed customers from the analysis who participated in other energy efficiency programs during the program evaluation period, with the exception of the Smart $aver Program, due to the very high rate of cross-participation with that program in particular. Table C-1. shows the breakdown of cross-participation.

Table C-1. Summary of Cross-Participation

Program Name	Unique Customers
DE Residential EE Products & Services	7
DE Smart $aver Residential	754
Elec Wtzn pay per kwh program	15
Energy Maintenance Service	2
Home Energy Solutions	1
My Home Energy Report	49
Refrigerator Replacement	1
Residential DR	9
Residential Energy Assessments	7
Weatherization Gas	8
Total	853

Table C-2. shows how many accounts were removed from the analysis based on exclusion criteria listed above.

Table C-2. Accounts Removed from Analysis

	Customer Count	Percent Remaining
Total Unique Accounts with Billing Data	**1,082**	**100%**
Customer has no participation date	1,082	100%
Suspicious bills: perfect duplicate observations	1,082	100%
Suspicious bills: zero days in billing period	1,082	100%
Too few pre-period bills (< 9)	971	90%
Too few post-period bills (< 9)	871	80%
Too few heating season days in pre- and post-period (< 75%)	871	80%
Low overall average usage (< 2kWh/day)	869	80%
High overall average usage (> 300kWh/day)	869	80%
Suspicious bills: zero or negative usage	869	80%
Too few cooling season days (less than 45 in pre-period or 60 in post)	869	80%
Low usage values in pre- or post-period (< 2kWh/day or > 300 kWh/day)	869	80%
Cross Participation	687	63%
Accounts Remaining for Analysis	**687**	**63%**

Weather

To include weather patterns in our model, we pulled daily weather data from numerous weather stations across the DEO territory, utilizing the site closest to each account's geographic location. By using multiple sites, we increase the accuracy of the weather data being associated with each account. We obtained these data from the National Climatic Data Center (NCDC). The daily data are based on hourly average temperature readings from each day. We calculated CDD and HDD for each day (in the analysis and historical periods) based on average daily temperatures, using the same formula used in weather forecasting.[6] Because the billing data is at a monthly level, when then summed CDD and HDD per month. We merged monthly weather data into the billing dataset so that each billing period captures the HDD and CDD for that billing period (including start and end dates[7]).

Assess Comparison Group Equivalency

A key challenge for estimating energy savings via a billing analysis is the identification of an appropriate comparison group or "counterfactual" to represent a baseline for what participants would have done (and how much energy they would have consumed) in the absence of the program. There are two key considerations in the design of a comparison group. A comparison group must: 1) have similar energy usage patterns (compared to participants) before participation (i.e. pre-participation period) and 2) effectively address self-selection bias (the correlation between the propensity to participate in a program and energy use). In an ideal experimental design, a control group would be equivalent to the treatment group in all aspects, save for the treatment being evaluated (participation in the NES in our case). A perfect post-participation match is impossible when studying the effects of energy efficiency programs, since we cannot know if any group of non-participants is equivalent to the participant group, especially on the dimension of what the participants would have done absent the program. We generally aim to use a comparison group that, on average, exhibits very similar usage patterns prior to participation. Achieving this ensures that estimates from our quasi-experiment are representative on usage patterns at least, which reflects not only a household's level of use but its energy-related responses to changes in the environment. It is more difficult to assure that the comparison group represents what the participants would have done absent the program, i.e. whether they capture who would have been a free rider if they had participated. Another way to put it is that it is difficult to know whether we have captured factors involved in customers' self-selection into the program, some of whom would have installed program-qualified measures outside of the program.

We planned to use future (from June 2018 onwards) participants as a comparison group for this analysis. The energy use patterns of the members of this type of comparison group, during their pre-participation period, reflect equipment installations and behavioral changes that treatment group participants might have performed in the absence of the program. Using a group of later actual participants mitigates self-selection bias that may be present when comparing 2017-2018 participants to some non-participating group of customers in the same time period. The appropriate use of the future-participant comparison group design depends on the two groups and the program being equivalent on as many dimensions as possible. Based on a comparative analysis of pre-period kWh consumption and housing stock of the treatment group and potential future comparison group, we found that participants from 2018-2019 are not a suitable comparison for 2017-2018 participants. As such, including them in our model would risk a substantial misrepresentation of the counterfactual.

Pre-participation energy usage of our potential comparison differed significantly the treatment group, and the differences were not uniform. Overall, usage in the pre-period was higher for the treatment group, but there were some periods where usage was slightly higher for the comparison group. For modeling purposes, it would have been better if usage patterns were consistently different. Where there are inconsistent differences

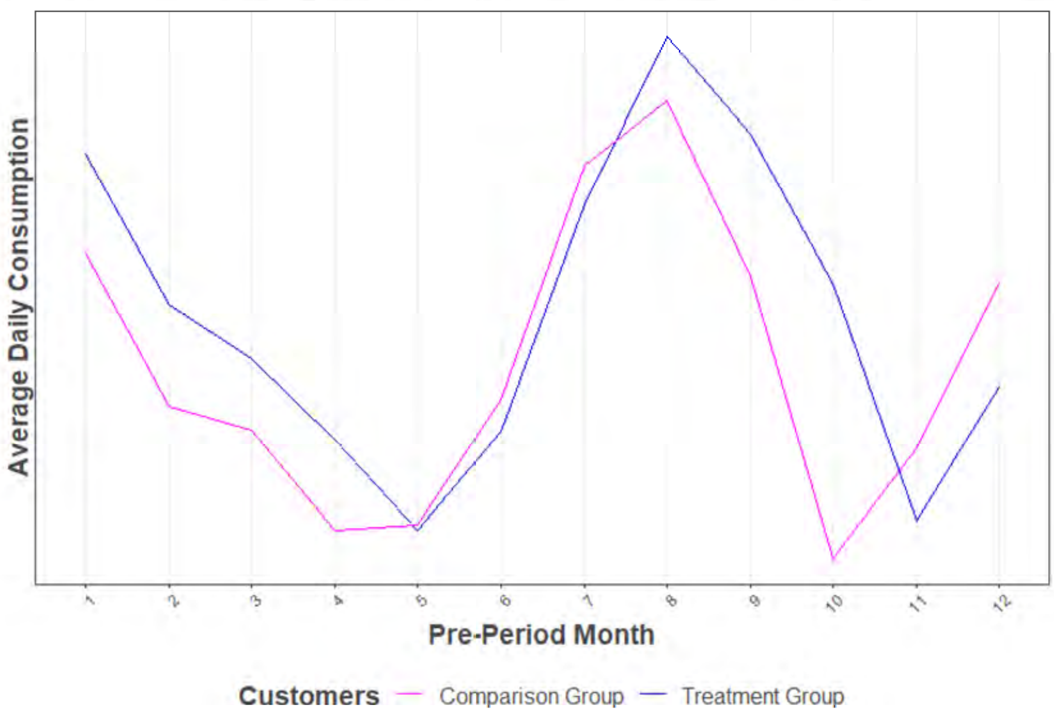
[6] A "degree-day" is a unit of measure for recording how hot or how cold it has been over a 24-hour period. The number of degree-days applied to any particular day of the week is determined by calculating the mean temperature for the day and then comparing the mean temperature to a base value of 65 (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 5 cooling degree-days. On the other hand, if the weather has been cool, and the mean temperature is, say, 55 degrees, then there have been 10 heating degree-days (65 minus 55). http://www.srh.noaa.gov/ffc/?n=degdays.

[7] Weather data are merged based on the given dates of the billing period. Assigning weather this way provides a more accurate representation of the weather experienced during the billing period than does using weather for the calendar month of the bill.

between groups and our controlling factors (e.g. electric heating incidence) cannot explain these differences, we lose faith in the model's ability to control for differences between the treatment and control group. Including a comparison group in these circumstances can make the modeling results less clear.

The evaluation team evaluated the baseline period average daily consumption (ADC) to determine if treatment participants were equivalent to the potential comparison participants, and therefore whether the potential comparison customers could be used as a valid comparison group. Similarity in ADC before engaging with the program might be a general proxy for behavioral similarities. The evaluation team compared the baseline ADC of participants in each group and found pre-participation energy usage of our potential comparison group differs from the treatment group (Figure C-2).

Figure C-2. Comparison of Average Daily kWh Consumption between Treatment and Comparison Customers



Modeling Program Impacts

To estimate savings for the NES Program, Opinion Dynamics used a LFER model that incorporates weather, use of electric hot water heaters, and changes in energy usage on a monthly basis, as well as interaction terms that show the effect of these factors in the post-period. The fixed-effect for the model is set at the account level, which allows us to control for all household factors that do not vary over time. In the process of determining the appropriate model for the analysis, we tested thirteen different models before selecting the best one.

Develop Model Specifications

Our final models were judged by a number of criteria. Primarily, we aimed to use a model that explained as much about changes in the dependent variable as possible. The most direct measure of this is the overall R-squared, which gives an estimate of how much the model explains. An R-squared of 1.0 would represent a model that explains 100% of the variance in the dependent variable, and an R-squared of 0.5 would explain 50%. In our quasi-experiment, R-squared will appear low because of our use of fixed effects. A higher R-squared relative to other potential models will still be a significant factor in selection of a final model. We also compared Akaike Information Criterion (AIC) values of each model specification within the same dataset. The AIC provides a measure of relative quality between models; a lower value indicates a relatively more efficient model.

With this type of model, we are unable to correct for non-program changes that occur during the post-participation period, which could bias the effect of program participation. Failing to account for non-program changes that occur during the post-participation period could misrepresent the treatment effect. However, after examining energy use data, we saw only the expected fluctuations attributable to seasonal changes and see no reason to believe there were any major exogenous factors that affected the change in energy use from the pre- to post-participation period. It is usually preferable to use comparison groups in billing analyses, because they represent patterns of consumption not attributable to the program that are then removed from the program effect. They may also represent what participants would have done absent the program. However, there is reason to believe that the pre/post participation analysis of participants reflects actual program savings. There were no obvious economic changes during the evaluated period, and there is reason to expect that gross effects (which are generally produced by our pre/post design) are essentially the same as net effects in this program for reasons articulated in the comparison group section of this appendix. In addition to an assumed low free-ridership, the removal of accounts who participated in other Duke Energy programs supports our confidence in saying that the treatment effect found here is representative of the change in energy use caused by the NES Program alone.

In the development of our model, we investigated monthly electricity usage before and after participation, how changes in weather affected the amount of energy used, how gas, electric or other kinds of space heating and hot water heating impact electricity usage, and differences in energy use in each month. We found a clear linear relationship between energy use and weather, as well as expected fluctuations in energy use through the year.

Opinion Dynamics' final model included interaction terms of weather and the post-participation period to account for the relationship between weather and consumption following treatment. We also included the incidence of electric hot water heaters, as the type of water heater (electric or gas) impacts the electricity savings that can be realized. The inclusion of these terms is meant to account for non-program-related changes that occur during the post-participation period, for example, the warmer summers that have been experienced. Failure to control for these potential changes could undervalue the treatment effect.

Final Model for Program Participants

Of all the models we tested, we found the model in Equation C-1 to have the best overall fit. The model takes into account changes in weather (heating and cooling degree-days) on a monthly basis, before and after participation, in order to model differences in the impact that weather had on energy savings after participation. The model also has interaction terms of electric water heater incidence with the post period. Controlling for that particular load improved the model's fit.

Equation C-1. Model Specification

$$Usage_{it} = \alpha + \alpha_i + B_{post}Post_{it} + B_{HDD}HDD_{it} + B_{CDD}CDD_{it} + B_{post\ ew}Post_{it} \cdot EW_i + \varepsilon_{it}$$

Where:

$Usage$ = Monthly consumption (in kWh) for the billing period
α = Overall intercept
α_i = Household-specific intercept (absorbed)
$Post_{it}$ = Indicator for treatment group in the post-program period for household *i* at time t
HDD_{it} = Monthly Heating Degree Days from NOAA for household *i* at time t
CDD_{it} = Monthly Cooling Degree Days from NOAA for household *i* at time t
EW_i = Indicator for electric hot water heater usage by household i
B_{post} = Difference in usage associated with any differences in the pre and the post-program period, unadjusted by weather, day of week and month
B_{HDD} = Difference in usage associated with one-unit increase in HDD
B_{CDD} = Difference in usage associated with one-unit increase in CDD
$B_{post\ ew}$ = Difference in usage associated with using an electric hot water heater in the pre and post-program period
ε_{it} = Error term

Estimate Gross Savings and Calculate Gross Realization Rate

This section contains the observed net savings and realization rates resulting from the billing analysis 2017-2018 participants. The results here do not specifically account for free-ridership, but do reflect savings associated with installed measures, spillover, and potential behavioral changes from energy efficiency knowledge gained during the assessment. As the NES program is income-qualified, we assume free ridership to be 0.

Estimated Savings

The regression model results presented in Table C-3 show a reduction in electricity use after customers participated in the NES Program, controlling for weather, time, and the household characteristics for each participant (reflected in the household-specific constant terms).

Table C-3. Final Model

Variable	Coefficient
Post (NES Program participation)	-13.08***
Heating Degree Days (HDD)	0.381***
Cooling Degree Days (CDD)	5.04***
Post-participation electric hot water (interaction of Post x presence of electric hot water)	42.37***
Constant	462.78
Observations	27,185
R-squared	0.62

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

Due to the post-period electric hot water heater interaction term in the model, it is necessary to calculate the treatment effect by multiplying the proportion of customers with electric hot water heaters with the coefficient for the interaction term and add that to the coefficient for the main effect term (Post) in the model. Evaluating the equation shown in Equation C-2, we can estimate the overall savings associated with the program.

Equation C-2. Model Evaluation

$$\Delta Usage = B_1 Post + ProportionEW_i \cdot (B_2 Post \cdot EW_i)$$

$\Delta Usage$ = Change in monthly electricity usage
$ProportionEW_i$ = Proportion of customers with electric hot water heaters

Table C-4. Adjusted Estimate of Monthly Program Savings Per Customer

Savings Estimate (kWh/Month)	Standard Error	90% Confidence Interval	
		Lower	Upper
18.01	5.87	8.4	27.7

The value of the NES Program estimate seen in Table C-4 represents 18.01 kWh reduction in monthly electricity usage associated with moving from pre-participation treatment to post-participation treatment. There is a 90% probability, or confidence, that actual overall first-year program savings fall between 8.4 kWh and 27.7 kWh per month for NES Program participants. These savings estimates shown for individual DEO NES Program participants in Table C-5.

We estimate that the average realized annual savings are 216 kWh for customers who participated in the NES Program in 2017 and 2018. To better facilitate comparisons of program performance across program years and territories, we also show savings here as a percentage of energy saved with respect to the treatment group's baseline.

Table C-5. Estimated Annual Savings from Billing Analysis Per Customer

Baseline Energy Use		Energy Savings		
Daily (kWh)	Annual (kWh)	Daily (kWh)	Annual (kWh)	Savings (%)
26.1	9,409	0.60	216	2.3%

Complete Model Results

Table C-6. Full Model Results

Term	Estimate	Standard Error	Statistic	P-Value
post	-13.08	4.39	-2.98	0.00
HDD	0.38	0.01	46.45	0.00
CDD	5.04	0.08	64.56	0.00
post:electric_water_heater_fuel	42.37	12.68	3.34	0.00
constant	462.78			

Appendix D. Survey Instruments and Detailed Survey Results

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Duke Energy Ohio

Retail Lighting Program Evaluation Report – Final

June 27, 2020

Opinion Dynamics

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1. Evaluation Summary

This report provides results of an impact and limited process evaluation of the Duke Energy Ohio (DEO) Retail Lighting Program. The program period under evaluation is August 1, 2018 through July 14, 2019. We refer to this period as the evaluation period throughout the remainder of this report.

1.1 Program Summary

Duke Energy launched the DEO Retail Lighting program in August 2018 with the goal of reducing electric energy consumption and peak demand through increased awareness and adoption of energy-efficient lighting technologies. As part of the Retail Lighting program, Duke Energy partners with retailers and manufacturers across the DEO service territory to provide point-of-sale price markdowns on customer purchases of LED products. The program promotes customer awareness and purchase of program-discounted products through a range of marketing and outreach strategies, including in-store collateral and events, mail and email marketing, and community events. The program also provides training to store staff. The product mix includes a wide range of standard and specialty ENERGY STAR® LED bulbs and fixtures, and participating retailers include a variety of store types.[1].

Over the course of the evaluation period, the program discounted 431,223 LEDs, achieving 19,212 MWh in ex ante energy savings, 1.8 MW in ex ante summer peak demand savings, and 4.0 MW in ex ante winter peak demand savings (Table 1-1).

Table 1-1. Sales and Ex Ante Savings Summary

Metric	Performance
Bulb sales	431,223
Ex ante energy savings (MWh)	19,212
Ex ante summer peak demand savings (MW)	1.8
Ex ante winter peak demand savings (MW)	4.0

Source: Opinion Dynamics analysis of program tracking data.

1.2 Evaluation Objectives and High-Level Findings

1.2.1 Evaluation Objectives

This evaluation of the DEO Retail Lighting program focused on the evaluation of program impacts but included a limited process and market assessment component. The evaluation addressed the following research objectives:

- Assess the program's performance and estimate gross and net energy (kWh) and peak summer and winter demand (kW) savings associated with program activity
- Develop gross and net impact estimates for regulatory compliance purposes
- Review the program's processes for savings tracking and forecasting and identify opportunities for improvement

[1] 60-watt equivalent standard LEDs are not a part of the Retail Lighting product mix, as they are offered through the Free LED program.

- Provide reliable estimates of evaluated program impacts that meet or exceed evaluation industry standards for rigor and the requirements of the Public Utilities Commission of Ohio (PUCO)

To achieve these research objectives, the evaluation team completed a range of data collection and analytic activities, including interviews with program staff, a review of deemed savings, program tracking data analysis, an analysis of commercial lighting logger data, retailer shelf audits, interviews with manufacturer and retailer staff, geographic information system (GIS) analysis to estimate leakage, and an impact analysis. Table 1-2 provides an overview of the evaluation activities, the scope of each, the research area that each activity supported, and an overview of the activity's purpose.

Table 1-2. Overview of Evaluation Activities

#	Activity	Scope	Impact	Process	Market	Purpose
1	Program staff interviews	n=1		X		▪ Provide insight into program design and delivery
2	Materials and program tracking data review	All materials provided		X		▪ Provide insight into program design and delivery ▪ Understand program performance in terms of product mix, retailer mix, and incentive levels
3	Deemed savings review	All data provided	X	X		▪ Review completeness, accuracy, and consistency of data and ex ante savings assumptions
4	Leakage analysis	All data provided	X			▪ Estimate program-specific leakage rate based on geographic information system (GIS) analysis
5	Commercial lighting logger analysis	n=202	X			▪ Develop hours of use (HOU) and coincidence factors (CFs) for LEDs installed in commercial applications
6	Gross impact analysis	All data provided	X			▪ Estimate gross energy and demand savings
7	Retailer and manufacturer interviews	n=11	X	X	X	▪ Estimate NTG ▪ Provide insight into program delivery and the current and future lighting market

1.2.2 High-Level Findings

The DEO Retail Lighting program achieved 17,856 MWh in ex post gross energy savings, 2.6 MW in ex post gross summer peak demand savings, and 3.0 MW in ex post gross winter peak demand savings. The respective gross realization rates are 93% for energy savings, 146% for summer peak demand savings, and 76% for winter peak demand savings. Opinion Dynamics conducted interviews with program participating retailers and manufacturers to estimate program net-to-gross (NTG). The analysis resulted in the program-level NTG of 30%. Applying this NTG rate to the ex post gross savings resulted in net energy savings of 5,357 MWh, net summer peak demand savings of 0.8 MW, and net winter peak demand savings of 0.9 MW. Table 1-3 presents the ex post gross and net results.

Table 1-3. Ex Post Gross and Net Savings Summary

Metric	Ex Ante Savings	Ex Post Gross Savings	Gross Realization Rate	NTG	Ex Post Net Savings	Net Realization Rate[a]
Bulbs	431,223	431,223				
Energy savings (MWh)	19,212	17,856	93%	30%	5,357	39%
Summer peak demand savings (MW)	1.8	2.6	146%		0.8	61%
Winter peak demand savings (MW)	4.0	3.0	76%		0.9	32%

Source: Opinion Dynamics analysis of program tracking data.
[a] Denominator is ex ante net savings.

Table 1-4 provides per-bulb ex post gross and net savings. Measure categories in the table below are consistent with the definitions used for DEO tracking purposes.

Table 1-4. Ex Post Per-Bulb Gross and Net Savings

Measure	Ex Post Gross Per-Bulb Savings			NTG	Ex Post Net Per-Bulb Savings		
	kWh	Summer Peak kW	Winter Peak kW		kWh	Summer Peak kW	Winter Peak kW
A-Line	41.37	0.0060	0.0071	30%	12.41	0.0018	0.0021
Reflector Outdoor	46.96	0.0068	0.0080	30%	14.09	0.0020	0.0024
Reflector Recessed	50.89	0.0074	0.0087	30%	15.27	0.0022	0.0026
Reflector Track	38.18	0.0056	0.0065	30%	11.45	0.0017	0.0020
3-Way	67.49	0.0098	0.0115	30%	20.25	0.0029	0.0035
Candelabra	27.85	0.0040	0.0047	30%	8.35	0.0012	0.0014
Globe	33.33	0.0048	0.0057	30%	10.00	0.0015	0.0017
Fixture	39.75	0.0058	0.0068	30%	11.92	0.0017	0.0020

Table 1-5 provides a second estimate of per-LED gross and net savings, representing savings claimable under Ohio Senate Bill 310 (SB 310). Gross savings reflect the maximum of ex ante and ex post gross savings values. We calculated net savings by multiplying gross savings claimable under SB 310 by the NTG of 30% developed through this evaluation.

Table 1-5. Per-Bulb Gross and Net Savings Claimable Under SB 310

Measure	Gross Per-Bulb Savings Claimable Under SB 310			NTG	Net Per-Bulb Savings Claimable Under SB 310		
	kWh	Summer Peak kW	Winter Peak kW		kWh	Summer Peak kW	Winter Peak kW
A-Line	50.65	0.0060	0.0093	30%	15.20	0.0018	0.0028
Reflector Outdoor	118.68	0.0108	0.0260	30%	35.61	0.0032	0.0078
Reflector Recessed	50.89	0.0074	0.0096	30%	15.27	0.0022	0.0029
Reflector Track	38.18	0.0056	0.0065	30%	11.45	0.0017	0.0020
3-Way	67.49	0.0098	0.0115	30%	20.25	0.0029	0.0035
Candelabra	27.85	0.0040	0.0047	30%	8.35	0.0012	0.0014
Globe	33.33	0.0048	0.0057	30%	10.00	0.0015	0.0017
Fixture	39.75	0.0058	0.0081	30%	11.92	0.0017	0.0024

Source: Opinion Dynamics analysis of program tracking data.

The program team leveraged well-established implementation approaches, demonstrating smooth and effective operational processes. These approaches included a purposeful selection of store locations to target underserved customers and minimize program leakage and active engagement with retailer and manufacturer contacts to monitor market changes and adjust program offerings as needed. The program offered incentives on 299 unique products across 65 participating storefronts during the evaluation period. Program marketing was versatile and targeted customers both at point of purchase and through email and direct mail campaigns and local events. Program tracking data was also generally clean and well maintained.

The lighting market continues to undergo rapid change, and LEDs have quickly become commonplace across retail channels. The subsequent increases in customer comfort and satisfaction has driven preferences for LEDs and adoption of the technology in residential applications. As a result, the lighting market for the most frequently sold bulb shapes is being rapidly saturated with LEDs. A number of key indicators gathered from research and data collection efforts across the country illustrate the rate and scale at which these changes to the lighting market have occurred in recent years.[2] In light of these trends and continuing uncertainty surrounding the future of federal lighting efficiency standards, programs will need to target interventions to pinpoint the remaining market imperfections, maximize cost-effectiveness, and minimize risk.

[2] Key market indicators are detailed and discussed in Section **Error! Reference source not found.**.

Based on the findings of this evaluation, Opinion Dynamics makes the recommendations presented below. Opinion Dynamics acknowledges that Duke Energy continues to actively modify the Retail Lighting offering and are either planning to or have already implemented a number of programmatic modifications that are well-aligned with the recommendations presented below. For instance, we understand from program staff feedback that Duke Energy plans to incentivize standard LEDs only in hard-to-reach stores starting in Q3 of 2020. Furthermore, efforts to further focus on hard-to-reach retailers, such as discount and dollar stores, are underway with a possibility of limiting program activity to just those stores in the future.

- Consistent with the current guidelines, Duke Energy should calculate future savings from the program using the savings values claimable under Ohio Senate Bill 310 (SB 310).
- Continue and, if possible, increase the program's focus on underserved customer segments. Such efforts could include targeting stores in areas with disproportionate shares of underserved customers and targeting retailers with disproportionate numbers of shoppers from underserved segments.
- Continue and, if possible, increase targeting of specialty products, focusing on lower-wattage specialty products, and adjust program marketing and messaging to focus on underserved sockets and increase messaging relevance (such as specialty sockets in dining rooms).
- Consider alternative program designs, such as free bulb giveaways targeting customer segments with lower rates of LED adoption (e.g. low-income, renters, rural areas, etc.) while maintaining efforts to avoid overlap with existing offerings such as the Free LED and Neighborhood Energy Saver programs.
- Monitor manufacturing practices and shelf stocking trends in anticipation of possible federal regulation to identify optimal timing for program completion.
- Continue to assume halogen baseline efficiency for standard products and incandescent baseline efficiency for specialty products given the state of the market after several years of EISA minimum federal efficiency standards.

2. Program Description

This section provides an overview of the design, implementation, and performance of the Duke Energy Ohio (DEO) Retail Lighting program. The program period under evaluation is August 1, 2018 through July 14, 2019.

2.1 Program Design

Duke Energy launched the DEO Retail Lighting program in August 2018 with the goal of reducing electric energy consumption and peak demand through increased awareness and adoption of energy-efficient lighting technologies. As part of the Retail Lighting program, Duke Energy partners with retailers and manufacturers across the DEO service territory to provide point-of-sale price markdowns on customer purchases of LED products. The program promotes customer awareness and purchase of program-discounted products through a range of marketing and outreach strategies, including in-store collateral and events, mail and email marketing, and community events. The program also provides training to store staff. The product mix includes a wide range of standard and specialty ENERGY STAR® LED bulbs and fixtures, and participating retailers include a variety of store types.[3]

[3] 60-watt equivalent standard LEDs are not a part of the Retail Lighting product mix, as they are offered through the Free LED program.

2.2 Program Implementation

DEO manages the Retail Lighting program and is responsible for overseeing program design, marketing, and operations. CLEAResult (formerly Ecova) is responsible for communicating directly with participating manufacturers and retailers, obtaining and processing program sales data, training retailer staff, and promoting program products through in-store events and point-of-purchase (POP) marketing materials. Duke Energy and CLEAResult staff maintained close communication throughout the evaluation period to monitor market changes and make adjustments to program offerings when needed.

2.3 Program Performance

Over the course of the evaluation period, the program discounted 431,223 LEDs, achieving 19,212 MWh in ex ante energy savings, 1.8 MW in ex ante summer peak demand savings, and 4.0 MW in ex ante winter peak demand savings (Table 2-1).

Table 2-1. Program Performance Summary

Metric	Performance
Bulb sales	431,223
Ex ante energy savings (MWh)	19,212
Ex ante summer peak demand savings (MW)	1.8
Ex ante winter peak demand savings (MW)	4.0

Source: Opinion Dynamics analysis of program tracking data.

Table 2-2 provides a summary of the product mix discounted through the program during the evaluation period. Reflector and specialty bulbs represented roughly two-thirds of all sales and savings, while standard bulbs accounted for one-quarter of bulb sales and slightly more than a quarter of program savings during the evaluation period.

Table 2-2. Ex Ante Savings by Product Type

Measure Type	Reported Bulbs		Ex Ante Energy Savings (kWh)		Ex Ante Summer Peak Demand Savings (kW)		Ex Ante Winter Peak Demand Savings (kW)	
	Bulbs	% of Total Sales	kWh Savings	% of Total Savings	kW Savings	% of Total Savings	kW Savings	% of Total Savings
Standard LED	108,643	25%	5,503,305	29%	537	30%	1,013	25%
Reflector LED	161,575	37%	10,131,898	53%	921	52%	2,223	55%
Specialty LED	131,876	31%	2,503,636	13%	228	13%	549	14%
LED Fixture	29,129	7%	1,073,062	6%	98	5%	235	6%
Total	**431,223**	**100%**	**19,211,901**	**100%**	**1,783**	**100%**	**4,020**	**100%**

Source: Opinion Dynamics analysis of program tracking data.
Note that percentages may not sum to 100% due to rounding.

3. Key Research Objectives

This evaluation of the DEO Retail Lighting program focused on the evaluation of program impacts but included a limited process and market assessment component. The evaluation addressed the following research objectives:

- Assess the program's performance and estimate gross and net energy (kWh) and peak summer and winter demand (kW) savings associated with program activity
- Develop gross and net impact estimates for regulatory compliance purposes
- Review the program's processes for savings tracking and forecasting and identify opportunities for improvement
- Provide reliable estimates of evaluated program impacts that meet or exceed evaluation industry standards for rigor and the requirements of the Public Utilities Commission of Ohio (PUCO)

4. Overview of Evaluation Activities

To achieve these research objectives, the evaluation team completed a range of data collection and analytic activities. Table 4-1 provides an overview of the evaluation activities, the scope of each, the research area that each activity supported, and an overview of the activity's purpose.

Table 4-1. Overview of Evaluation Activities

#	Activity	Scope	Impact	Process	Market	Purpose
1	Program staff interviews	n=1		X		▪ Provide insight into program design and delivery
2	Materials and program tracking data review	All materials provided		X		▪ Provide insight into program design and delivery ▪ Understand program performance in terms of product mix, retailer mix, and incentive levels
3	Deemed savings review	All data provided	X	X		▪ Review completeness, accuracy, and consistency of data and ex ante savings assumptions
4	Leakage analysis	All data provided	X			▪ Estimate program-specific leakage rate based on geographic information system (GIS) analysis
5	Commercial lighting logger analysis	n=202	X			▪ Develop hours of use (HOU) and coincidence factors (CFs) for LEDs installed in commercial applications
6	Gross impact analysis	All data provided	X			▪ Estimate gross energy and demand savings
7	Retailer and manufacturer interviews	n=11	X	X	X	▪ Estimate NTG ▪ Provide insight into program delivery and the current and future lighting market

4.1 Program Staff Interviews

Opinion Dynamics completed one interview with program staff at Duke Energy in April of 2019. The interview explored, among other topics, program performance; changes in program design and implementation; participating retailer, product, and incentive mix; data-tracking and communication processes; and outlooks for future program planning.

4.2 Materials and Program Tracking Data Review

Opinion Dynamics conducted a review of program materials and data, including program sales data extracts, planning documents, marketing materials, field reports, and relevant evaluation reports and studies.

4.3 Deemed Savings Review

In support of the impact evaluation, Opinion Dynamics completed a review of the energy savings assumptions used to estimate energy and peak demand savings. As part of this process, we also reviewed preliminary program sales data extracts and offered feedback to program staff regarding data quality and completeness. The objectives of the review were to identify and review the deemed savings values used for ex ante impacts and to check program sales data for any gaps, omissions, inconsistencies, or errors.

4.4 Leakage Analysis

Leakage occurs when non-Duke Energy customers purchase program-discounted products and install them in homes or businesses located outside of a utility's service territory. The program leakage rate reflects the percentage of program bulbs purchased by non-Duke Energy electric customers. Duke Energy cannot claim savings from those products, so the savings associated with them must be excluded from the overall program impacts.

The key factor affecting leakage for an upstream residential lighting program is the location of the participating stores in relation to DEO service territory borders. The evaluation team relied on geographic information system (GIS) analysis to estimate leakage rates for each jurisdiction. We leveraged three data sources to perform the analysis:

- Program tracking data with participating store locations and associated sales
- U.S. Census 2017 American Community Survey (ACS) five-year estimates by census block group[4]
- Customer data

To calculate leakage rates, we performed the following steps:

- Geocoded participating store locations and customer addresses
- Defined a store's territory as the area lying within a certain radius from participating stores. We customized radius designators depending on whether the stores were located in urban or rural

[4] The evaluation team used Table B25003 - TENURE, which provides total occupied housing units (both owned and rented) at the block group level. U.S. Census Bureau; American Community Survey, 2017 American Community Survey 5-Year Estimates, Table B25003; accessed via American FactFinder

areas. We relied on the U.S. Census definitions of urban area, urbanized cluster, and rural area,[5] and assigned a 5-mile radius to the stores located in urban areas, a 7-mile radius to the stores located in urbanized clusters, and a 10-mile radius to the stores located in rural areas. The customized radius assignments assume that customers will need to travel further in rural compared to urban areas to have access to the types of retailers that participate in the program

- Calculated the number of households living within each participating store's territory by summing the total number of households across all census block groups lying within the store-assigned radius (5, 7, or 10 miles). In cases where a portion of a census block group fell within the designated radius, we apportioned the population of shoppers based on the percentage of land mass falling within the designated radius of the store
- Calculated a leakage rate for each participating store location by dividing the total number of Duke Energy customers within the store's territory by the total number of households in the same territory and subtracting the quotient from 1 (see Equation 4-1 below)

Equation 4-1. Leakage Formula

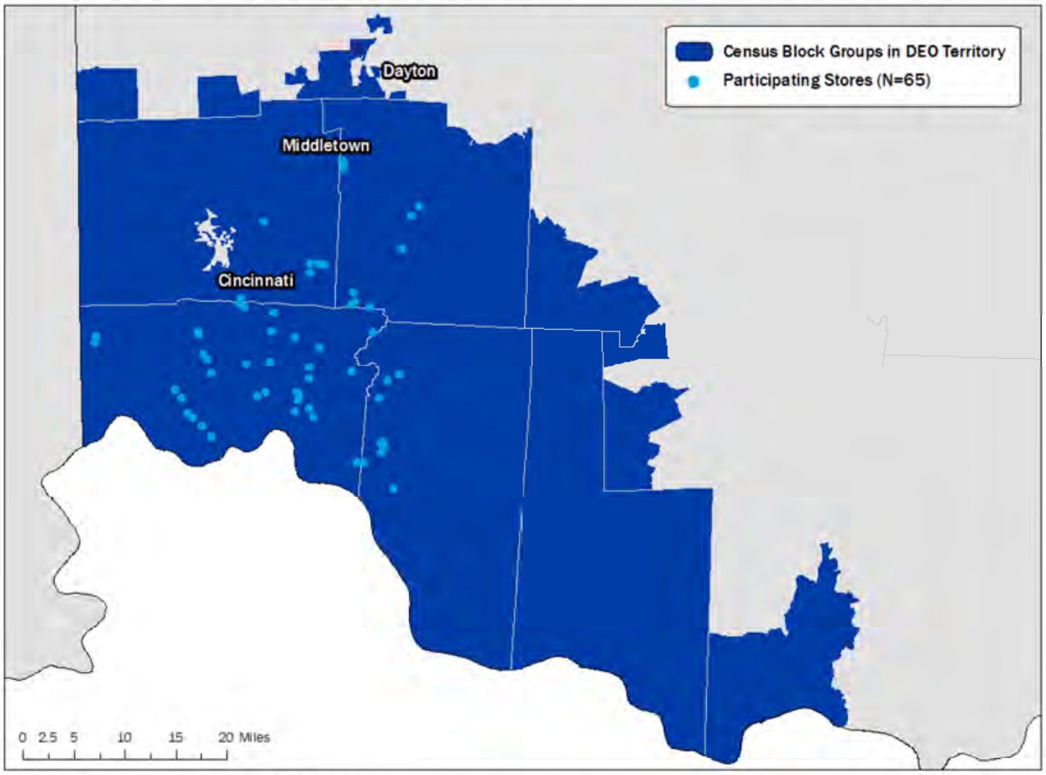
$$Leakage = 1 - \left(\frac{Duke\ Energy\ Customers\ within\ Designated\ Store\ Radius}{Total\ Households\ within\ Designated\ Radius\ of\ Store}\right)$$

- Aggregated leakage rates for individual store locations, weighting by program sales volume, to calculate a final program-level leakage rate.

[5] The U.S. Census defines urban area as an area with the population of 50,000 or more, an urbanized cluster as an area with population between 2,500 and 50,000, and a rural area as areas that are not urban areas or urbanized clusters. It should be noted that a store's territory and the shopping patterns are likely to be influenced by a number of factors, including the type of store, the road network, and the population density of the area. It was not possible to consider all of these factors for this analysis.

Figure 4-1 presents a visual map of participating store locations in relation to DEO service territory borders.

Figure 4-1. Participating Store Locations in Relation to DEO Service Territory



Source: Opinion Dynamics GIS analysis.

Leakage data analysis relied on sales data from the entire period under evaluation rather than a sample of the program sales records. Because no sampling was conducted, the concept of sampling error does not apply, so there is no estimate of precision for the resulting leakage rate estimates.

4.5 Commercial Hours of Use and Coincidence Factor Estimation

To determine hours of use (HOU) and coincidence factors for the commercial share of program sales, Opinion Dynamics relied on the commercial HOU study completed as part of the 2018 DEO Non-Residential Prescriptive program evaluation. The evaluation team designed the study to develop a coincidence factor estimated to support the bidding of demand savings from Duke Energy's programs into PJM's forward capacity markets. As such, the analytical efforts for the study included estimation of summer and winter peak coincidence factors using PJM definition of the peak periods. Opinion Dynamics used the lighting logger data collected through the study and analyzed it to develop HOU estimates and CF estimates using the following definitions of summer and winter peak periods:

- Summer: non-holiday weekdays 1 pm through 5 pm
- Winter: non-holiday weekdays 6 am through 8 am and 5 pm through 7 pm

We provide a summary of the study design and sample sizes in Appendix A.

We used lighting usage data collected over the study's metering period and calculated, for each logger, HOU and coincidence factors. We aggregated the HOU and CF results across individual loggers in stages. First, we aggregated individual loggers to space-type estimates within each facility in the sample, weighting the results by fixture count associated with each logger. We then weighted space type-level estimates to the individual facility level using total fixture counts across space types as the weighting parameter. Finally, we aggregated facility-level estimates to the overall estimates by applying facility fixture weights.

We used a common method of estimating sampling for lighting logger studies, which does not fully account for the 3-stage cluster sample design, though relative precision would be somewhat higher if it did. Conversely, the study very nearly achieved a within-site census of switches, which would produce site-level standard errors of zero and have a compensatory effect on precision. We used the following equation to estimate sampling error based on the study sample size, an assumed or empirically determined coefficient of variation, and a 90% confidence level:

Equation 4-2. Commercial HOU and CF Relative Precision Formula

$$e = \sqrt{\frac{z^2 cv^2}{n}}$$

Where:
- e=sampling error
- z=confidence level (1.28 for 90% one-tailed confidence level)
- cv=observed population coefficient of variation
- n=sample size

Table 4-2 summarizes achieved relative precision across all metrics.

Table 4-2. Standard Error and Relative Precision at 90% Confidence

Parameter	Standard Error	Relative Precision
HOU	0.585	5.2%
Summer CF	0.029	6.3%
Winter CF	0.033	8.8%

Source: Opinion Dynamics analysis of data collected by the 2018 DEO Commercial Light Logger Study

4.6 Impact Analysis

To estimate ex post gross and net program savings, the evaluation team conducted an engineering analysis using the recommended savings assumptions outlined in our deemed savings review.

4.7 Sales Data Modeling

The goal of the sales data modeling was to develop a NTG estimate. As part of this research activity, we first carefully reviewed the DEO program sales data to establish presence of the necessary price variation to ensure the modeling could be performed. We did not find sufficient variation for modeling purposes. Therefore, we did not perform the modeling.

4.8 Retailer and Manufacturer Interviews

Opinion Dynamics staff conducted in-depth interviews with corporate-level retailer and manufacturer contacts to obtain an estimate of NTG in the absence of the required price variation for sales data modeling. In addition, as part of the interview, we explored retailer and manufacturer perspectives on the state of the market and future trends.

The sample frame included a total of 22 corporate-level contacts from manufacturers and retailers producing and selling program-discounted products supplied to us by the program team. We drew a purposeful sample of 18 individuals with consideration of geographic and retail channel coverage while attempting to maximize representation of total program sales. We conducted interviews with 11 contacts from retailers and manufacturers, representing 72% of total program sales volume. Table 4-3 provides a summary of the retailer and manufacturer interviews.

Table 4-3. Retailer and Manufacturer Interview Fielding Summary

Sample Frame	Sample	Completed Interviews [a]	Percent of Program Sales
22	18	11	72%

Source: Opinion Dynamics analysis of retailer and manufacturer interview data.
[a] We spoke with 11 contacts, 9 of whom provided feedback to inform NTG estimates.

As described above, retailer and manufacturer interviews made use of a purposive sampling approach. As a non-probability sampling method, the concept of sampling error does not apply, so there is no estimate of precision for the resulting estimates, including NTG.[6]

5. Gross Impact Evaluation

This section describes the methodology the evaluation team used to conduct the gross impact analysis and the results of the analysis.

The evaluation team completed the following activities as part of the gross impact analysis:

- Reviewed program tracking data and ex ante savings values for accuracy, completeness, and consistency
- Reviewed and compiled appropriate ex post assumptions based on recent Indiana-specific research
- Conducted engineering analysis to develop estimates of ex post gross energy and demand savings

5.1 Methodology

As part of the impact evaluation, the evaluation team conducted a deemed savings review of ex ante savings assumptions and program tracking data. To compare the savings assumptions, assess their reasonableness, and develop recommendations for changes where appropriate, we reviewed past evaluations of other Duke Energy residential lighting programs, the Ohio Technical Reference Manual (TRM), and evaluation reports and

[6] There may be other sources of uncertainty, such as measurement error, that are associated with these interviews and all the NTG methods. It is not possible to quantify these errors like we can sampling error. We discuss these other research limitations throughout this report.

TRMs from other jurisdictions. As part of the review process, we also checked the program sales data for accuracy, consistency, and completeness.

We estimated gross ex post savings using the recommended approach in the Uniform Methods Project (UMP) protocols. Per the UMP protocols, savings calculations account for leakage, sales to residential and commercial customers, baseline wattages, actual bulb wattages, ISR, lighting operation (HOU and CFs), and interactive effects. These equations and all recommended savings parameters are detailed below. We reviewed program sales data and corrected any inconsistencies in product categorization or bulb specifications prior to calculating ex post gross savings.

5.1.1 Review of Program Tracking Data for Completeness and Consistency

Opinion Dynamics analyzed the program sales data for any gaps and inconsistencies. As part of the analysis, we performed the following steps:

- Checked the core data fields for missing values
- Checked the data for temporal gaps (due to missing invoices, transactions, etc.) by reviewing variation in monthly invoiced sales
- Verified consistency of product categorization for each product, cross-checked these categories with detailed measure descriptions, and corrected any inconsistent product categories based on available information from the ENERGY STAR or retailer websites
- Cross-checked wattages, lumen outputs, incandescent equivalent wattages, and detailed measure description data fields for consistency and accuracy and corrected inconsistent values
- Checked pack size and rebate information for outliers or unreasonable values

Opinion Dynamics identified and corrected slight inconsistencies in bulb categorizations and specifications. None of the inconsistencies were widespread, nor did they result in a significant difference in savings.

5.1.2 Recommended Savings Assumptions

In this section, we provide an overview of the savings assumptions applied to estimate ex post gross savings for each program. We chose savings parameters that meet the following criteria, where possible:

- Assumptions based on Indiana-specific research
- Assumptions based on the most recent available research and analysis
- Savings assumptions specific to LEDs

We relied on a standard equation to estimate program savings and estimated savings attributable to the residential vs. commercial installations separately. The equation incorporates baseline wattages, actual bulb wattages, ISR, lighting operation (HOU and CFs), and interactive effects. Equation 5-1 provides the formula that we used to estimate energy savings, while Equation 5-2 provides the formula for demand savings. These formulas are standard and are routinely used to estimate savings for lighting programs.

Equation 5-1. Annual Energy Savings

$$\Delta kWh = \left[Bulbs * \%Res * (1 - Leakage) * \left[\frac{(Watts_{base} - Watts_{ee})}{1{,}000} * ISR_{res} * HOU_{res} * HVACe_{res}\right]\right] + \left[Bulbs * \%Com * (1 - Leakage) * \left[\frac{(Watts_{base} - Watts_{ee})}{1{,}000} * ISR_{com} * HOU_{com} * HVACe_{com}\right]\right]$$

Equation 5-2. Annual Demand Savings

$$\Delta kW = \left[Bulbs * \%Res * (1 - Leakage) * \left[\frac{(Watts_{base} - Watts_{ee})}{1{,}000} * ISR_{res} * CF_{res} * HVACd_{res}\right]\right] + \left[Bulbs * \%Com * (1 - Leakage) * \left[\frac{(Watts_{base} - Watts_{ee})}{1{,}000} * ISR_{com} * CF_{com} * HVACd_{com}\right]\right]$$

Where:

- ΔkWh = First-year electric energy savings
- ΔkW = Electric peak demand savings
- Bulbs = Bulb quantity
- %Res = Portion of bulbs purchased for residential application
- %Com = Portion of bulbs purchased for commercial application
- $Watts_{base}$ = Baseline wattage
- $Watts_{ee}$ = Efficient bulb wattage
- ISR = In-service rate
- HOU = Annual hours of use
- CF = Peak coincidence factor
- HVACe = Cooling and heating interactive effects for energy
- HVACd = Cooling and heating interactive effects for demand
- Res = Residential values
- Com = Commercial values

Table 5-1 presents the sources of savings assumptions used to calculate program ex post gross energy and demand savings.

Table 5-1. Ex Post Savings Assumption Sources

Assumption	Source of Residential Assumptions	Source of Commercial Assumptions
Sales to residential/ commercial customers	Illinois TRM (V7.0)	
Leakage rate	2019 GIS analysis	
Baseline wattage	Minimum efficiency baseline adjusted for EISA and DOE Energy Conservation Standards	
Replacement wattage	Actual product wattage	
HOU	2017 DEO Residential Lighting Logger Study	2018 DEO Commercial Lighting Logger Study

Assumption	Source of Residential Assumptions	Source of Commercial Assumptions
First-year ISR and future installation rate trajectory	2017 DEO Online Store Participant Survey	2018 DEO Commercial Lighting Logger Study
Interactive effects	2015 DEO Online Store Program Evaluation	No interactive effects applied
Coincidence factor (summer and winter)	2017 DEO Residential Lighting Logger Study	2018 DEO Commercial Lighting Logger Study

Source: Opinion Dynamics analysis and secondary research.
Note: Commercial HOU and coincidence factors were developed as part of the current evaluation using logger data from prior research conducted with DEO Non-Residential Prescriptive program participants.

Table 5-2 provides the savings assumptions used to calculate ex post gross savings. Following the table, we provide greater detail on each assumption.

Appendix M contains a detailed overview of the ex ante savings assumptions and their sources.

Table 5-2. Ex Post Savings Assumption Values

Assumption	Residential Assumptions	Commercial Assumptions
Sales to residential/ commercial customers	97.0%	3.0%
Leakage rate	0.0%	
Baseline wattage	Minimum efficiency baseline adjusted for applicable federal standards in place during the evaluation period	
Replacement wattage	Actual product wattage	
HOU	2.43	14.43
ISR_{YR1}	79.3% (bulbs) 100% (fixtures)	100%
Interactive effects	0.994 (energy) 1.167 (summer peak demand) 1.0 (winter peak demand)	1.0
Summer CF	0.11	0.76
Winter CF	0.16	0.61

Source: Opinion Dynamics analysis and secondary research.

Sales to Commercial Customers and Leakage

Because all sales of program-discounted lighting products take place at retail locations, customers can purchase them for use in both residential and non-residential settings. Due primarily to the higher operating hours, the savings from lighting products installed in commercial settings are higher than residential savings. We relied on the recommended values from the most recent version of the Illinois TRM (V7.0) for estimates of the portion of program sales installed in residential versus commercial locations. The Ohio TRM does not address sales to commercial customers. To our knowledge, an Indiana-specific estimate of program sales split between residential and commercial customers does not exist. The Illinois TRM offers an estimate based on recent primary research conducted in the Midwest and is the best available estimate for the purposes of our evaluation. Table 5-3 summarizes the applied values.

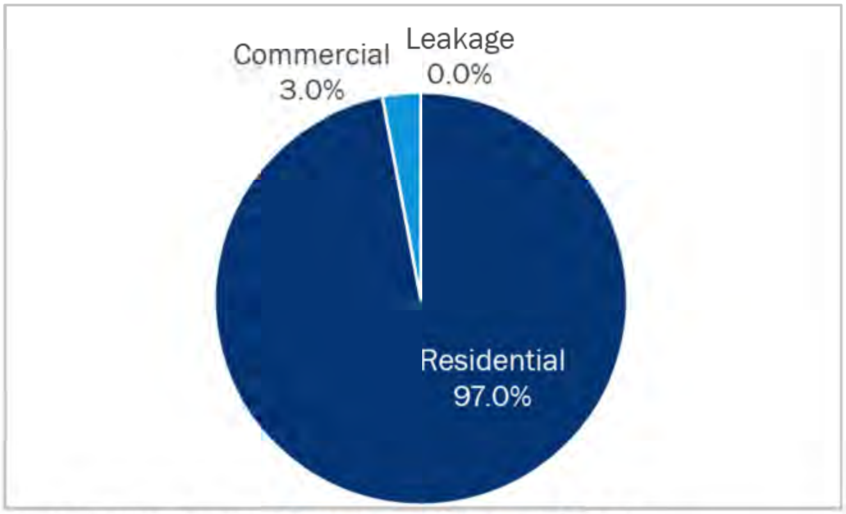
Table 5-3. Program Sales to Residential and Commercial Sector

Sector	Percent of Program Sales
Residential	97%
Commercial	3%

Source: Illinois TRM (V7.0)

The overall leakage rate is 0% for the DEO Retail Lighting program. Figure 5-1 provides a visualization of the resulting distribution of program bulb applications in residential customer homes and commercial customer facilities in the absence of any leakage identified by the GIS analysis.

Figure 5-1. Program Leakage and Application by Sector



Source: Opinion Dynamics GIS analysis and Illinois TRM (V7.0)

Baseline Wattages

We used the minimum efficiency baseline approach to determine baseline wattages for program-discounted products for both programs (in both residential and commercial settings). Minimum efficiency standards in the market vary by product type based on federal standards. Below we detail the methods we used to calculate baseline wattages for each product type.

Standard Products

Baseline wattages for standard LEDs are assigned based on lumen outputs and account for EISA efficiency standards in place throughout the evaluation period. Table 5-4 lists the baseline wattages as they were applied to calculate 2019 verified savings for standard LEDs.

Table 5-4. Baseline Wattages for Standard Products

Lumen Range		Baseline Wattage
Lower	Upper	
250	309	25
310	749	29
750	1,049	43

Lumen Range		Baseline Wattage
Lower	Upper	
1,050	1,489	53
1,490	2,600	72
2,601	2,999	150
3,000	5,279	200
5,280	6,209	300

Source: Opinion Dynamics analysis.

Reflector Products

To determine baseline wattages for floodlights and reflector bulbs and fixtures, the evaluation team relied on the approach established by the Navigant Consulting team during its PY2013 evaluation of the DEP EEL program. Baselines were assigned based on a combination of maximum allowable wattage and the available information for replacement bulbs regarding wattage and lumen output. We accounted for higher efficiency standards introduced by the DOE Energy Conservation Standards for some incandescent reflector lamps that went into effect in July 2012. We deemed this approach reasonable given the complexities associated with assigning baseline wattages to reflector products, which include a non-linear lumen-to-watt ratio, a variety of bulb shapes and sizes of varying efficacies, and the discrepancy between maximum allowable wattages and product availability on store shelves. Table 5-5 lists the baseline wattages as they were applied to calculate 2019 verified savings for reflector bulbs and fixtures.

Table 5-5. Baseline Wattages for Reflector Products

Bulb Type	Lumen Range		Baseline Watts
	Lower End	Upper End	
R, PAR, ER, BR, BPAR, or similar bulb shapes with medium screw bases with diameter >2.5" (*see exceptions below)	400	599	45
	600	739	50
	740	849	50
	850	999	55
	1,000	1,300	65
*ER30, BR30, BR40, ER40	400	449	40
	450	499	45
	500	1,419	65
*R20	400	449	40
	450	719	45
*All reflector lamps below the lumen ranges specified above	200	299	30
	300	399	40

Source: Opinion Dynamics analysis.

Specialty Products

Neither EISA nor DOE Energy Conservation standards for incandescent reflector lamps affect other specialty products, such as three-way bulbs, candelabra bulbs, and globe bulbs. As such, we used incandescent equivalent wattage as the baseline for these specialty products.

Replacement Wattage

For the replacement wattage, we used the actual bulb wattage associated with each discounted lighting product. We compared the listed wattage to lumen outputs and measure descriptions where possible to ensure that the most accurate wattage was applied.

Hours of Use and Coincidence Factors

Light metering studies are the industry standard to estimate HOU and CFs. For the residential share of program LEDs, the Evaluation Team used HOU and CF values derived through the 2017 Duke Energy Ohio (DEO) Residential LED Light Logger study to support savings for LED products, which is Ohio-specific and has the added benefit of being recent and LED-specific. Table 5-6 provides LED HOU and CF estimates from the study.

Table 5-6. Residential HOU and CF Assumptions

Statistic	Value
HOU	2.43
Summer CF	0.11
Winter CF	0.16

Source: 2017 DEO Residential Light Logger Study

On the commercial side, we applied commercial HOU and CF estimates developed as part of this evaluation using data collected as part of the 2018 DEO Non-Residential Prescriptive program evaluation. Similar to the residential HOU and CFs, which is Ohio-specific and has the added benefit of being recent and LED-specific. Table 5-7 provides recommended HOU and CF assumptions for the commercial share of program sales.

Table 5-7. Commercial HOU and CF Assumptions

Statistic	LED
HOU	14.43
Summer CF	0.76
Winter CF	0.61

Source: Opinion Dynamics analysis of data collected by the 2018 DEO Commercial Light Logger Study

First-Year In-Service Rate and Future Savings

First-year ISR varies by technology, application, and jurisdiction. For residential installations, we relied on the results from the 2017 DEO Online Store Participant survey. For commercial savings, we relied on the results of the 2018 DEO Smart $aver Prescriptive program evaluation. For lighting fixtures, we applied a first-year ISR of 100% for both residential and commercial sectors and across both programs. It is highly unlikely that customers who purchase lighting fixtures do not install them right away. Table 5-8 summarizes the first-year ISRs used in the impact analysis.

Table 5-8. First-Year In-Service Rates

Application	Bulbs	Fixtures
Residential	79.3%	100.0%
Commercial	100%	100.0%

Source: 2017 DEO Online Store and 2018 DEO Smart $aver Prescriptive evaluations

Although the first-year ISR is less than 100% for bulbs in residential applications, research studies across the country have found that customers continue to install bulbs from storage year over year. The two main approaches to claiming savings from these later installations are: (1) staggering the savings over time and claiming some in later program years and (2) claiming the savings from the expected installation in the program year the product was sold but discounting the saving by a societal or utility discount rate. While the "staggered" approach allows program administrators to more accurately capture the timing of the realized savings, the "discounted savings" approach allows for the simplicity of claiming all costs and benefits during the program year and eliminates the need to keep track of and claim savings from future installations.

Opinion Dynamics used the discounted savings approach to claim savings from future installations. To allocate installations over time, we relied on the trajectory recommended by the Uniform Methods Project by which bulbs are installed from storage at a rate of 24% per year after the first year of purchase. Table 5-9 outlines the approach to calculating incremental and cumulative installations over the five years following purchase.

Table 5-9. Installation Rate Trajectory Formulas

Year	Incremental ISR	Cumulative ISR
Year 1	Year 1 ISR	Year 1 ISR
Year 2	(1 – Year 1 ISR) * 24%	Year 1 ISR + Year 2 ISR
Year 3	(1 – Year 1 ISR – Year 2 ISR) * 24%	Year 1 ISR + Year 2 ISR + Year 3 ISR
Year 4	(1 – Year 1 ISR – Year 2 ISR – Year 3 ISR) * 24%	Year 1 ISR + Year 2 ISR + Year 3 ISR + Year 4 ISR
Year 5	(1 – Year 1 ISR – Year 2 ISR – Year 3 ISR – Year 4 ISR) * 24%	Year 1 ISR + Year 2 ISR + Year 3 ISR + Year 4 ISR + Year 5 ISR
Year 6	(1 – Year 1 ISR – Year 2 ISR – Year 3 ISR – Year 4 ISR – Year 5 ISR) * 24%	Year 1 ISR + Year 2 ISR + Year 3 ISR + Year 4 ISR + Year 5 ISR + Year 6 ISR

Source: Uniform Methods Project (UMP) Lighting Evaluation Protocols.

To claim savings from future installations of current sales, we discounted all future savings by the utility-specified discount rate using the net present value (NPV) formula (Equation 5-3). Program staff provided discount rates for each utility.

Equation 5-3. Net Present Value Formula

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

Where:

R = savings
t = number of years in the future savings take place
i = discount rate

Table 5-12 provides NPV-adjusted ISRs by sector and bulb type.

Table 5-10. Final NPV-Adjusted In-Service Rates

Year	DEO	
	LEDs	Fixtures
Residential	92.2%	100.0%
Commercial	100%	100.0%

Source: Opinion Dynamics analysis.

Interactive Effects

LEDs emit less heat than incandescents, resulting in increased heating loads as more energy is needed to supplement heat emitted by incandescent light bulbs. Efficient bulbs also decrease cooling loads as less energy is required to compensate for heat given off by incandescents. The application of interactive effects accounts for the changes in heating and cooling loads in the estimation of savings.

For the residential share of program sales, the evaluation team used the U.S. Department of Energy (DOE)-2.2 simulation of prototypical residential buildings as presented in 2012 TecMarket Works evaluation of the DEO Residential Smart $aver Energy Efficiency Products program. These interactive effects are adjusted using customer-specific HVAC system information collected through Duke Energy's appliance saturation survey in Ohio. As such, these values more accurately represent the participant population than the deemed values in the Ohio TRM, which do not take into account the specifics of the DEO heating and cooling system specifics. The interactive effects in this simulation are for CFLs. We are unaware of any existing modeling or simulation efforts to estimate LED-specific interactive effects. While interactive effects caused by LEDs are likely to be somewhat different than those caused by CFLs, the difference between CFL and LED interactive effects is, in our professional judgment, unlikely to have more than a marginal impact on energy and peak demand savings. Given the small anticipated difference in energy and peak demand savings estimates due to LED-specific interactive effects and the relatively high cost of conducting modeling and simulation to estimate those interactive effects, we use CFL interactive effects from the 2012 DEO Residential Smart $aver Energy Efficiency Products program evaluation to estimate savings for LED products.

For the commercial share of sales, we applied an interactive factor of 1. In the absence of a reliable interactive effects estimate and given the anticipated small impact of lighting products on commercial heating and cooling loads given the nature of commercial-scale HVAC systems, not applying interactive effects is both reasonable and appropriate. Table 5-11 provides the interactive effects applied when estimating ex post energy and demand savings.

Table 5-11. Interactive Effects

Interactive Effect	Residential Share	Commercial Share
Interactive effects for energy (HVACe)	0.994	1.0
Interactive effects for summer peak demand (HVACd – Summer)	1.167	1.0
Interactive effects for winter peak demand (HVACd – Winter)	1.0	1.0

Source: 2012 DEO Residential Smart $aver Energy Efficiency Products program evaluation.

5.2 Gross Impacts Results

This section presents the results of the gross impact analysis for the DEO Retail Lighting program.

5.2.1 Review of Program Tracking Data and Ex Ante Savings

As a first step in the gross impact analysis, the evaluation team analyzed the program sales data for any gaps, inconsistencies, and inaccuracies. We found that data fields were generally clean and fully populated, with very minor exceptions, and we did not identify any observable gaps between invoice dates and found the data to be complete and reasonable. Opinion Dynamics identified and corrected slight inconsistencies in bulb categorizations, bulb wattage, and lumen assignments. None of the inconsistencies were widespread or resulted in a significant difference in savings.

Ex ante savings were not available as part of the program tracking data extracts. We received per-bulb ex ante savings values based on bulb type in a spreadsheet with DSMORE outputs (referred to as DSMORE Outputs throughout the remainder of this memo). We also received a spreadsheet with assumptions used to calculate ex ante savings (referred to as Assumptions Spreadsheet throughout the remainder of this memo). We reviewed both and found the following:

- Ex ante gross energy and summer peak demand savings from the DSMORE outputs did not align with per-unit deemed savings in the Assumptions Spreadsheet
- Winter peak demand savings were not included in the Assumptions Spreadsheet
- Several of the savings parameters in the Savings Assumptions spreadsheet are from unknown sources, including in-service rate, hours of use for certain products, and net-to-gross ratio

Table 5-13 provides the savings assumptions listed in the DSMORE Outputs, which the evaluation team used to calculate ex ante savings.

Table 5-12. Ex Ante Gross Per-Bulb Savings by Product Category

Product Category	Ex Ante Gross Per-Bulb Savings		
	Energy (kWh)	Summer Peak (kW)	Winter Peak (kW)
Standard A-Line	50.65	0.0049	0.0093
Reflector Outdoor	118.68	0.0108	0.0260
Reflector Recessed	43.54	0.0040	0.0096
Reflector Track	22.85	0.0021	0.0050
3-Way	44.11	0.0040	0.0097
Candelabra	18.12	0.0016	0.0040
Globe	17.67	0.0016	0.0039
Fixture	36.84	0.0033	0.0081

Source: DSMore Outputs provided by program staff.

5.2.2 Ex Post Gross Savings

Following program tracking data review, the evaluation team calculated ex post gross energy and peak demand savings achieved by the DEO Retail Lighting program during the evaluation period. The program achieved 17,856,244 kWh in ex post gross energy savings, 2,596 kW in ex post gross summer peak demand savings, and 3,046 kW in ex post gross winter peak demand savings. The respective gross realization rates are 93% for energy savings, 146% for summer peak demand savings, and 76% for winter peak demand savings. Table 5-14 presents the results of the analysis.

Table 5-13. Ex Post Gross Savings Summary

	Ex Ante	Ex Post Gross			Gross Realization Rate
		Residential	Commercial	Total	
Energy savings (kWh)	19,211,901	14,888,534	2,967,710	17,856,244	93%
Summer peak demand savings (kW)	1,783	2,168	428	2,596	146%
Winter peak demand savings (kW)	4,020	2,702	344	3,046	76%

Source: Opinion Dynamics analysis of program tracking data.
Note that subtotals may not sum exactly due to rounding.

5.3 References

Department of Energy (DOE). 10 CFR Part 430. Energy Conservation Program: Energy Conservation Standards and Test Procedures for General Service Fluorescent Lamps and Incandescent Reflector Lamps; Final Rule. July 14, 2009. http://www.regulations.gov/#!documentDetail;D=EERE-2006-STD-0131-0005.

Illinois Energy Efficiency Stakeholder Advisory Group (SAG). *2019 Illinois Statewide Technical Reference Manual for Energy Efficiency Version 7.0*. September 28, 2018.

National Renewable Energy Laboratory (NREL). *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures. Chapter 6: Residential Lighting Protocol.* October, 2017. https://www.nrel.gov/docs/fy17osti/68562.pdf.

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

Opinion Dynamics. *Duke Energy Ohio Energy Efficient Appliances and Devices Program Final Evaluation Report*. Prepared for Duke Energy. September 11, 2018.

Opinion Dynamics. *Duke Energy Ohio Non-Residential Smart $aver® Prescriptive Program Evaluation Report*. Prepared for Duke Energy. December 7, 2018.

Opinion Dynamics. *Duke Energy Ohio Smart $aver Residential Program Final Evaluation Report*. Prepared for Duke Energy. November 10, 2015.

TecMarket Works. *Process and Impact Evaluation of the Residential Smart $aver Energy Efficiency Products (CFL) Program in Ohio.* Prepared for Duke Energy Ohio. September 28, 2012.

Vermont Energy Investment Corporation. *State of Ohio Energy Efficiency Technical Reference Manual.* Prepared for the Public Utilities Commission of Ohio. August 6, 2010.

6. Net-to-Gross Analysis

This section describes our approach for estimating NTG and presents the resulting NTG and net impacts.

6.1 Methodology

Net-to-gross (NTG) represents the portion of the gross energy savings associated with a program-supported measure or behavior change that would not have been realized in the absence of the program. In other words, the NTG represents the share of gross savings that are attributable to the program. The NTG consists of free-ridership (FR) and spillover (SO) and is calculated as $(1 - FR + SO)$. FR is the proportion of the program-achieved verified gross savings that would have been realized absent the program. SO represents additional energy-saving actions that are influenced by program interventions but did not receive program support. Sales data modeling only produces an estimate of FR.

The assessment of NTG for upstream residential lighting programs is especially challenging for the following reasons:

- Because customers purchase discounted bulbs in a retail setting where they do not need to provide contact information, there is no list of participants with whom we can conduct a follow-up self-report NTG survey (i.e., customers who purchased discounted bulbs through the program). Because light bulbs are a low-cost commodity product, most customers do not put extensive thought into or have reliable recall of their purchase decision. Customers may not even be aware that they purchased discounted bulbs. Therefore, we cannot conduct a general population survey in which we ask customers about their past light bulb purchases and the influence of program discounts on those purchases.
- Although we have detailed data regarding sales for the bulbs associated with the program, we lack any information about sales of other bulbs sold at the same retailers (including less efficient and

non-discounted products). Thus, while we can successfully model the relationship between bulb price and sales for the products associated with the program, we cannot take into consideration how other factors (e.g., discounts of non-program bulbs) may have affected our results.

- Program interventions (i.e. discounts on select products, marketing materials, field representative engagement) may affect manufacturer supply chains and retailer stocking practices, resulting in shelf space changes. Those changes are not visible to participants and therefore call for research with a range of market actors and, ultimately, triangulation of NTG estimates from multiple sources.

To understand counterfactual customer behaviors and develop estimates of program NTG, the evaluation team relied on interviews with retailer and manufacturer representatives. Opinion Dynamics staff conducted 11 in-depth interviews with corporate-level retailer and manufacturer contacts. Of those interviews, nine informed NTG estimates for the Retail Lighting program, and two provided process feedback but declined to give quantitative estimates relating to NTG. The nine interviews yielded feedback from retailers and manufacturers that account for 72% of total program sales.

We asked each interviewee to estimate the percentage by which the sales of efficient bulbs would be different in the absence of the program for each bulb category. Respondents who said that sales of energy-efficient products would have decreased received a follow-up question asking to estimate the percent that would have shifted to other energy-efficient products. The percentage of energy-efficient bulb sales expected to move to non-energy-efficient products in the program's absence represents the NTG for the respondent. To the degree possible, we asked the NTG questions for each major program-discounted product type, namely, standard, reflector, and specialty bulbs and fixtures. As part of the interview guide, we embedded a range of validation questions to check responses for consistency and asked respondents to provide their rationale for the reported percent change in sales in the absence of the program.

As part of the NTG analysis, we estimated NTG for each product category discussed with each respondent, which we then aggregated, weighting by program sales volume, to produce estimates for each retail channel. As part of the analysis and aggregation process, a single manufacturer could contribute to the NTGs across several retail channels, as long as that manufacturer was supplying its product to those retail channels.

6.2 NTG Results

Using the results from the retailer and manufacturer interviews, the evaluation team estimated NTG rates by retailer channel. Dollar and discount stores received the highest NTG of 100%, while NTG for other retail channels range from 16% for DIY stores to 28% for big box stores. Retailer and manufacturer contacts often anticipated a sizeable portion of customers would look to cheaper non-ENERGY STAR LEDs in the absence of program discounts. The NTG of 100% for the dollar/discount channel reflects feedback from interviewees that availability of energy-efficient lighting products these stores is solely dependent on the Retail Lighting program. Customers who shop at these stores, in turn, are likely to be price-sensitive and, in the absence of the energy-efficient products offered through the program, are assumed to purchase the lowest-cost alternative on the market (i.e., an incandescent or halogen product).

Opinion Dynamics aggregated NTGs across retail channels, weighting by program sales volume. The resulting program-level NTG is 30% (Table 6-1).

Table 6-1. Retailer and Manufacturer Interview NTG Results

Retailer Channel	Percent of Program Sales	NTG
Dollar/discount	14%	100%
All other	86%	18%
DIY	*73%*	*16%*
Big box	*10%*	*28%*
Hardware	*3%*	*25%*
Total	**100%**	**30%**

Source: Retailer and manufacturer interviews.

6.3 Net Impact Results

The evaluation team applied the program-level NTG rate to ex post gross energy and peak demand savings to arrive at ex post net savings (Table 6-2). Program net energy savings for the DEO Retail Lighting program during the evaluation period total 5,356,873 kWh, net summer peak demand savings were 779 kW, and net winter peak demand savings were 914 kW.

Table 6-2. Ex Post Net Savings Summary

Savings Type	Ex Ante Savings	Ex Post Gross Savings	NTG	Ex Post Net Savings	Net Realization Rate [a]
Energy savings (kWh)	19,211,901	17,856,242	30%	5,356,873	39%
Summer peak demand savings (kW)	1,783	2,596	30%	779	61%
Winter peak demand savings (kW)	4,020	3,046	30%	914	32%

[a] Denominator is ex ante net savings.
Source: Opinion Dynamics analysis of program tracking data.

7. Program-Level Impacts for Regulatory Compliance

In the state of Ohio, electric distribution utilities (EDUs), including DEO, are required to achieve a cumulative annual energy savings of more than 22% by 2027 per Ohio Senate Bill (SB) 310. SB 310 also introduced new mechanisms that adjust how EDUs may estimate their energy savings achieved through demand-side management programs. Specifically, SB 310 requires the Ohio Public Utilities Commission (PUCO) to permit EDUs to account for energy-efficiency savings estimated on an "as-found" or a deemed basis. That is, an EDU may claim savings based on the baseline operating conditions found at the installation location of the energy-efficiency measure, or the EDU may claim a deemed savings estimate.

To support compliance with SB 310, we developed a separate set of savings estimates. These estimates are based on the higher of ex ante and ex post savings values for each measure. We used the formula specified in the equation below to develop per-bulb gross impacts for SB 310 compliance. We used ex ante measure definitions that DEO uses for cost-effectiveness calculations in DSMORE.

Equation 7-1. Development of SB 310-Compliant Gross Savings Estimates

$$Sav_i = Max(ExAnte_i, ExPost_i)$$

Where:

Sav_i = Total annual savings for measure i

$ExAnte_i$= Per unit ex ante deemed gross savings estimate for measure i (kW or kWh)

$ExPost_i$= Per unit ex post deemed gross savings estimate for measure i (kW or kWh)

Table 7-1 provides per-bulb ex ante and ex post gross savings, as well as the per-bulb savings used to estimate savings claimable under SB 310.

Table 7-1. Per-Bulb Gross Savings Claimable Under SB 310

Measure	Ex Ante Gross Per-Bulb Savings			Ex Post Gross Per-Bulb Savings			Gross Per-Bulb Savings Claimable Under SB 310		
	kWh	Summer Peak kW	Winter Peak kW	kWh	Summer Peak kW	Winter Peak kW	kWh	Summer Peak kW	Winter Peak kW
A-Line	50.65	0.0049	0.0093	41.37	0.0060	0.0071	50.65	0.0060	0.0093
Reflector Outdoor	118.68	0.0108	0.0260	46.96	0.0068	0.0080	118.68	0.0108	0.0260
Reflector Recessed	43.54	0.0040	0.0096	50.89	0.0074	0.0087	50.89	0.0074	0.0096
Reflector Track	22.85	0.0021	0.0050	38.18	0.0056	0.0065	38.18	0.0056	0.0065
3-Way	44.11	0.0040	0.0097	67.49	0.0098	0.0115	67.49	0.0098	0.0115
Candelabra	18.12	0.0016	0.0040	27.85	0.0040	0.0047	27.85	0.0040	0.0047
Globe	17.67	0.0016	0.0039	33.33	0.0048	0.0057	33.33	0.0048	0.0057
Fixture	36.84	0.0033	0.0081	39.75	0.0058	0.0068	39.75	0.0058	0.0081

Table 7-2 provides per-bulb gross and net savings claimable under SB 310. We calculated net savings by multiplying gross savings claimable under SB 310 by the NTG of 30% developed through this evaluation.

Table 7-2. Per-Bulb Gross and Net Savings Claimable Under SB 310

Measure	Gross Per-Bulb Savings Claimable Under SB 310			NTG	Net Per-Bulb Savings Claimable Under SB 310		
	kWh	Summer Peak kW	Winter Peak kW		kWh	Summer Peak kW	Winter Peak kW
A-Line	50.65	0.0060	0.0093	30%	15.20	0.0018	0.0028
Reflector Outdoor	118.68	0.0108	0.0260	30%	35.61	0.0032	0.0078
Reflector Recessed	50.89	0.0074	0.0096	30%	15.27	0.0022	0.0029
Reflector Track	38.18	0.0056	0.0065	30%	11.45	0.0017	0.0020
3-Way	67.49	0.0098	0.0115	30%	20.25	0.0029	0.0035
Candelabra	27.85	0.0040	0.0047	30%	8.35	0.0012	0.0014
Globe	33.33	0.0048	0.0057	30%	10.00	0.0015	0.0017
Fixture	39.75	0.0058	0.0081	30%	11.92	0.0017	0.0024

8. Process Evaluation and Market Assessment

Opinion Dynamics relied on the following data collection and analytic activities to support evaluation of program processes and characterization of the lighting market in the DEO service territory:

- Program staff interviews
- Materials and program tracking data review
- Retailer and manufacturer interviews

Through our evaluation, we examined participating product and retailer mix and program incentive levels, documented program marketing and outreach, and explored market trends.

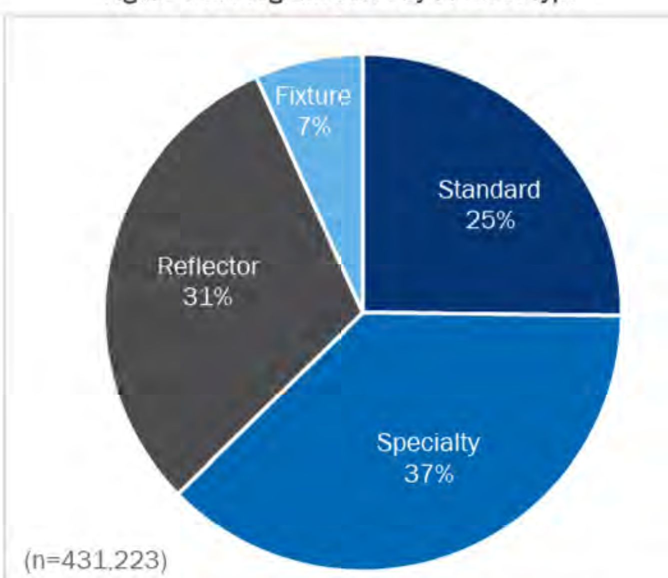
8.1 Key Findings

The sections below contain detailed processes and market assessment findings.

8.1.1 Product Mix

Over the course of the evaluation period, the DEO lighting program discounted 299 unique products across a range of bulb types and wattages. Program staff effectively managed this large portfolio of products, as evidenced by highly accurate and consistent program sales records. Reflector and specialty products accounted for more than two-thirds (68%) of all bulb sales during the evaluation period, while standard products represented 25% and fixtures made up the remaining 7% of all sales. Figure 8-1 summarizes the program's sales distribution of product types during the evaluation period.

Figure 8-1. Program Sales by Product Type



Source: Opinion Dynamics analysis of program tracking data.

Average program discounts ranged from $1.61 for specialty LEDs to $8.03 for LED fixtures. Depending on the product category, the average discount as a percentage of the retail price (or MSRP) ranged from 42% for specialty products to 54% for reflector bulbs. The average program discount across all product categories was $2.70, which represents, on average, 42% of MSRP. Figure 8-2 provides an overview of the program discounts by product type over the course of the evaluation period. As can be seen in the figure, discounts on fixtures were higher than discounts on any other product, in part as a result of this bulb category being generally more expensive.

Figure 8-2. Pricing Summary by Bulb Type

Source: Opinion Dynamics analysis of program tracking data.

8.1.2 Participating Retailer Coverage

Table 8-1 provides a breakdown of participating storefronts and program sales across retail channels. Do-it-Yourself (DIY) stores captured nearly three-quarters of all program sales (73%). Sales through the dollar/discount and big box retail channels collectively made up just under one-quarter of program sales.

Table 8-1. Program Sales by Retail Channel

Retail Channel	Store Locations	Percent of Program Sales
DIY	21	73%
Dollar/discount	16	14%
Big box	19	10%
Hardware	9	3%
Total	**65**	**100%**

Source: Opinion Dynamics analysis of program tracking data.

8.1.3 Program Marketing and Outreach

Over the course of the evaluation period, the DEO Retail Lighting program relied on a range of marketing and outreach tactics:

- **In-store events and special promotions.** Implementer field staff performed a total of 43 in-store events and demonstrations from mid-2018 through May of 2019, with an average of 3.9 visits per month. During these events, Duke field staff promoted program products and discounts and educated customers about the benefits of energy-efficient lighting products
- **Store visits and POP marketing material placement.** Over the course of the evaluation period, field staff completed a total of 659 store visits, during which they checked for the presence and proper placement of program POP materials, updated materials as necessary, and checked for sufficient levels of inventory of program-discounted lighting products. The frequency of store visits varied by retailer based on sales volume. This enabled team members to concentrate their visits on stores that had higher sales volumes and that tended to discount more products
- **Community events.** Over the course of the evaluation period, Duke field staff completed 2 community events in which the program field representatives visited community centers to provide educational materials
- **Direct mail, mass media, and other marketing.** Other sources of program marketing included targeted bill inserts and email blasts

8.1.4 Retailer and Manufacturer Perspectives

In speaking with retailer and manufacturer contacts, we asked about their observations of lighting market trends in recent years and expectations for future shifts, especially in the context of continuing uncertainty surrounding federal regulations. We repeatedly heard from these industry representatives about how dramatic the shift towards LED products has been over the past few years and about the parallel shifts in consumer preferences as customer familiarity with LEDs continues to increase and LED prices continue to decline. Several interviewees however noted that customers prefer what is familiar to them and pointed out that there are pockets of consumers that still prefer traditional incandescent or halogen bulb technologies, especially older shoppers.

At the time we interviewed retailers and manufacturers, decisions on EISA 2020 rollback were yet to be made. Retailer and manufacturer staff described widespread uncertainty surrounding the implications of possible upcoming EISA legislation. In the absence of firm regulatory changes, none of those we interviewed indicated their company had made any sweeping changes in preparation for 2020, and most did not expect a resolution in the immediate future. One of the manufacturer contacts explained that they expected they would be allowed some sell-through or grace period after any new efficiency standard was confirmed and did not feel the need to make those adjustments preemptively. Two interviewees expressed concern over tariffs on Chinese imports and indicated those were a more immediate concern than possible increases in federal efficiency standards. If enacted, those tariffs would have meant changes in pricing of LEDs, likely upward and likely absorbed by customers.

When asked about the future of the lighting market, interviewees uniformly anticipated continued growth in LED market share but did not expect complete transformation of the specialty bulb market to occur for several years in the absence of increased efficiency standards.

8.1.5 Market Dynamics and Outlook

Over the last decade, the lighting market across the country has been undergoing rapid change. Sales of energy-efficient products, namely CFLs and LEDs, increased as their prices decreased dramatically. In the past few years, LEDs have quickly become commonplace across retail channels, and the subsequent increases in customer comfort and satisfaction has driven preferences for LEDs and adoption of the technology in residential applications.

As a result, the lighting market for the most frequently sold bulb shapes (A-Line and reflectors) is being rapidly saturated with LEDs. The following key indicators gathered from research and data collection efforts across the country illustrate the rate and scale at which these changes to the lighting market have occurred in recent years. While these indicators are not specific to Ohio, industry feedback and the findings themselves suggest the trends are similar across the country:

- **LEDs are the most prominent technology in the market for A-line bulbs.** Based on bulb shipment data compiled by the National Electrical Manufacturers Association (NEMA), at the beginning of Q3 2019, LEDs accounted for 71% of the A-line consumer lamp market, and CFLs accounted for an additional 4%. Halogens accounted for the remaining 25% percent of the A-line consumer market. NEMA's shipment data also shows a continuously declining volume of halogen A-line products relative to LEDs. Notably, A-line products are by far the most common and represent the largest share of all lighting product shipments and sales.[7]

- **Market share for energy-efficient lighting products has increased rapidly.** Results of analysis conducted by the Consortium for Retail Energy Efficiency Data (CREED) shows market share for energy-efficient bulbs increased from 43% in 2015 to 54% in 2018. Over this same period, LED market share increased dramatically from 19% to 51%.[8] A 2018 NEEA study corroborates these results, estimating an LED market share of 55% in 2018.[9]
  - LED market share was especially prominent for reflector products, reaching 73% in 2018 as compared with 54% for A-line products.
  - LED market share in non-program states reached 45%, as compared to 58% in aggressive program states.[10]

- **Saturation of lighting sockets with energy-efficient products has been growing steadily.** The 2019 Massachusetts Lighting Market Assessment Study, found that energy-efficient bulb saturation, including LEDs and CFLs, had reached 57%, and that LEDs were the most common replacement bulb, demonstrating that customers are increasingly favoring LEDs when purchasing new bulbs.[11]

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7 National Electrical Manufacturers Association. *LED A-line, Halogen, and CFL Lamp Shipments Decrease in Second Quarter 2019 Compared to First Quarter 2019.* https://www.nema.org/Intelligence/Indices/Pages/LED-A-line-Halogen-and-CFL-Lamp-Shipments-Decrease-in-Second-Quarter-2019-Compared-to-First-Quarter-2019.aspx

8 Consortium for Retail Energy Efficiency Data (CREED) Analysis. http://www.creedlighttracker.com/

9 Apex Analytics. Results of the 2018 Northwest Residential Lighting Long-Term Monitoring and Tracking Study. Prepared for Northwest Energy Efficiency Alliance (NEEA). August 20, 2019.

10 Aggressive program states are defined as those with at least $5 of program spending per household.

11 NMR Group Inc. 2018-19 Residential Lighting Market Assessment Study. Prepared for Electric and Gas Program Administrators of Massachusetts. March 29, 2019. http://ma-eeac.org/wordpress/wp-content/uploads/RLPNC_1810_LtgMarketAssessment_FINAL_2019.03.29.pdf

Multiple forces contributed to these shifts in the lighting market, including technological advances, existing and future codes and standards, and combined energy efficiency efforts at both state and federal levels. Utility energy efficiency programs specifically have clearly contributed to the widespread availability and adoption of energy-efficient light bulbs. By reducing the retail cost at the point of sale, as well as educating customers about the benefits of energy-efficient bulbs, including bulb longevity, utility programs have helped to remove key barriers to efficient bulb adoption – upfront cost and lack of knowledge. The impact of utility programs on the lighting market is evident through comparisons of efficient bulb sales in program states relative to non-program states. As noted above, the market share of efficient bulbs is higher in states with large utility-supported lighting programs compared to states without programs.

In addition to utility programs, federal codes and standards have helped advance energy-efficiency in the lighting marketplace. Namely, EISA legislation which took effect in two phases. Phase 1 increased efficiency standards for general service products over 2012, 2013, and 2014, making halogen a new baseline for EISA-affected lighting products. Phase 2 was to take effect on January 1, 2020, setting an efficiency standard of 45 lumens per watt across nearly all screw-based products commonly used in residential applications. However, through a series of rules and determinations issued over the course of 2019, DOE effectively rolled back the EISA standards, leaving halogens and incandescent technologies as the minimum efficiency standards. Legal challenges to this rollback are likely to follow, but the resolution of any legal challenges will take time and will be unlikely to happen until at least late 2020. Anticipated litigation and the 2020 presidential election may change the course of events, adding to the uncertainty of the federal standards.

In the face of this continued uncertainty surrounding the possibility of increased federal efficiency standards, retailer and manufacturer staff we spoke with uniformly indicated that no sweeping changes had been made in preparation for 2020, and most did not expect a resolution in the immediate future. In the meantime, utilities across the country continue to rely on the current federal standards to determine baseline products to inform energy savings calculations, in some cases applying mid-life adjustments to account for a possible future change in the efficiency of baseline products. Utilities exercise various degrees of caution when planning for the future of the lighting programs, with some continuing to offer programs and others scaling the programs down considerably.

The continued effectiveness and impact of the utility lighting programs in the rapidly transforming market with such uncertainty surrounding efficiency standards will require strategic program design, continuous monitoring of the market trends, and ongoing assessment of the codes and standards and the regulatory landscape. More than ever, programs will need to target interventions to pinpoint the remaining market imperfections, maximize cost-effectiveness, and minimize risk. To that end, the following steps can be taken in the upcoming program cycle to help calibrate program interventions to remaining opportunity:

- Shelf-stocking studies – such studies will aid in continuous assessment of the shelf space dedicated to the various technologies as well as retail pricing trends of the various technologies. Understanding differences by retail channel as well as product type will allow Duke Energy to narrow its focus on both retailers and product types.
- Customer research to assess remaining barriers and isolate customer segments of greatest opportunity for the program. This research can take a variety of shapes, including discussions with customers at point-of-sale, customer surveys, customer profiling, and other analyses.
- Research with key market actors to assess manufacturing and stocking expectations and identify barriers to furthering market change.

Baseline studies and market research conducted across the country show that certain customer segments and certain socket types present opportunities for program impact. LED socket saturation is lagging among low-income customers, customers residing in multifamily and rental properties. Specialty lighting is also currently lagging in terms of LED market share and socket saturation. Focusing on those areas of opportunity, while strategically assessing the state of the market will allow Duke Energy to capitalize on the remaining market opportunity effectively.

9. Conclusions and Recommendations

9.1 Conclusions

From August 1, 2018 through July 14, 2019, the DEO Retail Lighting program discounted 431,223 lighting products, achieving 17,856 MWh in ex post gross energy savings, 2.6 MW in ex post gross summer peak demand savings, and 3.0 MW in ex post gross winter peak demand savings. The program realized 93% of gross energy savings, 146% of the gross summer peak demand savings, and 76% of the gross winter peak demand savings.

Opinion Dynamics used completed interviews with staff contacts at participating retailers and manufacturers to estimate program NTG. The analysis resulted in the program-level NTG of 30%. Applying this NTG to the ex post gross savings resulted in net energy savings of 5,357 MWh, net summer peak demand savings of 0.8 MW, and net winter peak demand savings of 0.9 MW. Table 9-1 provides a summary of the program's impacts by savings type and sector.

Table 9-1. Ex Post Gross and Net Savings Summary

Metric	Ex Ante Savings	Ex Post Gross Savings	Gross Realization Rate	NTG	Ex Post Net Savings	Net Realization Rate[a]
Bulbs	431,223	431,223				
Energy savings (MWh)	19,212	17,856	93%	30%	5,357	39%
Summer peak demand savings (MW)	1.8	2.6	146%		0.8	61%
Winter peak demand savings (MW)	4.0	3.0	76%		0.9	32%

Source: Opinion Dynamics analysis of program tracking data.
[a] Denominator is ex ante net savings.

Table 9-2 provides per-bulb ex post gross and net savings. Measure categories in the table below are consistent with the definitions used for Duke Energy tracking purposes.

Table 9-2. Ex Post Per-Bulb Gross and Net Savings

Measure	Ex Post Gross Per-Bulb Savings			NTG	Ex Post Net Per-Bulb Savings		
	kWh	Summer Peak kW	Winter Peak kW		kWh	Summer Peak kW	Winter Peak kW
A-Line	41.37	0.0060	0.0071	30%	12.41	0.0018	0.0021
Reflector Outdoor	46.96	0.0068	0.0080	30%	14.09	0.0020	0.0024
Reflector Recessed	50.89	0.0074	0.0087	30%	15.27	0.0022	0.0026
Reflector Track	38.18	0.0056	0.0065	30%	11.45	0.0017	0.0020
3-Way	67.49	0.0098	0.0115	30%	20.25	0.0029	0.0035
Candelabra	27.85	0.0040	0.0047	30%	8.35	0.0012	0.0014
Globe	33.33	0.0048	0.0057	30%	10.00	0.0015	0.0017
Fixture	39.75	0.0058	0.0068	30%	11.92	0.0017	0.0020

Source: Opinion Dynamics analysis of program tracking data.

Table 9-3 provides a second estimate of per-LED gross and net savings, representing savings claimable under Ohio Senate Bill 310 (SB 310). Gross savings reflect the maximum of ex ante and ex post gross savings values. We calculated net savings by multiplying gross savings claimable under SB 310 by the NTG of 30% developed through this evaluation.

Table 9-3. Per-Bulb Gross and Net Savings Claimable Under SB 310

Measure	Gross Per-Bulb Savings Claimable Under SB 310			NTG	Net Per-Bulb Savings Claimable Under SB 310		
	kWh	Summer Peak kW	Winter Peak kW		kWh	Summer Peak kW	Winter Peak kW
A-Line	50.65	0.0060	0.0093	30%	15.20	0.0018	0.0028
Reflector Outdoor	118.68	0.0108	0.0260	30%	35.61	0.0032	0.0078
Reflector Recessed	50.89	0.0074	0.0096	30%	15.27	0.0022	0.0029
Reflector Track	38.18	0.0056	0.0065	30%	11.45	0.0017	0.0020
3-Way	67.49	0.0098	0.0115	30%	20.25	0.0029	0.0035
Candelabra	27.85	0.0040	0.0047	30%	8.35	0.0012	0.0014
Globe	33.33	0.0048	0.0057	30%	10.00	0.0015	0.0017
Fixture	39.75	0.0058	0.0081	30%	11.92	0.0017	0.0024

Source: Opinion Dynamics analysis of program tracking data.

The program team leveraged well-established implementation approaches, demonstrating smooth and effective operational processes. These approaches included a purposeful selection of store locations to target underserved customers and minimize program leakage and active engagement with retailer and manufacturer contacts to monitor market changes and adjust program offerings as needed. The program offered incentives on 299 unique products across 65 participating storefronts during the evaluation period. Program marketing was versatile and targeted customers both at point of purchase and through email and direct mail campaigns and local events. Program tracking data was also generally clean and well maintained.

The lighting market continues to undergo rapid change, and LEDs have quickly become commonplace across retail channels. The subsequent increases in customer comfort and satisfaction has driven preferences for LEDs and adoption of the technology in residential applications. As a result, the lighting market for the most frequently sold bulb shapes is being rapidly saturated with LEDs. A number of key indicators gathered from research and data collection efforts across the country illustrate the rate and scale at which these changes to the lighting market have occurred in recent years. In light of these trends and continuing uncertainty surrounding the future of federal lighting efficiency standards, programs will need to target interventions to pinpoint the remaining market imperfections, maximize cost-effectiveness, and minimize risk.

9.2 Recommendations

Based on the findings of this evaluation, Opinion Dynamics makes the recommendations presented below. Opinion Dynamics acknowledges that Duke Energy continues to actively modify the Retail Lighting offering and are either planning to or have already implemented a number of programmatic modifications that are well-aligned with the recommendations presented below. For instance, we understand from program staff feedback that Duke Energy plans to incentivize standard LEDs only in hard-to-reach stores starting in Q3 of 2020. Furthermore, efforts to further focus on hard-to-reach retailers, such as discount and dollar stores, are underway with a possibility of limiting program activity to just those stores in the future.

- Consistent with the current guidelines, Duke Energy should calculate future savings from the program using the savings values claimable under Ohio Senate Bill 310 (SB 310).
- Continue and, if possible, increase the program's focus on underserved customer segments. Such efforts could include targeting stores in areas with disproportionate shares of underserved customers and targeting retailers with disproportionate numbers of shoppers from underserved segments.
- Continue and, if possible, increase targeting of specialty products, focusing on lower-wattage specialty products, and adjust program marketing and messaging to focus on underserved sockets and increase messaging relevance (such as specialty sockets in dining rooms).
- Consider alternative program designs, such as free bulb giveaways targeting customer segments with lower rates of LED adoption (e.g. low-income, renters, rural areas, etc.) while maintaining efforts to avoid overlap with existing offerings such as the Free LED and Neighborhood Energy Saver programs.
- Monitor manufacturing practices and shelf stocking trends in anticipation of possible federal regulation to identify optimal timing for program completion.
- Continue to assume halogen baseline efficiency for standard products and incandescent baseline efficiency for specialty products given the state of the market after several years of EISA minimum federal efficiency standards.

10. Program Summary Form

Duke Energy Ohio

Retail Lighting Program Evaluation

Program Description

The Duke Energy Ohio Retail Lighting program provides incentives to provide price markdowns on efficient LED lighting products. The program, launched in August of 2018, promotes customer awareness and adoption of program-discounted products through a range of marketing and outreach strategies. Product mix includes ENERGY STAR® standard, reflector, and specialty bulbs and fixtures, including a wide range of products in each category. Participating stores represent a variety of retail channels, including DIY, dollar/discount, and big box stores.

Date	June 27, 2020
Region(s)	Duke Energy Ohio
Evaluation Period	August 1, 2018 – July 14, 2019
Annual kWh Savings (ex post net)	5,357 MWh
Coincident kW Impact (ex post net)	0.8 MW (Summer), 0.9 MW (Winter)
Measure Life	Not Evaluated
Net-to-Gross Rate	30%
Process Evaluation	Yes (limited)
Previous Evaluation(s)	N/A

Evaluation Methodology

The evaluation team reviewed program tracking data and ex ante deemed savings assumptions and conducted an engineering analysis to develop ex post energy and demand savings estimates. To inform the engineering impacts analysis, we estimated leakage using GIS analysis, developed commercial HOU and CF assumptions from previously collected logger data, and estimated a net-to-gross ratio based on sales data modeling and feedback from retailers and manufacturers. The evaluation team also completed a process analysis based our review of program sales data extracts, marketing materials, and field reports.

Impact Evaluation Details

- Relied on UMP-recommended approach to estimate gross energy and peak demand savings
- Savings estimates use assumptions from the most recent available research and analysis and, wherever possible, are based on Ohio-specific research and are specific to LED lighting products
- Analyzed data from recent DEO commercial lighting logger study to develop HOU and CF assumptions
- Conducted a GIS-based analysis of program leakage
- Assigned baseline wattages using the minimum efficiency baseline approach with consideration of applicable federal efficiency standards
- Employed discounted savings approach to claim savings from future installations
- Developed estimate of NTG based on triangulation of results from sales data modeling and interviews with corporate retailer and manufacturer contacts
- Provided recommended savings assumptions for impacts claimable under SB 310

11. Chart with Measure-Level Inputs for Duke Energy Analytics

The Excel spreadsheet with measure-level inputs for Duke Energy Analytics is provided as a separate submission alongside this report.

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Nexant
Reimagine tomorrow.

Opinion Dynamics

Save Energy and Water Kits 2018-2019 Evaluation Report

Submitted to Duke Energy Ohio
by Nexant in partnership with Opinion Dynamics

April 6th, 2020

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1 Executive Summary

1.1 Program Summary

The Save Energy and Water Kit Program (SEWKP) is a Duke Energy program that provides free energy and water efficiency kits to pre-selected households in the Duke Energy Ohio (DEO) jurisdiction. The kits include aerators for kitchen and bathroom sink faucets, showerheads, and water heater pipe wrap.

1.2 Evaluation Objectives and Results

This report presents the results and findings of evaluation activities for DEO SEWKP conducted by the evaluation team, collectively Nexant Inc. and our subcontracting partner, Opinion Dynamics, for the program year of July 2018 – June 2019.

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 DEO program. The evaluation was divided into two research areas - to determine gross savings 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 SEWKP kit. Net impacts reflect the degree to which the gross savings are a result of the program efforts and funds.

Table 1-1, Table 1-2, and Table 1-3 present the summarized findings of the impact evaluation for the DEO jurisdiction. All totals in Table 1-1 and Table 1-2, excluding the population, are weighted averages based on the 2018-2019 evaluation sample and represent expected savings from the average participant.

Table 1-1: Energy Savings per Kit

Kit Size	Population	Reported Energy (kWh)	Energy Realization Rate	Gross Verified Energy (kWh)
Small	1,350	1,157	27.5%	319
Medium (new design)[1]	1,930	1,595	26.4%	422
Medium (previous design)[2]	4	1,817	24.0%	437
Program Total	**3,284**	**1,415**	**26.8%**	**379**

Table 1-2: Demand Savings per Kit

Kit Size	Summer Demand (kW)			Winter Demand (kW)		
	Reported	Realization Rate	Gross Verified	Reported	Realization Rate	Gross Verified
Small	0.092	24.9%	0.023	0.132	27.0%	0.035
Medium (new design)[1]	0.127	24.0%	0.030	0.182	26.1%	0.047
Medium (previous design)[2]	0.145	21.9%	0.032	0.207	23.9%	0.049
Program Total	**0.113**	**24.3%**	**0.027**	**0.161**	**26.4%**	**0.043**

Table 1-3: Program Level Savings

Measurement	Population	Reported	Realization Rate	Gross Verified
Energy (kWh)	3,284	4,647,978	26.8%	1,245,466
Summer Demand (kW)		370.2	24.3%	89.8
Winter Demand (kW)		528.9	26.4%	139.6

The portion of gross verified savings by measure type are presented in Figure 1-1. Per unit energy and demand savings by measure and program net to gross ratio details are presented in Table 1-4.

[1] 2 bathroom faucet aerators, 1 kitchen aerator, 2 showerheads

[2] 4 bathroom faucet aerators, 1 kitchen aerator, 2 showerheads

Figure 1-1: Portion of Program Verified Savings by Measure

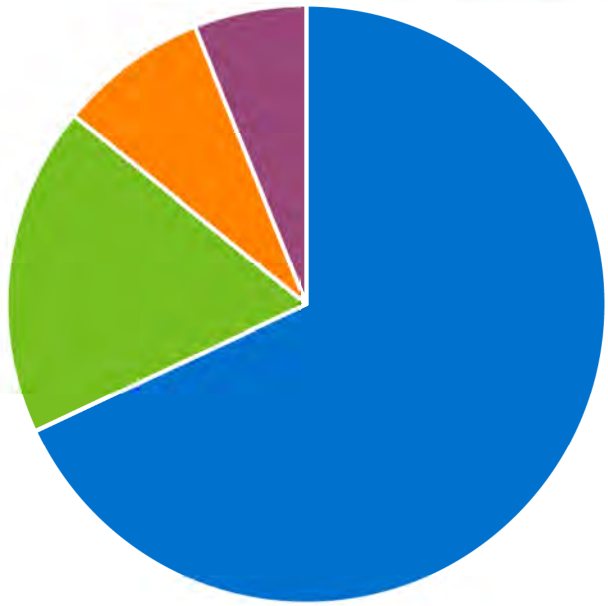


Table 1-4: DEO Program Year 2018-2019 Verified Impacts by Measure (per unit)

Measure	Energy Savings (kWh)	Summer Demand Savings (kW)	Winter Demand Savings (kW)	Free Ridership	Spillover	Net to Gross Ratio
Low-flow Showerhead	173.4	0.0127	0.0201	10.2%	15.5%	105.3%
Low-flow Kitchen Aerator	72.4	0.0043	0.0066			
Low-flow Bathroom Aerator	12.3	0.0010	0.0016			
Pipe Wrap*	6.7	0.0008	0.0008			

* Savings for pipe tape is a per linear foot measurement

1.2.1.1 Senate Bill 310 Compliance

In the state of Ohio, electric distribution utilities (EDUs), including DEO, are required to achieve a cumulative annual energy savings of more than 22% by 2027 per Ohio Senate Bill (SB) 310[3]. SB 310 also introduced new mechanisms that adjust how EDUs estimate the savings achieved through demand side management programs. Specifically, SB 310 permits EDUs savings to be "measured on the higher of an as found or deemed basis". That is, an EDU may claim the

[3] State of Ohio Substitute Senate Bill 310 Section 4928.662, sections (A) through (G), pages 30 and 31.

highest savings provided by deemed savings applied by the program, or gross/net verified savings provided by an evaluation. The relevant language from SB 310 is provided in Appendix C.

Table 1-5 and Table 1-6 provide the savings per measure that DEO can claim per SB 310 for the SEWKP 2018-2019 program year.

Table 1-5: SB 310 Compliance Gross Savings per Measure

Measure	Claimed Energy Savings (kWh)	Claimed Summer Demand Savings (kW)	Claimed Winter Demand Savings (kW)	Source
Low-flow Showerhead	438.0	0.035	0.050	DEO program reported savings
Low-flow Kitchen Aerator	451.4	0.036	0.051	DEO program reported savings
Low-flow Bathroom Aerator	110.9	0.009	0.012	DEO program reported savings
Pipe Wrap*	46.0	0.004	0.005	DEO program reported savings

* Savings for pipe tape is a per linear foot measurement

Table 1-6: SB 310 Compliance Savings per Kit

Kit Size	Population	SB 310 Claimed Energy (kWh)	SB 310 Claimed Summer Demand (kW)	SB 310 Claimed Winter Demand (kW)
Small Kit	1,350	1,157	0.092	0.132
Medium (new design)[4]	1,930	1,595	0.127	0.182
Medium (previous design)[5]	4	1,817	0.145	0.207
Total	**3,284**	**1,415**	**0.113**	**0.161**

Table 1-7: SB 310 Compliance Program Savings

Measurement	Ex-Ante Savings	Realization Rate	Ex-Post Savings
Energy (kWh)	4,647,978	100%	4,647,978
Summer Demand (kW)	370.2	100%	370.2
Winter Demand (kW)	528.9	100%	528.9

1.2.2 Process Evaluation

The process evaluation assessed opportunities for improving the program's design and delivery in the DEO service territory. It specifically documented participant experiences by investigating

[4] 2 bathroom faucet aerators, 1 kitchen aerator, 2 showerheads

[5] 4 bathroom faucet aerators, 1 kitchen aerator, 2 showerheads

participating household responses to the kits and the extent to which the kits effectively motivate households to save energy.

The evaluation team reviewed program documents and conducted telephone and web surveys with households that received a kit (n=328). The team also conducted in-depth interviews with utility and implementation staff.

Program Successes
The 2018-2019 DEO SEWKP evaluation found successes in the following areas:

Most participants are satisfied with kit items and report high satisfaction with the program overall. Less than 10% of participants reported dissatisfaction with any of the specific measures they installed, and 80% of participants reported they were highly satisfied with the program overall.

Kit instructions are perceived as highly helpful among SEWKP participants. Eighty-three percent of participants said they read the instructional insert from their kit that offers detailed instructions on self-installing the measures, more than three-quarters of whom said the instructions were highly helpful.

The program influenced households to install kit measures. Participants were highly influenced by the program to install kit measures, as demonstrated by low free ridership rates. Further, 18% of respondents reported program attributable spillover.

Program Challenges
The 2018-2019 DEO SEWKP evaluation found some challenges in the following areas:

Low water pressure is the primary contributor to dissatisfaction and uninstallation rates. Complaints of excessively low water pressure was the primary driver of dissatisfaction with and uninstallation of water-saving measures among a small minority of participants who were dissatisfied with or uninstalled items.

Fewer participants are installing at least one measure. About three-quarters of participants installed at least one measure compared with over 90% at the time of the previous evaluation, reflecting a decrease in ISR for all water-saving measures.

1.3 Evaluation Conclusions and Recommendations

The evaluation findings led to the following conclusions and recommendations for the program.

Conclusion 1: The program model is highly successful: it leverages low-cost measures to foster energy savings that would not have happened otherwise. Duke Energy's easy process for requesting and receiving a kit with free energy and water-saving items motivated nearly 3,300 customers to request and install energy saving measures in their home during the evaluation period. Most participants installed at least one measure from the kit, few measures get uninstalled, and many participants reported installing additional energy saving items since receiving the kit. The majority of participants said they would not have installed any of the items on their own, as represented by low free ridership rates, and the program is reaching a diverse range of customers in terms of household characteristics and demographics.

> **Recommendation**: Continue using SEWKP to encourage Duke Energy customers to save energy and water.

Conclusion 2: The water-saving measures' low flow water pressure results in some minor dissatisfaction and uninstallation issues. Complaints of excessively low water pressure was the primary driver of measure dissatisfaction and uninstallation. However, only a minority of participants were dissatisfied with or uninstalled water-saving items. The program has started offering showerhead upgrades for on-line participants that allow them to choose their preferred showerhead style, but this was unavailable during the 2018-19 evaluation period

> **Recommendation**: Monitor how showerhead upgrades affect satisfaction and uninstallation rates going forward.

Conclusion 3: Fewer participants are installing at least one measure. 74% of participants reported installing at least one item from the kit, down from 92% when the program was last evaluated in 2017. The reason for this trend is unclear, but there were substantially fewer installed showerheads, kitchen aerators, and bathroom aerators than in 2017.

> **Recommendation**: Monitor installation rates in other jurisdictions in upcoming evaluations to determine if this downward trend is unique to DEO, and reincorporate follow-up survey questions in future surveys to ask why participants had not installed any measures.

Conclusion 4: Recent program improvements have been largely successful. Despite lower overall installation rates than were found by the previous DEO evaluation, the new kitchen aerator appears to be a successful improvement for the measure category. Compared to the previously evaluated model, only slightly more than half as many uninstalled the measure. The new instructions provided with the kits also appear to denote a significant improvement from the prior instructions. Recent DEO participants rated the instructions as considerably more helpful than participants in the last evaluated program year (78% rated as "very helpful" up from 67% in 2017).

2 Introduction and Program Description

2.1 Program Description

2.1.1 Overview

The Save Energy and Water Kit Program (SEWKP) is a Duke Energy program that provides free energy and water efficiency kits to pre-selected households in Duke Energy Ohio (DEO) territory. The kits include low-flow aerators for kitchen and bathroom sink faucets, low-flow showerheads, and water heater pipe wrap.

2.1.2 Energy Efficiency Kit Measures

Table 2-1 lists the kit's contents included in the evaluation scope. There are two kit sizes, which dictate the number of showerheads and bathroom aerators the participant receives. In addition to the measures below, the kit includes plumbing tape, a rubber gasket opener to remove old aerators and showerheads, and an instructional insert that has detailed installation instructions. Duke Energy has additional installation instruction information available on their website.

Table 2-1: Kit Measures and Quantity

Measures	Small Kit	Medium Kit (new design)	Medium Kit (previous design)
Low-flow Showerhead (1.5 gpm)	1	2	2
Low-flow Bathroom Faucet Aerator (1.0 gpm)	2	2	4
Low-flow Kitchen Faucet Aerator (1.0 gpm)	1	1	1
Pipe Wrap (up to 10' of coverage)	1	1	1

2.2 Program Implementation

2.2.1 Participant Identification and Recruitment

Every month Duke Energy's internal analytics department identifies households to recruit into the program. They look through customer accounts for single family electric-only accounts that have not participated in SEWKP or any other programs with similar measures (specifically, the Energy Efficiency Education in Schools and Home Energy House Call programs). Pre-selected households are then assigned either a small or medium kit based on household square footage. Next, Duke Energy approaches these customers through either emails, if the pre-selected customer has an email address on file, or business reply cards (BRC). Simultaneously, Duke Energy sends the implementer – Energy Federation, Inc. (EFI) – a list of pre-selected accounts that received an offer to participate in the SEWKP that month. Email messages provide a link for the customer to join the program and households that receive the BRC simply detach the reply form and put it back in the mail (postage is pre-paid). Alternatively, customers may also call a toll free number, provided on the email or BRC, to confirm eligibility and request their free kit. EFI then ships the appropriate kit (small or medium) to registered households.

2.2.2 Participation

For the defined evaluation period of July 1st, 2018 through June 30th 2019, the program recorded a total of 3,324[6] kit recipients in DEO. During survey recruitment of sampled customers, 1.2% of participants reported that their kit did not arrive in the mail.

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) 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 DEO SEWKP:

- Quantify accurate and supportable energy (kWh) and demand (kW) savings 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.

[6] Verified savings are based on the number of participants who received a kit

2.3.2 Process

The process evaluation assessed opportunities for improving the design and delivery of the program in DEO service territory. It specifically documented participant experiences by investigating participant responses to the energy efficiency kits and the extent to which the kits effectively motivate households to save energy and water.

The evaluation team assessed several elements of the program delivery and customer experience, including:

Motivation:

- What motivated participants to request and install the measures in the kit?
- In what ways, if any, did the program motivate participants to adopt new energy and water saving behaviors?

Program experience and satisfaction:

- How satisfied are participants with the overall program experience and kit items in terms of ease of use and measure quality?

Challenges and opportunities for improvement:

- Are there any inefficiencies or challenges with the delivery of the program?
- Are there any measures that have particularly low installation rates? If so, why?
- Are there any measures that have particularly high uninstallation rates? If so, why?

Participant household characteristics:

- What are demographic characteristics of those who received the kits?

2.4 Evaluation Overview

The evaluation team divided its approach into key tasks to meet the goals outlined:

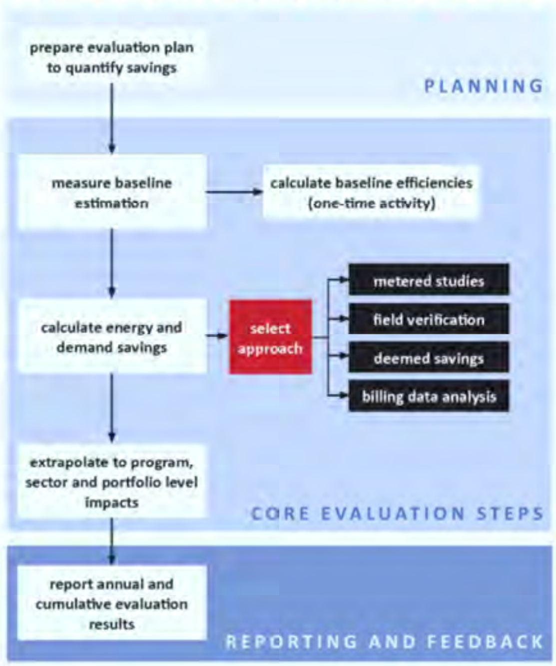
- Task 1 – Develop and manage an evaluation work plan to describe the processes that will be followed to complete the evaluation tasks outlined in this project;
- Task 2 – Conduct a process review to determine how successfully the programs are being delivered to participants and to identify opportunities for improvement;
- Task 3 – Verify gross and net energy and peak demand savings resulting from SEWKP through verification activities of a sample of 2018-2019 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 that we used 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.

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/or web-based survey with the participants. Table 2-2 below summarizes the number of surveys. 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:** 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

To satisfy the EM&V objectives for this research effort, the evaluation team reviewed program documents and conducted telephone and web surveys with participating households who received a kit. The team also held in-depth interviews (IDI) with utility and implementation staff. Table 2-2 provides a summary of the activities the evaluation team conducted as part of the DEO SEWKP process and impact evaluation.

Table 2-2: DEO SEWKP Summary of Evaluation Activities

Target Group	Population	Sample	Confidence /Precision	Method
Impact Activities				
DEO Participants	3,324[7]	328	90/4.3	Telephone/Web Survey
Process Activities				
DEO Participants	3,324	328	90/4.3	Telephone/Web Survey
Duke Energy Program Staff	N/A	1	N/A	Telephone IDI
Implementer Staff: EFI	N/A	1	N/A	Telephone IDI

[7] Full population is 3,324 kits. Our participant survey found that 1.2% of participants did not remember receiving their kit so the total program population was reduced to 3,284 kits for the impact evaluation

3 Impact Evaluation

3.1 Methodology

The evaluation team's impact analysis focused on the energy and demand savings attributable to the SEWKP for the period of July 2018 through June 2019. The evaluation was divided into two research areas: to determine gross savings 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 DEO participant database.
- 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-reported 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

Duke Energy provided the evaluation team with a program database for the SEWKP participation within each jurisdiction. The program database provided participant contact information including account number, address, phone number, email address (if available), and whether or not the participant was willing to be contacted. Because Duke Energy was 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.

The evaluation team conducted a benchmarking review of the uncertainty of ex-ante savings estimates by comparing multiple technical reference manuals (TRMs) and SEWKP evaluations conducted in select Duke Energy jurisdictions. The details of the benchmarking review are referenced in Table 3-1. The listed savings values include the impact of in-service rates.

Table 3-1: Comparison of Ex-Ante SEWKP Savings to Peer Group Estimates

Measure	DEO 2018 ex-ante savings[1] (kWh)	Ohio 2010 TRM[2] (kWh)	Illinois 2019 TRM[3] (kWh)	Indiana 2015 TRM[4] (kWh)	Mid-Atlantic 2018 TRM[5] (kWh)	Pennsylvania 2016 TRM[6] (kWh)
Showerhead (1.5 gpm)	438.0	165.3	155.5	293.9	390.1	363.9
Bathroom Faucet Aerator (1.0 gpm)	110.9	20.2	13.5	15.9	26.2	56.4
Kitchen Faucet Aerator (1.0 gpm)	451.4	20.2	105.6	122.2	200.8	145.0
Pipe Wrap	46.0	18.6	19.3	18.6	9.4	20.9

[1] Provided by Duke Energy
[2] State of Ohio Energy Efficiency Technical Reference Manual. August, 2010
[3] Illinois Statewide Technical Reference Manual for Energy Efficiency, v7.0. September, 2018
[4] Indiana Technical Reference Manual, v2.1. July, 2015
[5] Mid-Atlantic Technical Reference Manual v8. May, 2018
[6] Pennsylvania Public Utility Commission Technical Reference Manual. June, 2016

While Table 3-1 does illustrate variation in deemed savings among each source for each given measure, much of this variation reflects different in-service rate and water heat fuel type assumptions. Also of note is that the Ohio and Mid-Atlantic TRMs do not differentiate parameter assumptions between bathroom and kitchen faucet aerators. For this reason, the evaluation team ultimately used assumptions outlined by the Indiana and Pennsylvania TRMs to capture different usage patterns between each aerator location. All other parameters not mined from the participant survey generally relied on either the Ohio or Indiana TRM assumptions.

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, we identified a population of 3,324 participants within our defined evaluation period. Based on this population, the evaluation team established sub-sample frames for phone and web-based survey administration. Customers who were flagged as "do not contact" in the participation database were excluded from the sample frame. As illustrated in Table 3-2 below, we completed a total of 328 surveys between October 12th and 20th, 2019. This sample size resulted in a precision of ±4.3% at a 90% confidence interval.

Table 3-2: DEO Impact Sampling

Survey Mode	Sample Frame	Sampled Participants	Achieved Precision at 90% Confidence
Phone	1,058	70	±4.3%
Web-based	1,993	258	
Total	**3,051**[8]	**328**	

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 of 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
Showerhead Bathroom Faucet Aerator Kitchen Faucet Aerator	Units Installed	In-Service Rate
	Units Later Removed	
	Hot Water Fuel Type	% Electric DHW
	Frequency of Showers	Hot Water Consumption
	Duration of Showers	
Pipe Wrap	Pipe Wrap Used	In-Service Rate
	Pipe Wrap Removed	
	Hot Water Fuel Type	% Electric DHW
	Length of Insulated Pipe	Pipe Length

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 bathroom aerator each, and five customers reported to still have the aerator 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.

[8] Participants on Duke Energy's 'Do Not Contact' list were excluded from the sample

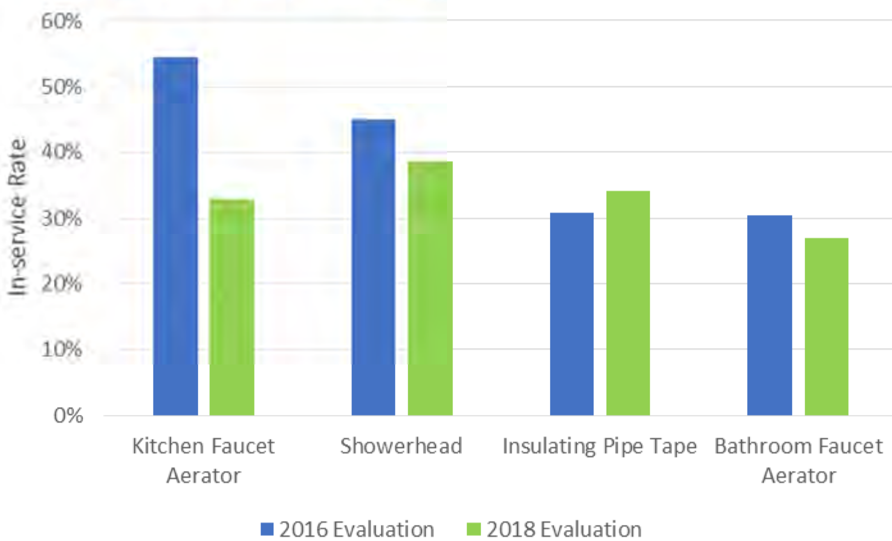
Table 3-4: DEO SEWKP In-Service Rates

Measure	Distributed	Installed	Removed	ISR
Showerhead	505	218	23	39%
Bathroom Faucet Aerator	656	196	19	27%
Kitchen Faucet Aerator	328	117	9	33%
Pipe Wrap*	328	117	5	34%

*Quantity of pipe tape packages

Comparison of the 2018-2019 measure in-service rates to the previous 2016 evaluation shows that nearly all measures have lower in-service rates in this evaluation (Figure 3-1). The cause of this drop is unknown at the moment, but may be due to introduction of email recruitment that lessens the effort needed to participate in the program and results in participants who are less committed to installing the equipment, program saturation within the targeted population that is now reaching into homes that are less motivated to complete installs, or market wide shifts in energy and water efficiency within the DEO service territory. The latter of these options will be tested as evaluations are completed for other Duke Energy service territories, but those results are unavailable at this time.

Figure 3-1: Comparison of 2016 and 2018 In-service Rates



3.4.3 Kit Measure Savings

The next section of the evaluation report provides a summary of the algorithms used to estimate energy and demand savings for each of the kit items. Input parameters were provided by program participant responses in the surveys. For more technical inputs, the evaluation applied secondary data sources such as the Ohio or Indiana TRMs. Where the Ohio 2010 TRM made appropriate distinctions, the evaluation team used Ohio parameter assumptions due to its geographic relevance to the DEO territory. However, where the Ohio TRM lacked granularity, the evaluation team elected to use the Indiana TRM as the secondary data source for savings inputs. Specifically the Indiana TRM provided more comprehensive savings algorithms along with the most applicable secondary source for differentiating between kitchen and bathroom water use.

Demand savings coincident factors (CF) for the summer and winter seasons were estimated to align with peak demand periods for Duke Energy Ohio[9] using the study on residential domestic hot water use referenced by the Ohio TRM[10]. This method takes into account the average hot water use by fixture type (showerhead, faucet aerator) during the peak period along with the probability of the evaluated daily hours of use occurring at the same time.

3.4.3.1 Faucet Aerators

The Save Energy and Water Kit contained one kitchen faucet aerator and multiple bathroom faucet aerators. Participants receiving a small kit received two bathroom faucet aerators; those qualifying for a medium kit also received two bathroom faucet aerators. The equations below outline the algorithms utilized to estimate savings accrued by the faucet aerator measures with parameters defined in Table 3-5.

Equation 3-1: Faucet Aerator Energy Savings

$$\Delta kWh = ISR \times ELEC \times \left[\frac{\Delta GPM \times MPD \times PH \times DR \times 8.3\frac{BTU}{gal \cdot {}^{\circ}F} \times \Delta T \times 365\frac{days}{year}}{FH \times 3{,}412\frac{BTU}{kWh} \times RE}\right]$$

Equation 3-2: Faucet Aerator Demand Savings

$$\Delta kW = \frac{ISR \times ELEC \times \Delta GPM \times 60 \times DR \times 8.3\frac{BTU}{gal \cdot {}^{\circ}F} \times CF \times \Delta T}{3{,}412\frac{BTU}{kWh} \times RE}$$

Table 3-5: Inputs for Faucet Aerator Measures Savings Calculations

Input	Units	Aerator Savings Input		Source
		Kitchen	Bathroom	
ISR	n/a	33%	27%	Participant survey responses
ELEC	n/a	88%		Participant survey responses
ΔGPM	gpm	1.2		Baseline, federal code minimum Retrofit, product specification sheet
MPD	minutes/day	4.5	1.6	Indiana TRM v2.1
PH	people in home	2.9	2.9	Participant survey responses
DR	n/a	50%	70%	Indiana TRM v2.1

[9] Summer Demand Peak: July, 3pm to 4pm and Winter Demand Peak: January, 7pm to 8pm

[10] Aquacraft, DeOreo and Mayer, *The End Uses of Hot Water in Single Family Homes from Flow Trace Analysis*

Input	Units	Aerator Savings Input		Source
		Kitchen	Bathroom	
ΔT	°F	35.2	28.2	$Temp_{in}$, Ohio 2010 TRM $Temp_{out}$, Indiana TRM v2.1
FH	Units	1.0	1.9	Participant survey responses
RE	N/A	98%		Ohio 2010 TRM
CF, summer	n/a	0.0048	0.0012	Ohio 2010 TRM, adjusted
CF, winter	n/a	0.0073	0.0019	Ohio 2010 TRM, adjusted

Outside of the Ohio TRM, the evaluation team determined that Indiana TRM (v2.1) provided the most applicable secondary source by differentiating between kitchen and bathroom water use and providing more comprehensive algorithms. Where the Ohio 2010 TRM made appropriate distinctions, the evaluation team used the Ohio parameter assumptions due to its geographic relevance to the DEO territory. However, where the Ohio TRM lacked granularity, the evaluation team elected to use the Indiana TRM as the secondary data source for estimating savings.

3.4.3.2 Showerheads

The Save Energy and Water Kit contained either one or two low-flow showerheads, with the quantity depending on the size of the kit received. Participants receiving a small kit received one showerhead; those qualifying for a medium kit received two showerheads. The equations below outline the algorithms utilized to estimate savings accrued by the showerhead measure with parameters defined in Table 3-6.

Equation 3-3: Showerhead Energy Savings

$$\Delta kWh = ISR \times ELEC \times \left[\frac{\Delta GPM \times MS \times SPD \times PH \times 8.3 \frac{BTU}{gal \cdot °F} \times \Delta T \times 365 \frac{days}{year}}{SH \times 3{,}412 \frac{BTU}{kWh} \times RE} \right]$$

Equation 3-4: Showerhead Demand Savings

$$\Delta kW = \frac{ISR \times ELEC \times \Delta GPM \times 60 \times 8.3 \frac{BTU}{gal \cdot °F} \times CF \times \Delta T}{3{,}412 \frac{BTU}{kWh} \times RE}$$

Table 3-6: Inputs for Showerhead Savings Calculations

Input	Units	Showerhead Savings Input	Source
ISR	n/a	39%	Participant survey responses
ELEC	n/a	88%	Participant survey responses
ΔGPM	gpm	1.0	Baseline, federal code minimum Retrofit, product specification sheet

Input	Units	Showerhead Savings Input	Source
MS	minutes/shower	9.8	Participant survey responses
SPD	showers/person/day	0.63	Participant survey responses
PH	people in home	2.9	Participant survey responses
ΔT	°F	43.2	$Temp_{in}$, Ohio 2010 TRM $Temp_{out}$, Indiana TRM v2.1
SH	showers/home	1.34	Participant survey responses
RE	n/a	98%	Ohio 2010 TRM
CF, summer	n/a	0.0059	Ohio 2010 TRM, adjusted
CF, winter	n/a	0.0093	Ohio 2010 TRM, adjusted

3.4.3.3 Insulating Pipe Wrap

All participants received a 15 foot roll of pipe wrap insulation with their kit. To estimate the impacts resulting from the installation pipe wrap measure, the evaluation team used the algorithms presented below.

Equation 3-5: Insulating Pipe Wrap Energy Savings

$$\Delta kWh = ISR \times ELEC \times \frac{\left(\frac{1}{R_{ex}} - \frac{1}{R_{new}}\right) \times L \times C \times \Delta T \times 8{,}760}{\eta DHW \times 3{,}413}$$

Equation 3-6: Insulating Pipe Wrap Demand Savings

$$\Delta kW = \frac{\Delta kWh}{8{,}760}$$

Table 3-7: Inputs for Insulating Pipe Wrap Savings Calculations

Input	Units	Pipe Wrap Savings Input	Source
ISR	n/a	34%	Participant survey responses
ELEC	n/a	88%	Participant survey responses
R_{ex}	n/a	1.00	Ohio 2010 TRM
R_{new}	n/a	3.00	Product specification sheet
L	linear feet	4.9	Survey Responses*
C	feet	0.20	Indiana TRM (Average of 1/2" and 3/4" pipe)
ΔT	°F	65	Ohio 2010 TRM
ηDHW	n/a	98%	Ohio 2010 TRM

*Participant-provided estimated lengths of hot water pipe covered by the pipe tape was used to estimate verified savings.

Through a combination of participant survey responses as well as TRM and other deemed values, we estimated the parameter inputs presented above in Table 3-7.

3.5 Targeted and Achieved Confidence and Precision

We developed the SEWKP evaluation plan with the goal of achieving a target of 10% relative precision at the 90% confidence interval across both jurisdictions at the program level. Due to a high response rate from the web-based surveys, the evaluation team was able to surpass this target and achieve a high level of statistical precision. The final DEO sample yielded a relative precision of +/- 4.3% at the 90% confidence level (Table 3-8).

Table 3-8: Targeted and Achieved Confidence and Precision

Program	Targeted Confidence/Precision	Achieved Confidence/Precision
DEO SEWKP	90/10.0	90/4.3

3.6 Results

Measure-level energy savings values for the DEO jurisdiction are detailed in Figure 3-2 and Table 3-9.

Figure 3-2: Gross Verified Energy Savings

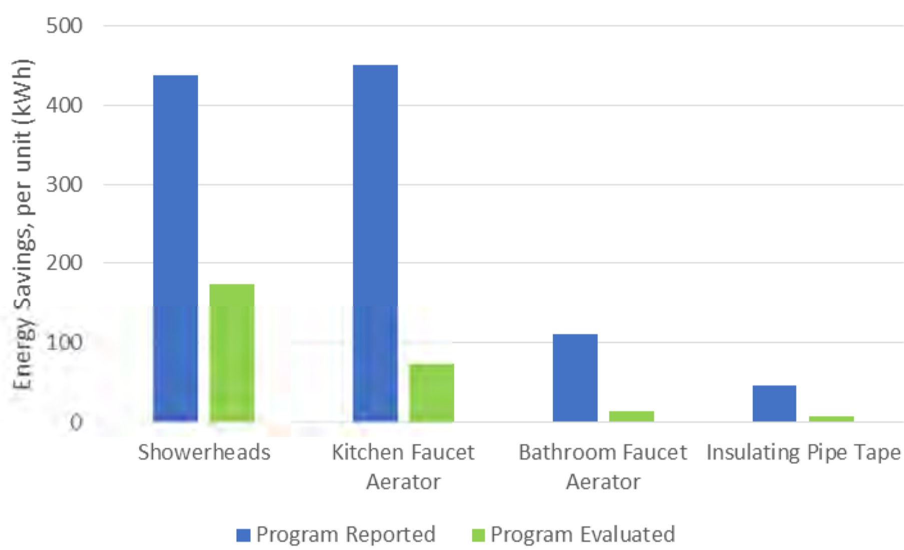


Table 3-9: Measure-Level Reported and Verified Gross Energy Savings

Measure	Reported Energy Savings, per unit (kWh)	Realization Rate	Verified Gross Energy Savings, per unit (kWh)
Low-flow Showerhead	438.0	39.6%	173.4
Low-flow Kitchen Aerator	451.4	16.0%	72.4
Low-flow Bathroom Aerator	110.9	11.1%	12.3
Pipe Wrap*	46.0	14.5%	6.7

* Savings for pipe wrap is a per linear foot measurement

Measure-level demand savings are detailed in Table 3-10.

Table 3-10: DEO Measure-Level Reported and Verified Demand Gross Savings

Measure	Summer Demand, per unit (kW)			Winter Demand, per unit (kW)		
	Reported	Realization Rate	Gross Verified	Reported	Realization Rate	Gross Verified
Low-flow Showerhead	0.0350	36.3%	0.0127	0.0499	40.3%	0.0201
Low-flow Kitchen Aerator	0.0360	12.0%	0.0043	0.0514	12.9%	0.0066
Low-flow Bathroom Aerator	0.0087	11.8%	0.0010	0.0125	12.6%	0.0016
Pipe Wrap*	0.0037	20.6%	0.0008	0.0053	14.4%	0.0008

* Savings for pipe wrap is a per linear foot measurement

The impact evaluation for the 2018-2019 program resulted in a program energy realization rate of 27% and a demand realization rates of 24% (summer) and 26% (winter) as presented in Table 3-11 and Table 3-12.

Table 3-11: Energy Savings per Kit

Kit Size	Population	Reported Energy (kWh)	Energy Realization Rate	Gross Verified Energy (kWh)
Small	1,350	1,157	27.5%	319
Medium (new design)[11]	1,930	1,595	26.4%	422
Medium (previous design)[12]	4	1,817	24.0%	437
Program Total	**3,284**	**1,415**	**26.8%**	**379**

[11] 2 bathroom faucet aerators, 1 kitchen aerator, 2 showerheads

[12] 4 bathroom faucet aerators, 1 kitchen aerator, 2 showerheads

Table 3-12: Demand Savings per Kit

Kit Size	Summer Demand (kW)			Winter Demand (kW)		
	Reported	Realization Rate	Gross Verified	Reported	Realization Rate	Gross Verified
Small	0.092	24.9%	0.023	0.132	27.0%	0.035
Medium (new design)[11]	0.127	24.0%	0.030	0.182	26.1%	0.047
Medium (previous design)[12]	0.145	21.9%	0.032	0.207	23.9%	0.049
Program Total	**0.113**	**24.3%**	**0.027**	**0.161**	**26.4%**	**0.043**

Table 3-13 presents the reported and verified energy and demand savings for the 2018-2019 program year.

Table 3-13: Program Level Savings

Measurement	Population	Reported	Realization Rate	Gross Verified
Energy (kWh)	3,284	4,647,978	26.8%	1,245,466
Summer Demand (kW)		370.2	24.3%	89.8
Winter Demand (kW)		528.9	26.4%	139.6

3.6.1 Senate Bill 310 Compliance

As noted in Section 1.2.1.1, DEO may claim alternate savings values for each program measure per the terms of Ohio Senate Bill 310 in order to comply with its energy savings goals. The relevant language from Senate Bill 310 is provided in Appendix C.

Table 3-14 provides the gross savings per measure that DEO will claim per SB 310 for the SEWKP 2018-2019 program year.

Table 3-14: SB 310 Compliance Savings per Measure

Measure	Claimed Energy Savings (kWh)	Claimed Summer Demand Savings (kW)	Claimed Winter Demand Savings (kW)	Source
Low-flow Showerhead	438.0	0.035	0.050	DEO program reported savings
Low-flow Kitchen Aerator	451.4	0.036	0.051	DEO program reported savings
Low-flow Bathroom Aerator	110.9	0.009	0.012	DEO program reported savings
Pipe Wrap*	46.0	0.004	0.005	DEO program reported savings

* Savings for pipe tape is a per linear foot measurement

Table 3-15: SB 310 Compliance Savings per Kit

Kit Size	Population	SB 310 Claimed Energy (kWh)	SB 310 Claimed Summer Demand (kW)	SB 310 Claimed Winter Demand (kW)
Small Kit	1,350	1,157	0.092	0.132
Medium (new design)[13]	1,930	1,595	0.127	0.182
Medium (previous design)[14]	4	1,817	0.145	0.207
Total	**3,284**	**1,415**	**0.113**	**0.161**

Table 3-16: SB 310 Compliance Program Savings

Measurement	Ex-Ante Savings	Realization Rate	Ex-Post Savings
Energy (kWh)	4,647,978	100%	4,647,978
Summer Demand (kW)	370.2	100%	370.2
Winter Demand (kW)	528.9	100%	528.9

[13] 2 bathroom faucet aerators, 1 kitchen aerator, 2 showerheads

[14] 4 bathroom faucet aerators, 1 kitchen aerator, 2 showerheads

4 Net-to-Gross Methodology and Results

The evaluation team used participant survey data to calculate a net-to-gross (NTG) ratio for SEWKP. 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:

$$NTG = 1 - FR + SO$$

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.

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: respondents were only asked free ridership questions about items that remained installed by the date of the survey.

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.

$$FR = FRC + FRI$$

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 respondents who installed more than one of a given measure (bathroom

[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.*

aerators or showerheads) that indicated they would have installed either of the multi-count measures on their own, we asked them a follow up question that determined how many of the number installed through the program that they would have installed on their own.

For each measure, the evaluation team assigned one of the FRC values shown in the Table 4-1, based on the respondents' responses. FRC values range from 0.0 to 0.5.

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	$\frac{\text{Count respondent said would install on their own}}{\text{Count respondent installed through program}}$

*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 four 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 mailed to their home
- Information provided by Duke Energy about how the items would save energy and water
- Other information or advertisements from Duke Energy, including its website

Asking respondents to separately rate the influence of each of the four above items had on the decision to install each measure would have been overly burdensome. Therefore, while the survey assessed FRC for each measure type, it assessed collective FRI for all measures.

FRI is based on the highest-rated item in the FRI battery. The evaluation team assigned the following FRI scores, based on that rating (Table 4-2).

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 Total Free Ridership

The evaluation team calculated total free ridership by measure by calculating

- First, measure-specific FR scores for each respondent by summing each respondent's measure-specific FRC score with their FRI score.
- Second, a measure-specific average FR score across all respondents, weighted by the number of units installed by each respondent.

The evaluation team then estimated overall program-level free ridership by calculating a savings-weighted mean of the measure-specific FR scores. Table 4-3 presents the measure-specific and overall FR estimates.

Table 4-3: Measure-Specific Free Ridership Scores

End-use	Measure-Specific Free Ridership
Showerhead	0.116
Kitchen Faucet Aerator	0.059
Bathroom Faucet Aerator	0.081
Insulating Pipe Tape	0.093
Overall	**0.102**

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. 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 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, gross verified savings from DEO Smart $aver Program Evaluations, and algorithms and parameter assumptions listed in the 2010 Ohio TRM and the Illinois TRM v7.0.

Since Duke Energy offered program incentives for a variety of energy-saving measures throughout the evaluation period, we compared the list of customers reporting measures as spillover against participation records for other Duke Energy programs that offered the measure. To avoid double-counting savings for measures already claimed by another Duke Energy offering, we excluded savings from measures that appeared in another program's tracking data from our estimation of spillover savings.

Participant measure spillover is calculated as follows:

$$PMSO = Deemed\ Measure\ Savings * Program\ Attributable\ Percentage$$

The evaluation team summed all PMSO savings (Table 4-4).

Table 4-4: DEO Sample PMSO, by Measure by Category

Measure Category	Total kWh for Category	Percent Share of kWh
LEDs	5,612	27%
Water Heater	4,760	23%
HVAC	4,519	22%
Appliance	2,643	13%
Duct Sealing	1,261	6%
Insulation	1,116	5%
CFLs	332	2%
Windows	290	1%
Total	**20,533**	**100%**

The evaluation team then calculated gross program savings associated with sampled participants by summing the products of each measure's average per household savings and the total sample size (Table 4-5).

Table 4-5: DEO Sample Gross Program Savings (n=143)

Measure	Average per Household Savings (kWh)	Verified Sample Savings (kWh)
Showerhead	275.6	90,384
Kitchen Faucet Aerator	72.4	23,748
Bathroom Faucet Aerator	24.6	8,068
Insulating Pipe Tape	32.6	10,691
Total	**405.2**	**132,891**

The evaluation team then divided the summed jurisdictional PMSO values by the sample's gross program savings to calculate an estimated spillover percentage for the program:

$$Program\ SO = \frac{\sum PMSO}{\sum Sample\ Gross\ Program\ Savings}$$

$$DEO\ SO = \frac{20{,}533}{132{,}891} = 15.5\%$$

These calculations produced a spillover estimate of 15.5% for the DEO program.

4.3 Net-to-Gross

Inserting the FR and SO estimates into the NTG formula (NTG = 1 – FR + SO) produces an NTG value of 1.05 for the program (Table 4-6). The evaluation team applied this NTG ratio to program-wide verified gross savings to calculate SEWKP kit net savings for the jurisdiction (Table 4-7).

Table 4-6: Net-to-Gross Results

Jurisdiction	Free Ridership	Spillover	NTG
DEO	0.102	0.155	1.053

Table 4-7: Program Level Savings

Measurement	Population	Gross Verified	Net-to-Gross Ratio	Net Verified
Energy (kWh)		1,245,466		1,311,125
Summer Demand (kW)	3,284	89.8	105.3%	94.6
Winter Demand (kW)		139.6		147.0

5 Process Evaluation

5.1 Summary of Data Collection Activities

The process evaluation is based on interviews and surveys with program staff, implementer staff, and households who received a kit during the program 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: EFI	Phone in-depth interview	1	N/A	N/A
DEO participants	Mixed mode (web/phone) survey	328	3,284	90/±4.3

Comparisons with census data confirm that the DEO sample is fairly representative of income for the region, although higher income residents were slightly underrepresented and middle income residents were slightly overrepresented. Additionally, the sample demonstrated slightly greater educational attainment than that of the region.[16]

5.2 Process Evaluation Findings

Installation Rates

Nearly three-quarters (74%) of kit recipients installed at least one measure, each installing an average of two measures, and 9% of respondents reported initially installing at least one of each measure type. About half of kit recipients (53%) initially installed at least one of the showerheads, with roughly two-fifths (41%) reporting they installed at least one of the bathroom faucet aerators. A smaller portion reported installing kitchen faucet aerators (36%) or pipe wrap (36%). Of the respondents who received a medium-sized kit, about a quarter (24%) installed both showerheads[17]. Regardless of kit size, participants installed an average of one bathroom aerator and one showerhead.

Of the respondents who installed at least one item from the kit, 16% said they later uninstalled at least one of the measures, and 6% uninstalled everything that they had initially installed. In total, 8% of all initially installed measures were uninstalled at the time of the survey. Showerheads and bathroom faucet aerators had the highest uninstallation rates, with about one-tenth of respondents who installed them later uninstalling them (11% for showerheads and 10% for bathroom faucet aerators). Respondents who uninstalled these water-saving measures

[16] Region comparisons come from 2017 American Community Survey (Census) 5-year period estimates data for Brown, Butler, Clermont, Hamilton, and Warren Counties in Ohio.

[17] 54% of medium kit recipients installed at least one showerhead, 45% of which installed both that came with the kit.

indicated they did so because they did not like how they worked, later elaborating that the water pressure provided was insufficient for their preferences.

Customer Satisfaction

Nearly all kit recipients reported moderate to high satisfaction with the items they installed from their kit and with the program overall (Figure 5-1). We asked respondents to rate their satisfaction with all measures they installed, including those they later uninstalled to best gauge the experience of all participants. Respondents were most satisfied with the pipe wrap and kitchen faucet aerator, and nearly all participants (98%) were at least moderately satisfied with the program overall.

Figure 5-1: Participant Satisfaction with Measures and Overall Program*

* Respondents rated their satisfaction with the measures on a scale ranging from 0 ("very dissatisfied") to 10 ("very satisfied"). Dissatisfied indicates 0-4 ratings, moderately satisfied indicates 5-7 ratings, and highly satisfied indicates 8-10 ratings. Don't know ratings excluded.

Kit Instructional Materials

In addition to energy-saving measures, the Save Energy and Water Kit includes a detailed instruction insert booklet that provides information on how to install the provided measures. Most respondents (83%) said they read the booklet, and among those who did, more than three-quarters (78%) found it highly helpful.[18] Duke Energy also offers a customer care hotline that participants can call for additional assistance, but just 1% of respondents took advantage of the service.

Additional Energy Saving Actions

Some respondents (37%) reported purchasing and installing additional energy efficiency measures since receiving their kit (Table 5-2). Participants most commonly reported installing

[18] We asked respondents to rate the helpfulness of the instruction booklet on a scale from 0 ("not at all helpful") to 10 ("very helpful"). Two-hundred and twelve of the 273 (or 78%) respondents who reported reading the booklet gave a rating of 8 or higher.

LEDs (26%) or buying energy efficient appliances (11%). The majority of respondents (81%) who installed additional measures said DEO SEWKP at least partially influenced their decision to purchase and install additional energy-saving measures.

Table 5-2: Additional Energy Saving Measures Purchased by DEO Participants (Multiple Responses Allowed; n=328)

	Percent of Respondents Reporting Purchases After Receiving the Kit	Percent Reporting at Least Some DEO Program Influence on Purchase
At least one measure	37%	30%
LEDs	26%	22%
Efficient appliances	11%	9%
Air sealing	10%	8%
Efficient heating or cooling equipment	9%	7%
Insulation	9%	7%
Efficient water heater	6%	4%
Efficient windows	6%	4%
CFLs	3%	2%
Duct sealing	2%	2%
Other*	3%	3%

*Other measures included smart thermostats, water heater tank wrap, efficient doors, water-saving toilets, power surge protectors, window shades, and moving into an ENERGY STAR home, each of which represented <1% of respondents.

6 Conclusions and Recommendations

The evaluation findings led to the following conclusions and recommendations for the program.

Conclusion 1: The program model is highly successful: it leverages low-cost measures to foster energy savings that would not have happened otherwise. Duke Energy's easy process for requesting and receiving a kit with free energy and water-saving items motivated nearly 3,300 customers to request and install energy saving measures in their home during the evaluation period. Most participants installed at least one measure from the kit, few measures get uninstalled, and many participants reported installing additional energy saving items since receiving the kit. The majority of participants said they would not have installed any of the items on their own, as represented by low free ridership rates, and the program is reaching a diverse range of customers in terms of household characteristics and demographics.

> **Recommendation**: Continue using SEWKP to encourage Duke Energy customers to save energy and water.

Conclusion 2: The water-saving measures' low flow water pressure results in some minor dissatisfaction and uninstallation issues. Complaints of excessively low water pressure was the primary driver of measure dissatisfaction and uninstallation. However, only a minority of participants were dissatisfied with or uninstalled water-saving items.

> **Recommendation**: Monitor how showerhead upgrades affect satisfaction and uninstallation rates going forward.

Conclusion 3: Fewer participants are installing at least one measure. 74% of participants reported installing at least one item from the kit, down from 92% when the program was last evaluated in 2017. The reason for this trend is unclear, but there were substantially fewer installed showerheads, kitchen aerators, and bathroom aerators than in 2017.

> **Recommendation**: Monitor installation rates in other jurisdictions in upcoming evaluations to determine if this downward trend is unique to DEO, and reincorporate follow-up survey questions in future surveys to ask why participants had not installed any measures.

Conclusion 4: Recent program improvements have been largely successful. Despite lower overall installation rates than were found by the previous DEO evaluation, the new kitchen aerator appears to be a successful improvement for the measure category. Compared to the previously evaluated model, only slightly more than half as many uninstalled the measure. The new instructions provided with the kits also appear to denote a significant improvement from the prior instructions. Recent DEO participants rated the instructions as considerably more helpful than participants in the last evaluated program year (78% rated as "very helpful" up from 67% in 2017).

Appendix A Summary Form

Save Energy and Water Kit Program

Completed EMV Fact Sheet

Description of program

The Duke Energy Save Energy and Water Kit Program (SEWKP) is an energy efficiency program that offers energy-efficient water fixtures and water pipe insulation to residential customers. The program is designed to reach customers who have not adopted energy-efficient water devices. The kits are provided to residents through a Direct Mail Campaign, allowing eligible customers to request to have the items shipped directly to their homes, free of charge.

Date	April 6, 2020
Region(s)	Ohio
Evaluation Period	July 1, 2018 – June 30, 2019
Annual Gross MWh Savings	4,648*
Per Kit Gross kWh Savings	1,415*
Annual Gross MW Savings	Summer: 0.370* Winter: 0.529*
Net-to-Gross Ratio	1.053
Process Evaluation	Yes
Previous Evaluation(s)	2016
*Gross savings represent SB 310 claimed values	

Evaluation Methodology

Impact Evaluation Activities

- Telephone/web surveys (n=328) and analysis of 4 unique measures

Impact Evaluation Findings

- Realization rate: 100% for energy impacts; 100% for demand impacts
- Net-to-gross ratio: 105.3%

Process Evaluation Activities

- Telephone/web surveys with SEWKP participants (n=328) and analysis of 4 unique measures
- 1 interview with program staff
- 1 interview with implementation staff

Process Evaluation Findings

- The SEWKP influences participants to install kit measures and adopt new behaviors
- Participants are generally satisfied with kit items and report high satisfaction with overall program
- Kit size assignment algorithm is fairly accurate
- Low water pressure is a significant contributor to dissatisfaction among participants for water-saving kit items
- Pipe wrap is least popular measure; less than half of SEWKP participants installed pipe wrap

Appendix B Measure Impact Results

Table B-1: 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
Low-flow Showerhead (1.5 gpm)	438.0	0.035	0.050	100.0%	0.116	15.5%	103.9%	103.9%	10
Kitchen Faucet Aerator (1.0 gpm)	451.4	0.036	0.051	100.0%	0.059		109.5%	109.5%	10
Bathroom Faucet Aerator (1.0 gpm)	110.9	0.009	0.012	100.0%	0.081		107.4%	107.4%	10
Insulating Pipe Tape	46.0	0.004	0.005	100.0%	0.093		106.2%	106.2%	13

* Gross savings represent SB 310 claimed values

Appendix C Senate Bill 310 Legislation on Energy Efficiency Accounting

130th General Assembly Senate Bill Number 310

Sec. 4928.662. For the purpose of measuring and determining compliance with the energy efficiency and peak demand reduction requirements under section 4928.66 of the Revised Code, the public utilities commission shall count and recognize compliance as follows:

(A) Energy efficiency savings and peak demand reduction achieved through actions taken by customers or through electric distribution utility programs that comply with federal standards for either or both energy efficiency and peak demand reduction requirements, including resources associated with such savings or reduction that are recognized as capacity resources by the regional transmission organization operating in Ohio in compliance with section 4928.12 of the Revised Code, shall count toward compliance with the energy efficiency and peak demand reduction requirements.

(B) Energy efficiency savings and peak demand reduction achieved on and after the effective date of S.B. 310 of the 130th general assembly shall be measured on the higher of an as found or deemed basis, except that, solely at the option of the electric distribution utility, such savings and reduction achieved since 2006 may also be measured using this method. For new construction, the energy efficiency savings and peak demand reduction shall be counted based on 2008 federal standards, provided that when new construction replaces an existing facility, the difference in energy consumed, energy intensity, and peak demand between the new and replaced facility shall be counted toward meeting the energy efficiency and peak demand reduction requirements.

(C) The commission shall count both the energy efficiency savings and peak demand reduction on an annualized basis.

(D) The commission shall count both the energy efficiency savings and peak demand reduction on a gross savings basis.

(E) The commission shall count energy efficiency savings and peak demand reductions associated with transmission and distribution infrastructure improvements that reduce line losses. No energy efficiency or peak demand reduction achieved under division (E) of this section shall qualify for shared savings.

(F) Energy efficiency savings and peak demand reduction amounts approved by the commission shall continue to be counted toward achieving the energy efficiency and peak demand reduction requirements as long as the requirements remain in effect.

(G) Any energy efficiency savings or peak demand reduction amount achieved in excess of the requirements may, at the discretion of the electric distribution utility, be banked and applied toward achieving the energy efficiency or peak demand reduction requirements in future years.

Appendix D Program Performance Metrics

This appendix provides key program performance metrics, or PPIs. See Chapter 5 for the underlying results and more detailed findings.

Figure D-1: DEO Program Experience PPIs

	Participants %	Participants n
Program experience & satisfaction		
Overall program satisfaction	80%	242
Usefulness of kit instructions	78%	273
Measure satisfaction		
Showerhead	71%	174
Kitchen faucet aerator	83%	114
Bathroom faucet aerator	76%	132
Pipe wrap	78%	114
Program influence on behavior		
Installed at least one kit measure	74%	328
Most common measure installed: *showerhead*	53%	328
Respondents reporting program attributable spillover	18%	328
Challenges and opportunities for improvement		
Measure with lowest installation rate: *pipewrap*	36%	328
Measure with highest uninstallation rate: *kitchen faucet aerator*	11%	174
Measure with highest dissatisfaction: *showerhead*	6%	174

Figure D-2: DEO Participant Demographics PPIs

Ownership Status	
Own	93%
Rent	6%
Refused / Don't know	1%

Household Size	
One to two	56%
Three	16%
Four	13%
Five +	12%
Refused / Don't know	3%

Education	
High school or less	17%
Some college	32%
Bachelor's degree	26%
Graduate degree	19%
Refused / Don't know	6%

Income	
<$30k	5%
$30k to <$60k	24%
$60k to <$75k	12%
$75k to <$100k	15%
$100k+	16%
Refused / Don't know	29%

Age	
18 to 34	14%
35 to 44	16%
45 to 64	29%
65 and older	19%
Refused / Don't know	12%

Figure D-3: DEO Participant Household Characteristics PPIs

Housing Type	
Detached	77%
Attached	12%
Mobile	4%
Apartment or condo	3%
Duplex or triplex	2%

Water Heater Fuel Type	
Electric	87%
Natural Gas	8%
Other	4%

Home Size		
Area (ft^2)	Small Kit	Medium Kit
Less than 1,000	17%	1%
1,000-1,499	27%	12%
1,500-1,999	2%	34%
2,000-2,999	12%	28%
3,000+	5%	9%

Number of Showers		
Count	Small Kit	Medium Kit
1	46%	15%
2	46%	65%
3	5%	15%
4+	2%	4%

Number of Kitchen Faucets		
Count	Small Kit	Medium Kit
1	93%	89%
2	6%	8%
3+	1%	2%

Number of Bathroom Faucets		
Count	Small Kit	Medium Kit
1-2	68%	36%
3-4	29%	53%
5+	3%	10%

Appendix E Instruments

E.1 Program Staff In-Depth Interview Guide

Introduction

Today, we'll be discussing your role in the SEWKP or water kit program. We would like to learn about your experiences in administering this program.

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.

Roles & Responsibilities

Q1. Has your position at Duke Energy or your role in the water kit program changed at all since we spoke last year?

Program Delivery

Next, I'd like to learn more about how this program was delivered since your involvement. If the program implementation is different in 2019, please let me know.

Q2. Historically, the program used BRC mailers in the kit program. But recently you added some online components – which you told me about last year. Have these changes been rolled out to all jurisdictions? Have there been any changes since we last spoke?

Q3. Has Duke launched the upgrade store, where customers could upgrade to a higher-end item?

Q4. How popular or common are the upgrade requests?

Q5. How has the online channel been going? How successful is the online channel? How many kits come online vs. BRC?

Q6. Have you changed your BRC at all in the last year?

Q7. After the last time we spoke, you sent me a story board for a new video featuring a piggy bank character. I don't see that video online – was it ever made?

Q8. Are there any other changes to program delivery that have recently happened or are in the works?

Q9. EFI is still the implementer, right? Can you describe EFI's role? Any challenges with EFI lately? [IF NEEDED: what is EFI's role with the online component?]

Q10. Can you confirm the kit contents? Small with 1 showerhead, 2 bathroom aerators, 1 kitchen aerator, and one set of pipewrap; and large with the same contents except two showerheads instead of one?

Q11. Have any kit items changed since we last spoke other than the kitchen aerator?

Q12. Are there any other program delivery components that are unique to a specific jurisdiction?

Evaluation

Q13. Is there anything else about the program that we have not discussed that you feel should be mentioned? Is there anything else you'd like to learn from the program evaluation?

Q14. We are about to start surveying participants. Are there any questions or topics you'd like us to add before we start surveying?

Q15. One thing we need to do each year is make sure any LEDs that survey respondents said they installed on their own weren't from any Duke programs. I know of the following ways to get free/discounted LEDs from Duke (and some of these may be out of date):

1. Online savings store
2. Home energy house calls
3. School kits
4. Buy down brick-and-mortar locator – was that discontinued?
5. Any others I'm missing?
6. And do these all apply to all jurisdictions?

Those are all of my questions. Thank you very much for your time.

E.2 Implementer Staff In-Depth Interview Guide

Introduction

[*Note: Interviewer will schedule calls ahead of time via email.*]

Roles & Responsibilities

Q1. Can you describe your role in the SEWKP or water kit program?

Q2. How long have you been in this role?

Program Delivery

Q3. Can you describe your program processes? (From receipt of kit forms to sending kits)

Q4. [IF NOT DISCUSSED] Historically, the program used BRC mailers in the kit program. But recently Duke added some online components – can you tell me about this process?

Q5. I know the kitchen aerator was changed a year ago or so. Does the new one have three flow settings? What are they and what are they labeled as?

Q6. Have there been any other measure changes in the last year or so?

Q7. Are there any other changes to program delivery that have recently happened or are in the works?

Q8. Do these changes apply to all jurisdictions?

Q9. Are there any other program delivery components that are unique to a specific jurisdiction?

Q10. Are there any other issues unique to Kentucky that we should know about?

Q11. Are there any other issues unique to Carolinas that we should know about?

Q12. Are there any other issues unique to Progress that we should know about?

Q13. Are there any other issues unique to Ohio that we should know about?

Q14. What is the biggest challenge in implementing the water kit program?

Q15. If you could change one thing, what would it be?

Evaluation

Q16. Is there anything else about the program that we have not discussed that you feel should be mentioned?

Q17. We are about to start surveying participants. Are there any questions or topics you'd like us to add before we start surveying?

Q18. Is there anything else you'd like to learn from the program evaluation?

Those are all of my questions. Thank you very much for your time.

E.3 Participant Survey

Introduction/ Screening

[READ IF MODE=PHONE]

Q1. Hi, I'm _____, calling on behalf of Duke Energy. We are calling about the Save Energy and Water Kit you got from Duke Energy.
This kit included faucet aerators, one or two showerheads, and pipe wrap that can help you save water and 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?]

[INTERVIEWER INSTRUCTIONS: *If no adults are able to speak about the kit, thank and terminate*.]

Q2. [DISPLAY IF MODE=WEB]
We are conducting surveys about the Save Energy and Water Kit you got from Duke Energy. This kit included faucet aerators, one or two showerheads, and pipe wrap that can help you save water and energy in your home.
Do you recall receiving this kit?

1. Yes
2. No [TERMINATE]
98. Don't know [TERMINATE]

Motivation and Collateral

Q4. Did you read the included instructions on how to install the items that came in the kit?

1. Yes
2. No
98. Don't remember

[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 were the instructions on how to install the items that came in the kit?

0. Not at all helpful
1.
2.
3.
4.
5.
6.
7.
8.

9.
10. Very helpful
98. Don't know

[ASK IF Q5<7]
Q6. What might have made the instructions more helpful?
[RECORD VERBATIM ANSWER]

Assessing Measure Installation

[DISPLAY IF KIT_SIZE=SMALL]
We'd like to ask you about the energy and water-saving items included in your kit. The kit contained a showerhead, faucet aerators for the bathroom and kitchen, and pipe wrap.

[DISPLAY IF KIT_SIZE=MEDIUM]
We'd like to ask you about the energy and water-saving items included in your kit. The kit contained two showerheads, faucet aerators for the bathroom and kitchen, and pipe wrap.

Q10. Have you or anyone else installed any of those items in your home, even if they were taken out later? [SINGLE RESPONSE]
[*Interviewer: Throughout interview, remind respondent as needed to report whether someone else in the home installed or uninstalled any items.*]
1. Yes
2. No [→ Q24a]
98. Don't know [→ TERMINATE]

[ASK IF Q10 = 1]
Q11. Which of the items did you install, even if they were taken out later?
[MULTIPLE RESPONSE]
[*Interviewer: Record each response, then prompt with the list items.*]

Item
a. Showerhead
b. Kitchen faucet aerator
c. Bathroom faucet aerator
d. Pipe wrap
e. I don't remember which items were installed [→ TERMINATE]

[ASK IF Q11A = 1 AND KIT_SIZE=MEDIUM]
Q12. Your kit contained two showerheads. Did you install one or both of the showerheads in the kit, even if one or both were taken out later?
[SINGLE RESPONSE]
1. I installed both
2. I only installed one showerhead
98. Don't know

[ASK IF Q11C = 1]

Q13. How many of the bathroom faucet aerators from the kit did you install in your home, even if one or more were taken out later?

[SINGLE RESPONSE]

1. One
2. Two
3. Three [*DISPLAY IF KIT_SIZE=MEDIUM*]
4. Four [*DISPLAY IF KIT_SIZE=MEDIUM*]
98. Don't know

[ASK IF Q11D = 1]

Q14. Did you install all of the pipe insulation that was included with the kit?

[SINGLE RESPONSE]

1. Yes
2. No
98. Don't know

[ASK IF Q14 IS DISPLAYED]

Q15. About how many feet of the pipe extruding from your water heater did you wrap with the insulation **that came in the kit**? Please go over to your water heater if you need to check. [SINGLE RESPONSE]

1. About three feet or less
2. About five feet
3. About ten feet
4. About fifteen feet or more
98. Don't know

[ASK IF ANY PART OF Q11 = 1]

Q16. Overall, how satisfied are you with the item[s] you installed?

[DISPLAY IF MODE=PHONE] Please use a 0 to 10 scale, where 0 is very dissatisfied and 10 is very satisfied. How satisfied are you with...

DISPLAY IF	Item	Rating
Q11a = 1	a. Showerhead	0-10 with DK
Q11b = 1	b. Kitchen faucet aerator	0-10 with DK
Q11c = 1	c. Bathroom faucet aerator	0-10 with DK
Q11d = 1	d. Pipe wrap	0-10 with DK

[ASK IF ANY ITEMS IN Q16<7]

Q16a. Can you please explain any dissatisfaction you had with [DISPLAY ALL ITEMS IN Q16 THAT ARE <7]?

[OPEN END: RECORD VERBATIM]

Q17. Overall, how satisfied are you with Duke Energy's Save Energy and Water Kit Program? [DISPLAY IF MODE=PHONE] [IF NEEDED: Please use that same 0 to 10 scale, where 0 is very dissatisfied and 10 is very satisfied.]

0.	0. Very dissatisfied
1.	1.
2.	2
3.	3
4.	4
5.	5.
6.	6.
7.	7.
8.	8.
9.	9.
10.	10. Very satisfied
98.	Don't Know

[ASK IF ANY PART OF Q11 = 1]
Q18. Have you (or anyone in your home) uninstalled any of the items from the kit that you had previously installed? [SINGLE RESPONSE]

1. Yes
2. No
98. Don't know

[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 Q11a = 1] Showerhead[s]
2. [DISPLAY IF Q11b = 1] Kitchen faucet aerator
3. [DISPLAY IF Q11c = 1] Bathroom faucet aerator[s]
4. [DISPLAY IF Q11d = 1] Pipe wrap
98. Don't know [*EXCLUSIVE ANSWER*]

[ASK IF Q19.1 = 1 AND Q12 = 1]
Q20. Did you uninstall one or both of the showerheads you had previously installed? [SINGLE RESPONSE]

1. I uninstalled both
2. I only uninstalled one of the showerheads
98. Don't know

[ASK IF Q19.3 = 1 AND Q13 = 2-4]
Q21. How many bathroom faucet aerators did you uninstall? [SINGLE RESPONSE]

1. One [*DISPLAY IF Q13 = 1-4*]
2. Two [*DISPLAY IF Q13 = 2-4*]

3. Three [*DISPLAY IF Q13 = 3-4*]
4. Four [*DISPLAY IF Q13 = 4*]
98. Don't know

[CALCULATE SHOWERHEAD:
IF Q12 = 1, THEN SHOWERHEAD = 2;
IF Q12 = 2 OR (Q11_1 = 1 AND KIT_SIZE = SMALL), THEN SHOWERHEAD = 1;
ELSE SHOWERHEAD = 0]

[CALCULATE KITCHEN:
IF Q11_2 = 1, THEN KITCHEN = 1, ELSE KITCHEN=0]

[CALCULATE BATH:
IF Q13 = 2, THEN BATH = 2;
IF Q13 = 1, THEN BATH = 1;
ELSE BATH = 0]

[CALCULATE PIPEWRAP:
IF Q11_4 = 1, THEN PIPEWRAP = 1, ELSE PIPEWRAP=0]

[CALCULATE SHOWERHEAD_I:
IF SHOWERHEAD = 1 AND Q19_1 = 1, THEN SHOWERHEAD_I = 0;
IF Q19_1 = 1 AND (Q20 = 1 OR Q20 = 98), THEN SHOWERHEAD_I = 0;
IF Q19_1 = 1 AND Q20 = 2, THEN SHOWERHEAD_I = 1;
ELSE SHOWERHEAD_I = SHOWERHEAD]

[CALCULATE KITCHEN_I:
IF Q19_2 = 1, THEN KITCHEN_I = 0;
ELSE KITCHEN_I = KITCHEN]

[CALCULATE BATH_I:
IF BATH = 1 AND Q19_3 = 1, THEN BATH_I = 0;
IF Q19_3 = 1 AND (Q21 = 2 OR Q21 = 98), THEN BATH_I = 0;
IF Q19_3 = 1 AND Q21 = 1, THEN BATH_I = 1;
ELSE BATH_I = BATH]

[CALCULATE PIPEWRAP_I:
IF Q19_4 = 1, THEN PIPEWRAP_I = 0;
ELSE PIPEWRAP_I = PIPEWRAP]

CALCULATE TOTAL_I:
[SHOWERHEAD_I + BATH_I + KITCHEN_I + PIPEWRAP_I]

[ASK IF ANY OF Q19.1-4 IS SELECTED]
Q22. Why were those items uninstalled?
[READ IF MODE=PHONE] 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, or 96. Some other reason (specify: _______) 98. Don't know
	b. Kitchen faucet aerator	Repeat reason options
	c. Bathroom faucet aerator	Repeat reason options
	d. Pipe wrap	Repeat reason options

Q24a. Customers that need additional assistance with their items can call a toll-free customer care hotline. Did you call the customer care hotline to seek assistance in installing any of your items?

1. Yes
2. No
98. Don't know

[ASK IF Q24a = 1]
Q24b. Did you call the customer care hotline to seek assistance in installing your kitchen faucet aerator?

1. Yes
2. No
98. Don't know

[ASK IF Q24b = 1]
Q24c. Did the customer care hotline offer to send you an adapter for the kitchen faucet aerator?

1. Yes
2. No
98. Don't know

[ASK IF Q24a = 1]
Q24d. Did you call the customer care hotline to seek assistance in installing your bathroom faucet aerator?

1. Yes
2. No
98. Don't know

[ASK IF Q24d = 1]

Q24e. Did the customer care hotline offer to send you an adapter for the bathroom faucet aerator?

1. Yes
2. No
98. Don't know

[ASK IF Q11a = 1 AND AT LEAST ONE SHOWERHEAD STILL INSTALLED]

Q29. On average, what is the typical shower length in your household?

1. One minute or less
2. Two to four minutes
3. Five to eight minutes
4. Nine to twelve minutes
5. Thirteen to fifteen minutes
6. Sixteen to twenty minutes
7. Twenty-one to thirty minutes
8. More than thirty minutes
98. Don't know

[ASK IF AT LEAST ONE SHOWERHEAD STILL INSTALLED]

Q30. [DISPLAY IF TWO SHOWERHEADS STILL INSTALLED: Thinking of the efficient showerhead you installed that gets the most usage…]
[DISPLAY IF ONE SHOWERHEAD STILL INSTALLED: Thinking of the efficient showerhead currently installed in your home…]
On average, how many showers per day are taken in this shower?

1. Less than one
2. One
3. Two
4. Three
5. Four
6. Five
7. Six
8. Seven
9. Eight or more
98. Don't know

[ASK IF TWO SHOWERHEADS STILL INSTALLED]

Q31. Thinking of the other efficient showerhead you installed…
On average, how many showers per day are taken in this shower?

1. Less than one
2. One
3. Two
4. Three
5. Four
6. Five
7. Six
8. Seven
9. Eight or more

98. Don't know

Q32. [This question was moved to demographics section – but not renumbered for programming purposes]

NTG

[IF TOTAL_I = 0, SKIP TO Q40]

Q33. 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

[ASK IF Q33 = 1]

Q34. What items would you have purchased and installed within the next year?
[MULTIPLE RESPONSES]

Q34_1. [IF SHOWERHEAD_I > 0] Energy-efficient showerhead[s]
Q34_2. [IF KITCHEN_I > 0] Energy-efficient kitchen faucet aerator
Q34_3. [IF BATH_I > 0] Energy-efficient bathroom faucet aerator[s]
Q34_4. [IF PIPEWRAP_I > 0] Pipe wrap
Q34_7. Don't know [EXCLUSIVE ANSWER]

[ASK IF Q34_1 = 1 AND SHOWERHEAD_I = 2]

Q35. If you had not received them in your free kit, how many energy-efficient showerheads would you have purchased and installed within the next year?

1. One
2. Two

98. Don't know

[ASK Q34.3=1 AND IF MORE THAN ONE BATHROOM AERATOR IS STILL INSTALLED]

Q36. If you had not received them in your free kit, how many energy-efficient bathroom aerators would you have purchased and installed within the next year?

1. One
2. Two
98. Don't know

Q37. Now, thinking about the energy and 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 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
The fact that the items were mailed to your house	0-10 scale with DK
Information provided by Duke Energy about how the items would save energy and water	0-10 scale with DK
Other information or advertisements from Duke Energy, including its website	0-10 scale with DK

Q40. Since receiving your 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

[ASK IF Q40 = 1]
Q41. 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]
Q41_4. Bought energy efficient appliances
Q41_5. Moved into an ENERGY STAR home
Q41_6. Bought efficient heating or cooling equipment
Q41_7. Bought efficient windows
Q41_8. Added insulation
Q41_9. Sealed air leaks in windows, walls, or doors
Q41_10. Sealed or insulated ducts
Q41_11. Bought LEDs
Q41_12. Bought CFLs
Q41_13. Installed an energy efficient water heater
Q41_14. None – no other actions taken [EXCLUSIVE ANSWER]
Q41_15. Other, please specify: ____________________
Q41_16. Don't know [EXCLUSIVE ANSWER]

[ASK IF Q41_5 = 1]
Q42. Is Duke Energy still your gas or electricity utility?
1. Yes

2. No
98. Don't know

[ASK IF ANY ITEM IN Q41 WAS SELECTED]

Q46. 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 Save Energy and Water Kit Program have on your decision to…

[MATRIX QUESTION: SCALE]

[LOGIC] ITEM	Response
[IF Q41_4 IS SELECTED] Q46_4 Buy energy efficient appliances	0-10 scale with DK
[IF Q41_5 IS SELECTED] Q46_5 Move into an ENERGY STAR home	0-10 scale with DK
[IF Q41_6 IS SELECTED] Q46_6 Buy efficient heating or cooling equipment	0-10 scale with DK
[IF Q41_7 IS SELECTED] Q46_7 Buy efficient windows	0-10 scale with DK
[IF Q41_8 IS SELECTED] Q46_8 Add insulation	0-10 scale with DK
[IF Q41_9 IS SELECTED] Q46_9 Seal air leaks in windows, walls, or doors	0-10 scale with DK
[IF Q41_10 IS SELECTED] Q46_10 Seal or insulate ducts	0-10 scale with DK
[IF Q41_11 IS SELECTED] Q46_11 Buy LEDs	0-10 scale with DK
[IF Q41_12 IS SELECTED] Q46_12 Buy CFLs	0-10 scale with DK
[IF Q41_13 IS SELECTED] Q46_13 Install an energy efficient water heater	0-10 scale with DK
[IF Q41_15 IS SELECTED] Q46_15 **[Q41 open ended response]**	0-10 scale with DK

[ASK IF Q41_1 IS SELECTED AND Q46_1 <> 0]

Q47. What kinds of appliance(s) did you buy?
[*Do not read list*] [MULTIPLE RESPONSE]

Q47_4 Refrigerator
Q47_5 Stand-alone Freezer
Q47_6 Dishwasher
Q47_7 Clothes washer
Q47_8 Clothes dryer
Q47_9 Oven
Q47_10 Microwave
Q47_11 Other, please specify: ____________
Q47_12 Don't know

[ASK IF Q47 = 4, 5, 6, 7, 8, 10, OR 11]

Q48. Was the [INSERT Q47 RESPONSE] an ENERGY STAR or high-efficiency model?

1. Yes
2. No
98. Don't know
99. Refused

[REPEAT THIS QUESTION FOR EACH ITEM MENTIONED IN Q47]

[ASK IF Q47 = 8]

Q49. Does the new clothes dryer use natural gas?

1. Yes - it uses natural gas

2. No – does not use natural gas
98. Don't know
99. Refused

[ASK IF Q41 = 6 AND Q46_6 > 0]
Q50. What type of heating or cooling equipment did you buy?
[*Do not read list*] [MULTIPLE RESPONSE]
Q50_4 Central air conditioner
Q50_5 Window/room air conditioner unit
Q50_6 Wall air conditioner unit
Q50_7 Air source heat pump
Q50_8 Geothermal heat pump
Q50_9 Boiler
Q50_10 Furnace
Q50_11 Wifi
Q50_12 Other, please specify: ________________
Q50_13 Don't know

[ASK IF Q50 = 9 OR 10]
Q51. Does the new [INSERT Q50 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 Q50= 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, OR 12]
Q52. Was the [INSERT Q50 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 Q50, EXCLUDING WIFI THERMOSTAT]

[ASK IF Q41 = 7 AND Q46_7 > 0]
Q53. Do you know how many windows you installed??
1. Yes (please specify how many you installed) [NUMERIC OPEN END]
2. No

[ASK IF Q41=8 AND Q46_8 > 0]
Q54. Please let us know what spaces you added insulation to. Also, let us know the proportion of each space you added insulation to (for example, if you added insulation that covered your entire attic space, you would type in 100%).

	Check here for each space you added insulation to	Use these boxes to type in the approximate proportion of each space you added insulation to
1. Attic		[NUMERIC 0-100] %
2. Walls		[NUMERIC 0-100] %
3. Below the floor		[NUMERIC 0-100] %

[ASK IF Q41= 11 AND Q46_11 > 0]
Q55. Do you know how many LEDs you installed at your property?
1. Yes (please specify how many you installed) [NUMERIC OPEN END]
2. No

[ASK IF Q41 = 12 AND Q46_12 > 0]
Q56. Do you know how many CFLs you installed at your property?
1. Yes (please specify how many you installed) [NUMERIC OPEN END]
2. No

[ASK IF Q41 = 13 AND Q46_13 > 0]
Q57. 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

[ASK IF Q41 = 13 AND Q46_13 > 0]
Q58. Which of the following water heaters did you purchase?
1. A traditional water heater with a large tank that holds the hot water
2. A tankless water heater that provides hot water on demand
3. A solar water heater
4. Other, please specify: _______________
98. Don't know

[ASK IF Q41= 13 AND Q46_13 > 0]
Q59. Is the new water heater an ENERGY STAR model?
[SINGLE RESPONSE]
1. Yes
2. No
98. Don't know

Demographics

Lastly, we have some basic demographic questions for you. Please be assured that your responses are confidential and are for statistical purposes only.
Q60. 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. Prefer not to say

Q61. How many showers are in your home? Please include both stand-up showers and bathtubs with showerheads.

1. One
2. Two
3. Three
4. Four
5. Five or more
98. Don't know

Q62. How many bathroom sink faucets are in your home? (Keep in mind that some bathrooms may have multiple bathroom sink faucets in them)

1. One
2. Two
3. Three
4. Four
5. Five
6. Six
7. Seven
8. Eight or more
98. Don't know

Q63. How many kitchen faucets are in your home?

1. One
2. Two
3. Three
4. Four or more
98. Don't know

Q63a. [ASK IF [Q63=2,3,4] You mentioned that you have more than one kitchen faucet. Where is/are your other kitchen faucet(s) located in your home?
[OPEN-ENDED: RECORD VERBATIM RESPONSE]

Q32. What fuel type does your water heater use?

1. Electric
2. Natural Gas

3. Other, please specify: [OPEN-ENDED RESPONSE]
4. Don't know

Q64. 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. Prefer not to say

Q65. Do you or members of your household own your home, or do you rent it?

1. Own / buying
2. Rent / lease
3. Occupy rent-free
98. Don't know
99. Prefer not to say

Q66. 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. Prefer not to say

Q67. What was your total annual household income for 2016, 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

Q68. 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

Q69. Finally, what is your year of birth?

[Scroll box with years 1900-2010, and Prefer not to say

Appendix F DEO Participant Survey Results

This section reports the results from each question in the DEO participant survey. Since the results reported in this appendix represent the "raw" data (that is, none of the open-ended responses have been coded and none of the scale questions have been binned), some values may be different from those reported in the Process Evaluation Findings chapter (particularly: percentages in tables with "Other" categories and scale response questions). Only respondents who completed the survey are included in the following results.

Q1. [Read if mode = phone] Hi, I'm ______, calling on behalf of Duke Energy. We are calling about the Save Energy and Water Kit you got from Duke Energy.

This kit included faucet aerators, one or two showerheads, and pipe wrap that can help you save water and energy in your home. Do you recall receiving this kit?

Response Option	Percent (n=70)
Yes	100%
No	0%
Don't know	0%

Q2. [Display if mode = web] We are conducting surveys about the Save Energy and Water Kit you got from Duke Energy. This kit included faucet aerators, one or two showerheads, and pipe wrap that can help you save water and energy in your home.

Do you recall receiving this kit?

Response Option	Percent (n=258)
Yes	100%
No	0
Don't know	0

Q4. Did you read the included instructions on how to install the items that came in the kit?

Response Option	Percent (n=328)
Yes	83%
No	12%
Don't remember	5%

Q5. [Ask if Q4 = YES] On a scale from 0 to 10, where 0 is not at all helpful and 10 is very helpful, how helpful were the instructions on how to install the items that came in the kit?

Response Option	Percent (n=273)
Not at all helpful	0%
1	0%
2	1%
3	1%
4	1%
5	4%
6	3%
7	8%
8	23%
9	19%
10 - Very helpful	36%
Don't Know	4%

Q6. [Ask if Q5<7] What might have made the instructions more helpful?

Verbatim Response	Count (n=25)
Don't know	2
Us not knowing how to do it	1
Unable to remember, it was a long time ago.	1
Too confusing for me to figure out	1
someone to help an old lady	1
Nothing, the items just weren't very complicated to need much instruction.	1
Nothing, just didn't need em'	1
Nothing, I already had a good understanding of how all components in the kit work	1
nothing	1
None	1
no clue.	1
More user friendly instructions	1
More details	1
Larger print	1
It was like of the things fit anything, the only that fit was the shower head, none of the spouts for the sink fit	1
Illustrations	1
I had trouble understanding them but I was able to find someone to help me	1
I dont think these items really require instructions.	1
I don't remember too well	1
I don't know. I'm not sure	1
I don't know. I didn't install it.	1

Verbatim Response	Count (n=25)
I didn't need them	1
Don't remember	1
Better pictures	1

Q10. Have you or anyone else installed any of those items in your home, even if they were taken out later?

Response Option	Percent (n=328)
Yes	74%
No	26%
Don't Know	0%

Q11. [Ask if Q10 = YES] Which of the items did you install, even if they were taken out later?

Response Option	Percent (n=328)*
Showerhead	53%
Kitchen faucet aerator	36%
Bathroom faucet aerator	41%
Pipe wrap	36%
I don't remember	0%

* Multiple responses were allowed for this question

Q12. [Ask if Q11 = SHOWERHEAD AND KIT_SIZE= MEDIUM] Your kit contained two showerheads. Did you install one or both of the showerheads in the kit, even if one or both were taken out later?

Response Option	Percent (n=96)
I installed both	45%
I only installed one showerhead	55%
Don't know	0%

Q13. [Ask if Q11 = BATHROOM FAUCET AERATOR] How many of the bathroom faucet aerators from the kit did you install in your home, even if one or more were taken out later?

Response Option	Percent (n=137)
One	54%
Two	45%
Don't know	1%

Q14. [Ask if Q11 = PIPEWRAP] Did you install all of the pipe insulation that was included with the kit?

Response Option	Percent (n=117)
Yes	80%
No	17%
Don't know	3%

Q15. [Ask if Q14 is displayed] About how many feet of the pipe extruding from your water heater did you wrap with the insulation **that came in the kit**? Please go over to your water heater if you need to check.

Response Option	Percent (n=117)
About three feet or less	38%
About four to five feet	28%
About six feet or more	8%
Don't know	26%

Q16. [Ask if any part of Q11 = YES] Overall, how satisfied are you with the item[s] you installed?

Showerhead

Response Option	Percent (n=175)
0 - Very dissatisfied	2%
1	1%
2	1%
3	1%
4	3%
5	3%
6	7%
7	10%
8	12%
9	16%
10 - Very satisfied	43%
Don't know	1%

Kitchen Faucet Aerator

Response Option	Percent (n=117)
0 – Very dissatisfied	1%
1	0%
2	1%
3	3%
4	2%

Response Option	Percent (n=117)
5	5%
6	2%
7	3%
8	21%
9	15%
10 - Very satisfied	45%
Don't know	1%

Bathroom Faucet Aerator

Response Option	Percent (n=135)
0 – Very dissatisfied	1%
1	0%
2	1%
3	0%
4	3%
5	6%
6	4%
7	9%
8	18%
9	15%
10 - Very satisfied	41%
Don't know	1%

Pipe Wrap

Response Option	Percent (n=117)
0 – Very dissatisfied	1%
1	0%
2	0%
3	0%
4	2%
5	4%
6	7%
7	8%
8	13%
9	13%
10 - Very satisfied	50%
Don't know	3%

Q16a. Can you please explain any dissatisfaction you had with [DISPLAY ALL ITEMS IN Q16 THAT ARE <7]?

Showerhead

Verbatim Response	Count (n=31)
No	2
Works well, just not very good looking. Looks cheap	1
Weak stream	1
very light pressure	1
The water flow wasn't very forceful	1
Prefer hand held	1
plastic	1
Our water pressure is already low, showerhead decreases pressure even more	1
Not good water pressure	1
Not enough settings	1
None	1
My husband didn't like it with only 1 shower head.	1
lower flow	1
Low water pressure, takes longer to rinse.	1
Limited spray area	1
like harder spray	1
less water pressure	1
its just the water pressure that comes out, its weak	1
it took about thirty minutes to take a shower because no water came out of the shower, water don't come out and its suppose to save water	1
it didn't affect my bill at all. I pay the same price for any amount of usage	1
I think it hold up to use, just using it broke on us, it broke with normal, it wasn't very long, a couple weeks	1
I have use adapter	1
I have no water pressure so this showerhead just made it worse	1
I don't know, my dad replaced it with a better one, it was just heavier, material was better	1
I don't care for the spray pattern	1
I did not care for the style and it seemed to have less pressure.	1
flow	1
Feel like the water output isn't very strong. Would like more power.	1
Decreased pressure	1
Cut water pressure	1

Kitchen Faucet Aerator

Verbatim Response	Count (n=15)
No	2
Wasn't a great design, cheaply made	1
Very low pressure. It takes a lot longer to wash dishes, fill pots, pitchers, etc...	1
slow sink fill	1
None	1
made water too slow	1
less water pressure	1
It seems cheap and flimsy	1
it just kinda got in the way, I kinda liked it I liked how it swiveled around, but it kinda got in the way	1
It has very low flow so it is not a practical item day to day.	1
didnt seem to flow correctly but still on	1
Did not work properly	1
Cut water pressure	1
Bulky	1

Bathroom Faucet Aerator

Verbatim Response	Count (n=20)
Wasn't the same pressure we were used to	1
too slow	1
They are fine just haven't had long enough to know if any issues	1
There was a noticeable drop in water pressure after the aerators were installed.	1
slow water pressure	1
reduced flow in an already low flowing faucet. Now it takes 3 minutes or more to get hot water	1
N/A	1
light pressure	1
less water pressure	1
It was ok	1
It sprays water out of a tiny crack in the base	1
It seems like the water pressure is worse.	1
It just didn't put out the wAter pressure I wanted	1
It decreased pressure immediately (which is fine), but the pressure has continued to decrease overtime and	1

now it only a trickle of water. It seems clogged and I haven't had the time to uninstall to check it.	
I put it in a utility sink and it does not allow enough water to clean the items I out under it. It does restrict the water flow. I guess that is the purpose of it.	1
Doesn't fit the faucet correctly.	1
Didn't fit well or work well	1
Didn't fit well	1
Did not work properly	1
A little slow	1

Pipe wrap

Verbatim Response	Count (n=16)
N/A	3
To short	1
Not enough	1
Not as adhesive as needed	1
None really... just not sure I see much value	1
No easy to use... I only have one arm so it was not used friendly	1
As it hasn't been colder yet have not been able to see if it will help	1
N	1
It was ok wish that it came with more and easier to start	1
I have none.	1
Didn't stick well	1
couldn't wrap very much. i only got about 1 and half feet wrapped. i have a few 90 degree angle of pipe that were hard to wrap and probably used more than i needed to get them wrapped. still its better than nothing and it was free. :D	1
Can't really tell effectiveness	
Came unwrapped	1

Q17. Overall, how satisfied are you with Duke Energy's Save Energy and Water Kit Program?

Response Options	Percent (n=242)
0 - Very dissatisfied	1%
1	1%
2	0%
3	1%
4	1%

5	5%
6	2%
7	10%
8	10%
9	17%
10 - Very satisfied	52%
Don't know	2%

Q18. [Ask if any part of Q11 = YES] Have you (or anyone in your home) uninstalled any of the items from the kit that you had previously installed?

Response Option	Percent (n=242)
Yes	16%
No	80%
Don't know	4%

Q19. [Ask if Q18 = YES] Which of the items did you uninstall?

Response Option	Count (n= 38)*
Showerhead	20
Kitchen faucet aerator	9
Bathroom faucet aerator	14
Pipe wrap	4
Don't know	0

* Multiple responses were allowed for this question

Q20. [Ask if Q19 = SHOWERHEAD and Q12 = INSTALLED BOTH] Did you uninstall one or both of the showerheads you had previously installed?

Response Option	Percent (n=3)
I only uninstalled one of the showerheads	67%
Don't know	33%

Q21. [Ask if Q19 = BATHROOM FAUCET AERATOR and Q13 = 2-4] How many bathroom faucet aerators did you uninstall?

Response Option	Percent (n=7)
One	29%
Two	57%
Don't know	14%

Q22. [Ask if any item of Q19 is selected] Why were those items uninstalled?

Showerhead

Response Option	Percent (n=20)*
It was broken	5%
Didn't like how it worked	35%
Didn't like how it looked	5%
Other	55%
Don't know	5%

* Multiple responses were allowed for this question

Verbatim Other Responses	Count (n=11)
We replaced the faucets.	1
We did not remove the showerhead--we are still using it now.	1
Water pressure	1
Replaced with larger shower head with more water pressure	1
Not enough settings	1
Not enough pressure.	1
My husband didn't like it	1
it wasn't removed. i marked it wrong. wouldn't let mecorrect it.	1
i wanted to install a shower head that is on a hose that I could remove from the wall	1
he had found a better one	1
clogged	1

Kitchen faucet aerator

Response Options	Percent (n=9)*
It was broken	11%
Didn't like how it worked	56%
Didn't like how it looked	11%
Other	33%
Don't know	0%

* Multiple responses were allowed for this question

Verbatim Other Response	Count (n=3)
We needed a water filter attached	1
just kinda got in the way	1
Didn't fit	1

Bathroom faucet aerator

Response Options	Percent (n=14)*
It was broken	0%
Didn't like how it worked	43%
Didn't like how it looked	7%
Other	50%
Don't know	7%

* Multiple responses were allowed for this question

Verbatim Other Responses	Count (n=7)
We replaced the faucets.	1
The faucet broke and a new one was purchased it wouldn't fit the one bought.	1
it seemed clogged	1
had to get new plumbing	1
Faucet was broken upon removal of old aerator	1
clogged	1
calcium is build up	1

Pipe wrap

Response Options	Percent (n=4)*
It was broken	0%
Didn't like how it worked	0%
Didn't like how it looked	25%
Other	25%
Don't know	50%

* Multiple responses were allowed for this question

Verbatim Other Responses	Count (n=1)
Came unwrapped	1

Q24a. Customers that need additional assistance with their items can call a toll-free customer care hotline. Did you call the customer care hotline to seek assistance in installing any of your items?

Response Option	Percent (n=328)
Yes	1%
No	98%
Don't know	1%

Q24b. [ASK IF Q24a = YES] Did you call the customer care hotline to seek assistance in installing your kitchen faucet aerator?

Response Option	Percent (n=5)
Yes	20%
No	80%
Don't know	0%

Q24c. [ASK IF Q24b = YES] Did the customer care hotline offer to send you an adapter for the kitchen faucet aerator?

Response Option	Percent (n=1)
Yes	100%
No	0%
Don't know	0%

Q24d. [ASK IF Q24a = YES] Did you call the customer care hotline to seek assistance in installing your bathroom faucet aerator?

Response Option	Percent (n=5)
Yes	20%
No	80%
Don't know	0%

Q24e. [ASK IF Q24d = YES] Did the customer care hotline offer to send you an adapter for the bathroom faucet aerator?

Response Option	Percent (n=1)
Yes	100%
No	0%
Don't know	0%

Q29. [Ask if Q11 = SHOWERHEAD and at least one showerhead is still installed] On average, what is the typical shower length in your household?

Response Option	Percent (n=155)
One minute or less	0%
Two to four minutes	5%
Five to eight minutes	34%
Nine to twelve minutes	36%

Response Option	Percent (n=155)
Thirteen to fifteen minutes	12%
Sixteen to twenty minutes	8%
Twenty-one to thirty minutes	3%
More than thirty minutes	1%
Don't know	3%

Q30. [DISPLAY IF TWO SHOWERHEADS STILL INSTALLED: Thinking of the efficient showerhead you installed that gets the most usage…]

[DISPLAY IF ONE SHOWERHEAD STILL INSTALLED: Thinking of the efficient showerhead currently installed in your home…]

On average, how many showers per day are taken in this shower?

Response Option	Percent (n=155)
Less than one	8%
One	32%
Two	39%
Three	12%
Four	7%
Six	1%
Seven	1%
Eight or more	0%
Don't know	0%

Q31. [Ask if two showerheads still installed] Thinking of the other efficient showerhead you installed…

On average, how many showers per day are taken in this shower?

Response Option	Percent (n=40)
Less than one	22%
One	28%
Two	33%
Three	8%
Four	5%
Five	2%
Six	0%
Seven	0%
Eight or more	0%
Don't know	2%

Q32. What fuel type does your water heater use?

Response Option	Percent (n=328)
Electric	87%
Natural gas	8%
Other (please specify in the box below)	4%
Don't know	2%

Verbatim Other Response	Count (n=13)
Propane	5
Fuel oil	2
Propaq	1
propane, in the process of having natural gas installed	1
Pellet stove	1
Oil and heat pump	1
LP	1
geo thermal	1

Q33. [Ask if any item was selected in Q11 and it's not the case that all parts of Q19 are selected (that is, they installed anything and did not uninstall everything they installed)] 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	Percent (n=227)
Yes	24%
No	58%
Don't know	18%

Q34. [Ask if Q33 = YES] What items would you have purchased and installed within the next year?

Response Option	Count (n=54)*
Showerhead	32
Kitchen faucet aerator	10
Bathroom faucet aerator	17
Pipe wrap	17
Don't know	2

*Multiple responses were allowed for this question

Q35. [Ask if Q34 = SHOWERHEAD and two showerheads are still installed] If you had not received them in your free kit, how many energy-efficient showerheads would you have purchased and installed within the next year?

Response Option	Percent (n=11)
One	45%
Two	55%
Don't know	0%

Q36. [Ask if Q34 = BATHROOM FAUCET AERATOR and if more than one bathroom aerator is still installed] If you had not received them in your free kit, how many energy-efficient bathroom aerators would you have purchased and installed within the next year?

Response Option	Percent (n=6)
One	17%
Two	83%
Don't know	0%

Q37. [If Q33 was displayed] Now, thinking about the energy and 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 items from the kit? How influential was…

The fact that the items were free

Response Option	Percent (n=227)
Not at all influential	2%
1	0%
2	0%
3	1%
4	1%
5	6%
6	1%
7	4%
8	11%
9	14%
10 - Extremely influential	61%
Don't know	0%

The fact that the items were mailed to your home

Response Option	Percent (n=227)
0- Not at all influential	3%
1	1%
2	0%

3	0%
4	1%
5	2%
6	1%
7	5%
8	10%
9	15%
10 - Extremely influential	63%
Don't know	0%

Information provided by Duke Energy about how the items would save energy and water

Response Option	Percent (n=227)
0- Not at all influential	1%
1	1%
2	1%
3	1%
4	1%
5	6%
6	4%
7	9%
8	14%
9	13%
10 - Extremely influential	50%
Don't know	0%

Other information or advertisements from Duke Energy, including its website

Response Option	Percent (n=227)
0- Not at all influential	12%
1	3%
2	4%
3	2%
4	3%
5	10%
6	3%
7	8%
8	10%
9	10%
10 - Extremely influential	29%

Response Option	Percent (n=227)
Don't know	6%

Q40. Since receiving your 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	Percent (n=328)
Yes	37%
No	60%
Don't know	3%

Q41. [If Q40 = YES] What **products** have you purchased and installed to help save energy in your home?

Response Option	Percent (n=328)*
Bought energy efficient appliances	11%
Moved into an ENERGY STAR home	0%
Bought efficient heating or cooling equipment	9%
Bought efficient windows	6%
Added insulation	9%
Sealed air leaks in windows, walls, or doors	10%
Sealed or insulated ducts	2%
Bought LEDs	26%
Bought CFLs	3%
Installed an energy efficient water heater	6%
None – no other actions taken	0%
Other	4%
Don't know	0%

* Multiple responses were allowed for this question

Verbatim Other Responses	Count (n=14)
toilets	1
Thermostat.	1
the curly lightbulbs	1
Solar exterior lighting	1
Replaced older style lightbulbs with LED bulbs	1
put a energy saving blanket on my water hearter	1
power surge protector	1
New shades	1
New door and seals	1

Nest	1
Installed term regulating plastic folie on windows	1
hot water tank wrap	1
Heat Pump, Water Heater.	1
energy saving doors	1

Q42. [If Q41 = MOVED INTO AN ENERGY STAR HOME] Is Duke Energy still your gas or electricity utility?

Response Option	Count (n=1)
Yes	100%
No	0%
Don't know	0%

Q46. [Ask if any item in Q41 was selected] 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 Save Energy and Water Kit Program have on your decision to…

Response Option	0	1	2	3	4	5	6	7	8	9	10	Don't know	n
Buy energy efficient appliances	19%	0%	3%	8%	8%	5%	3%	3%	11%	5%	32%	3%	37
Move into an ENERGY STAR home	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1
Buy efficient heating or cooling equipment	24%	3%	7%	0%	7%	3%	7%	3%	3%	14%	28%	0%	29
Buy efficient windows	37%	0%	5%	0%	11%	5%	5%	11%	11%	5%	11%	0%	19
Add insulation	21%	0%	7%	3%	3%	10%	7%	3%	14%	7%	24%	0%	29
Seal air leaks	22%	0%	0%	9%	3%	6%	3%	3%	16%	13%	25%	0%	32
Seal ducts	0%	0%	0%	0%	0%	29%	0%	14%	14%	29%	14%	0%	7
Buy LEDs	16%	1%	0%	5%	4%	9%	1%	7%	11%	11%	34%	1%	85
Buy CFLs	25%	0%	0%	0%	0%	0%	13%	13%	0%	25%	25%	0%	8
Install an energy efficient water heater	33%	0%	0%	11%	6%	6%	0%	11%	6%	0%	28%	0%	18
Other	7%	0%	0%	0%	0%	14%	0%	7%	14%	21%	36%	0%	14

Q47. [Ask if Q41 = BOUGHT ENERGY EFFICIENT APPLIANCES and Q46_BUY ENERGY EFFICIENT APPLIANCES <> 0] What kinds of appliance(s) did you buy?

Response Option	Percent (n=30)*
Refrigerator	30%
Stand-alone freezer	3%
Dishwasher	37%
Clothes washer	33%
Clothes dryer	30%
Oven	20%
Microwave	23%
Other	10%
Don't know	0%
Refused	0%

* Multiple responses were allowed for this question

Verbatim Other Responses	Count (n = 3)
toliet	1
Dehumidifier	1
air conditioner and heaters	1

Q48. [Ask if Q47 <> DON'T KNOW] Was the [INSERT Q47 RESPONSE] an ENERGY STAR or high-efficiency model?

Respons e Option	Mic row ave	Refrig erator	Stand-alone Freezer	Dish wash er	Clot hes was her	Clot hes drye r	Ot he r
Yes	7	9	1	9	10	9	3
No	0	0	0	1	0	0	0
Don't know	0	0	0	1	0	0	0
Total	7	9	1	11	10	9	3

Q49. [Ask if Q47 = CLOTHES DRYER] Does the new clothes dryer use natural gas?

Response Option	Percent (n=9)
Yes	0%
No	100%
Don't know	0%
Refused	0%

Q50. [Ask if Q41 = BOUGHT EFFICIENT HEATING OR COOLING EQUIPMENT and Q46_BUY EFFICIENT HEATING OR COOLING EQUIPMENT > 0] What type of heating or cooling equipment did you buy?

Response Option	Percent (n=22)*
Central air conditioner	23%
Window/room air conditioner unit	14%
Wall air conditioner unit	5%
Air source heat pump	41%
Geothermal heat pump	0%
Boiler	0%
Furnace	18%
Wifi thermostat	14%
Other	14%
Don't know	5%
Refused	0%

* Multiple responses were allowed for this question

Q51. [Ask if Q50 = BOILER OR FURNACE] Does the new [INSERT Q50 RESPONSE] use natural gas?

Response Option	Percent (n=4)
Yes - it uses natural gas	0%
No – does not use natural gas	100%
Don't know	0%

Q52. [Ask if Q50 <> WIFI-ENABLED THERMOSTAT, DON'T KNOW, OR REFUSED] Was the [INSERT Q50 RESPONSE] an ENERGY STAR or high-efficiency model?

Response Option	Other	Central air conditioner	Window / room air conditioner unit	Wall air conditioner unit	Air source heat pump	Geothermal heat pump	Boiler	Furnace
Yes	2	3	3	1	6	0	0	0
No	1	2	0	0	0	0	0	0
Don't know	0	0	0	0	3	0	0	0
Total	3	5	3	1	9	0	0	0

Q53. [Ask if Q41= BOUGHT EFFICIENT WINDOWS and Q46_BUY EFFICIENT WINDOWS >0] Do you know how many windows you installed?

Response Option	Percent (n=12)
Yes [please specify how many you installed in the box below]	92%
No	8%

Verbatim Responses	Percent (n=11)
1	1
2	1
5	1
6	1
7	3
10	2
13	1
22	1

Q54. [Ask if Q41 = ADDED INSULATION and Q46_ADD INSULATION > 0] Please let us know what spaces you added insulation to. Also, let us know the proportion of each space you added insulation to (for example, if you added insulation that covered your entire attic space, you would type in 100%).

Response Option	Percent (n=22)*
Attic	55%
Walls	36%
Below the floor	32%

* Multiple responses were allowed for this question

Attic

Verbatim Response	Count (n=12)
100%	3
500	1
N	1
50	1
most of the space	1
crawl space	1
10	1
Small area that had gotten wet from rain storm	1
attic door accessible from master bedroom closet	1

20%	1

Walls

Verbatim Response	Count (n=8)
Two windows that were drafty.	1
started on basement walls with the foam board, still have more to install. 25% completed.	1
On garage and basement	1
N	1
laundry room family room	1
Added insulated siding to the exterior of the house.	1
100%	1
10%	1

Below the floor

Verbatim Response	Count (n=7)
N	1
crawlspace under laundry room 100%	1
All	1
80% wrapped crawlspace pipe. repaired fallen insulation. sealed crawlspace vents and installed exhaust circulating fan.	1
50%	1
100% of the laundry room floor, not insulated when i moved in.	1
100%	1

Q55. [Ask if Q41 = BOUGHT LEDS and Q46_BUY LEDS > 0] Do you know how many LEDs you installed at your property?

Response Option	Percent (n=71)
Yes	86%
No	14%

[Please specify how many you installed in the box below:]

Verbatim Response	Count (n=61)
10	6
10 or more	1
10?	1

12	4
14	1
15	4
16	1
18	1
19	1
20	2
20+	1
25	2
3	3
30	2
4	4
40+	1
42	1
5	2
5 locations	1
5-10	1
50	1
6	3
7	1
75	1
8	2
8-10	1
84	1
9	2
all bulb mailed to me by duke - plus purchased 4	1
all light in the house	1
all of our lights our currently LED	1
approx 25, and i am planning on changing my outbuilding's 5 12ft fluorescent with LED's.	1
Between 10 and 20	1
Over 25	1
probably ten	1
Ten.	1
whole house remodel...lots	1

Q56. [Ask if Q41 = BOUGHT CFLS and Q46_BUY CFLS > 0] Do you know how many CFLs you installed at your property?

Response Option	Percent (n=6)

Yes	100%
No	0%

[Please specify how many you installed in the box below:]

Verbatim Response	Count (n=6)
2	2
4	1
5	1
12	1
Many	1

Q57. [Ask if Q41 = INSTALLED AN ENERGY EFFICIENT WATER HEATER and Q46_INSTALL AN ENERGY EFFICIENT WATER HEATER > 0] Does the new water heater use natural gas?

Response Option	Percent (n=12)
Yes	17%
No	83%
Don't know	0%

Q58. [Ask if Q41 = INSTALLED AN ENERGY EFFICIENT WATER HEATER and Q46_INSTALL AN ENERGY EFFICIENT WATER HEATER > 0] Which of the following water heaters did you purchase?

Response Option	Percent (n=12)
A traditional water heater with a large tank that holds the hot water	67%
A tankless water heater that provides hot water on demand	0%
A solar water heater	0%
Other	25%
Don't know	8%

Verbatim Other Responses	Count (n=3)
It was a heat pump.	1
Heat pump water heater	1
Absorb and change heat from air	1

Q59. [Ask if Q41 = INSTALLED AN ENERGY EFFICIENT WATER HEATER and Q46_INSTALL AN ENERGY EFFICIENT WATER HEATER > 0] Is the new water heater an ENERGY STAR model?

Response Option	Percent (n=12)
Yes	67%
No	8%
Don't know	25%

Q60. Which of the following types of housing units would you say best describes your home? It is . . .?

Response Option	Percent (n=328)
Single-family detached house	77%
Single-family attached home (such as a townhouse or condo)	12%
Duplex, triplex or four-plex	2%
Apartment or condo with 5 units or more	4%
Manufactured or mobile home	3%
Other	1%
Prefer not to say	0%
Don't know	1%

Verbatim Other Response	Count (n=2)
Condo-4 units	1
Bi-level	1

Q61. How many showers are in your home? Please include both stand-up showers and bathtubs with showerheads.

Response Option	Percent (n=328)
One	29%
Two	56%
Three	11%
Four	2%
Five or more	1%
Don't know	1%

Q62. How many bathroom sink faucets are in your home? (Keep in mind that some bathrooms may have multiple bathroom sink faucets in them)

Response Option	Percent (n=328)

One	15%
Two	36%
Three	28%
Four	13%
Five	5%
Six	2%
Seven	0%
Eight or more	0%
Don't know	1%

Q63. How many kitchen faucets are in your home?

Response Option	Percent (n=328)
One	91%
Two	7%
Three	1%
Four or more	1%
Don't know	1%

Q63A. [IF Q63 > 1] You mentioned that you have more than one kitchen faucet. Where is/are your other kitchen faucet(s) located in your home?

Verbatim Other Response	Count (n=31)
A bar	1
Bar on first floor, bar on basement	1
basement	3
Basement	2
Basement kitchenette	1
Downstairs	1
Downstairs bar area.	1
Downstairs.	1
Finished lower level space	1
Guest home	1
hobby room	1
I hit the wrong button. I only have 1 kitchen faucet that is in the kitchen.	1
In a second kitchen space	1
in an apartment that my garage was transformed into	1
In kitchen	1
In the basement, in a bar dry sink in the basement	1

kitchen	1
kitchen, laundry, 2 basement utiilty	1
Laundry	1
Laundry room	2
laundryroom has a sink	1
None. Only 1	1
One in the kitchen and one in the lower level wet bar.	1
one in upstairs kitchen, and one in downstairs/basement 50's diner I built.	1
Utility room	1
Vegetable Sink in kitchen	1
Wet bar (2)	1

Q64. 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	Percent (n=328)
Less than 500 square feet	1%
500 to under 1,000 square feet	8%
1,000 to under 1,500 square feet	19%
1,500 to under 2,000 square feet	29%
2,000 to under 2,500 square feet	14%
2,500 to under 3,000 square feet	6%
Greater than 3,000 square feet	7%
Prefer not to say	1%
Don't know	14%

Q65. Do you or members of your household own your home, or do you rent it?

Response Option	Percent (n=328)
Own / buying	93%
Rent / lease	6%
Occupy rent-free	0%
Prefer not to say	1%
Don't know	01%

Q66. Including yourself, how many people currently live in your home year-round?

Response Option	Percent (n=328)
I live by myself	16%
Two people	40%

Response Option	Percent (n=328)
Three people	16%
Four people	13%
Five people	7%
Six people	4%
Seven people	1%
Eight or more people	0%
Prefer not to say	2%
Don't know	1%

Q67. What was your total annual household income for 2016, before taxes?

Response Option	Percent (n=328)
Under $20,000	1%
$20,000 to under $30,000	3%
$30,000 to under $40,000	8%
$40,000 to under $50,000	7%
$50,000 to under $60,000	9%
$60,000 to under $75,000	12%
$75,000 to under $100,000	15%
$100,000 to under $150,000	11%
$150,000 to under $200,000	2%
$200,000 or more	3%
Prefer not to say	25%
Don't know	4%

Q68. What is the highest level of education achieved among those living in your household?

Response Option	Percent (n=328)
Less than high school	0%
Some high school	1%
High school graduate or equivalent (such as GED)	16%
Trade or technical school	5%
Some college (including Associate degree)	27%
College degree (Bachelor's degree)	24%
Some graduate school	3%
Graduate degree, professional degree	16%
Doctorate	2%
Prefer not to say	5%
Don't know	1%

Q69. Finally, what is your year of birth?

Verbatim Response	Count (n=328)
1928	1
1931	1
1932	1
1934	1
1939	2
1940	2
1941	2
1942	1
1943	3
1944	2
1945	5
1946	3
1947	5
1948	2
1949	4
1950	3
1951	9
1952	4
1953	2
1954	8
1955	3
1956	6
1957	5
1958	9
1959	4
1960	5
1961	5
1962	8
1963	4
1964	5
1965	3
1966	3
1967	5
1968	5
1969	2

1970	4
1971	5
1972	5
1973	5
1974	4
1975	3
1976	8
1977	2
1978	4
1979	10
1980	6
1981	7
1982	5
1982	5
1983	2
1984	6
1985	7
1986	4
1987	10
1988	8
1989	4
1990	3
1991	6
1992	2
1993	1
1994	1
1995	1
Prefer not to say	72

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Duke Energy 2020-2021 Delivery Year

EE Post-Installation Measurement and Verification Final Report – Non-Residential Lighting

May 7, 2020

Opinion Dynamics

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1. Executive Summary

1.1 Submission Date

May 7, 2020

1.2 Applicable Delivery Year

2020-2021 Delivery Year (DY)

1.3 Company Name

Duke Energy Ohio – Energy Efficiency Resource Provider

Opinion Dynamics – Measurement and Verification Contractor

1.4 Company Address and Contact Information

Table 1 contains Duke Energy's contact information of the person associated with this project.

Table 1. Duke Energy Address and Contact Information

Company Name:	Duke Energy Ohio, Inc
Company Shortname in eSuite:	DEOEFR
Name of Company Contact:	Lisa Ehrichs
Phone Number:	513-287-1915
Email Address:	lisa.ehrichs@duke-energy.com

Table 2 contains Opinion Dynamics' contact information of the person associated with this project.

Table 2. Opinion Dynamics Address and Contact Information

Company Name:	Opinion Dynamics
Company Shortname in eSuite:	N/A
Name of Company Contact:	Evan Tincknell
Phone Number:	617-301-4648
Email Address:	etincknell@opiniondynamics.com

1.5 Type(s) of Energy Efficiency (EE) Installation(s)

Energy efficiency installations include energy efficient lighting products delivered to DEO non-residential customers through a variety of programs. Opinion Dynamics attests that the definition of an Energy Efficiency (EE) Resource meets the one outlined in Section 1.1 of Manual 18B, which describes an EE Resource as:

> *A project that involves the installation of more efficient processes/systems, exceeding then-current building codes, appliance standards, or other relevant standards, at the time of the*

installation, as known at the time of commitment, and meets the requirements of Section 6 (section M)[1] of the Reliability Assurance Agreement. The EE Resource must achieve a permanent, continuous reduction in electric energy consumption (during the defined EE Performance Hours and during winter performance hours if such EE Resource is a Capacity Performance Resource) that is not reflected in the peak load forecast used for the Auction Delivery Year (DY) for which the EE Resource is proposed. The EE Resource must be fully implemented at all times during the Delivery Year (DY), without any requirement of notice, dispatch, or operator intervention.

Below are descriptions of the programs whose lighting EE Resources are nominated into the 2020-2021 DY.

Non-Residential Smart $aver Prescriptive Incentive Program

The Non-Residential Smart $aver Prescriptive Incentive Program provides incentives to commercial and industrial consumers for the installation of high efficiency equipment in applications involving new construction, retrofit, and replacement of failed equipment. The program promotes prescriptive incentives for lighting, HVAC, pumps, pumps and drives, food services, process, and information technology equipment. The program also uses incentives to encourage maintenance of existing equipment in order to reduce energy usage. Program incentives are designed to help reduce the cost differential between standard and high efficiency equipment, offer a quicker return on investment, save money on customers' utility bills that can be reinvested in their business, and foster a cleaner environment.

Program discounted lighting measures historically included high performance T8s, high performance reduced wattage T8s, LED tubes, LED panels, T8 and T5 high bay lighting, LED high bay and low bay lighting fixtures, screw-in CFLs and LEDs, case lighting, task lighting, and a range of other applications. The current product mix is predominantly comprised of LEDs lamps and fixtures.

In addition, the program encourages dealers and distributors (or market providers) to stock and provide these high efficiency alternatives to meet increased demand for the products, including sometimes directly providing the incentive to customers. Duke Energy also offers the Business Savings Store on the Duke Energy website. The site provides customers the opportunity to take advantage of a limited number of incented measures by purchasing qualified products from an on-line store and receiving an instant incentive that reduces the purchase price of the product.

Program marketing is targeted and includes email and direct mail, online marketing, print marketing and supporting partnerships.

Non-Residential Smart $aver Custom Program

The Non-Residential Smart $aver® Custom Incentive Program is designed to meet the needs of Duke Energy Ohio customers with electrical energy saving projects involving more complicated or alternative technologies, or those measures not covered by Prescriptive Smart $aver incentives. The intent of the Smart $aver Custom Program is to encourage the implementation of energy efficiency projects that would not otherwise be completed without the program. Unlike prescriptive program measures, custom incentives require approval prior to the customer's implementation of the project. Proposed energy efficiency measures may be eligible for custom incentives if they clearly reduce electrical consumption and/or demand. There are two approaches for supplying savings for custom Incentives, Classic Custom and Custom-to-Go. Application documents vary

[1] While Manual 18B refers to Section M in Section 6 of the Reliability Assurance Agreement, we believe that the reference is in correct and should be to Section L in Section 6 of the Reliability Assurance Agreement. http://www.pjm.com/media/documents/merged-tariffs/raa.pdf

only slightly. The difference between the two approaches is the eligible project size and the method by which energy savings are calculated. Projects eligible for the Classic Custom approach are projects with over 700,000 kWh in energy savings or no applicable Custom-to-Go calculator. Projects eligible for the Custom-to-Go approach are projects with less than 700,000 kWh and applicable Custom-to-Go calculator. Customers eligible for the Custom-to-Go approach may elect to apply under the Classic Custom approach if that is their preference.

The marketing strategy for the Smart $aver® Custom Program is closely aligned with the Smart $aver Prescriptive Program.

Smart Business Energy Saver Program

The purpose of Duke Energy's Small Business Energy Saver (SBES) Program is to reduce energy usage through the direct installation of energy efficiency measures within qualifying small non-residential Duke Energy Ohio customer facilities. All aspects of the program are administered by a single authorized vendor. Program measures address major end-uses in lighting, refrigeration, and HVAC applications. Program participants receive a free, no-obligation energy assessment of their facility followed by a recommendation of energy efficiency measures to be installed in their facility, including the projected energy savings, costs of all materials and installation, and up-front incentive amount from Duke Energy Ohio. Upon receiving the results of the energy assessment, if the customer decides to move forward with the proposed energy efficiency project, the customer makes the final determination of which measures will be installed. The energy efficiency measure installation is then scheduled at a convenient time for the customer, and the measures are installed by electrical subcontractors of the Duke Energy Ohio-authorized vendor.

Program marketing includes direct mail, Duke Energy website advertisement, small business group outreach events, and direct-to-business outreach.

1.6 Applicable Energy Efficiency Performance Standards

The following regulations currently guide commercial lighting efficiency standards in the market.

Department of Energy (DOE) Energy Conservation Standards for General Service Fluorescent Lamps (2009 Fluorescent Lamps Rule)

The 2009 Fluorescent Lamps Rule[2] specifies the standards for general service fluorescent lamps (GSFLs) manufactured on or after July 14, 2012. Any products failing to meet these standards are prohibited from manufacture in the United States.

Table 3 provides a summary of the efficiency standards covered by the 2009 Fluorescent Lamps Rule.

Table 3. 2009 Fluorescent Lamps Rule Efficacy Standards for GSFLs

Lamp Type	Correlated Color Temperature (K)	Minimum Average Lamp Efficacy (lm/W)
Four-Foot Medium Bipin	<4,500	89
	>4,500 and <7,000	88
Two-Foot U-Shaped	<4,500	84

[2] Code of Federal Regulations 10 CFR Part 430: Energy Conservation Standards for General Service Fluorescent Lamps and Incandescent Reflector Lamps: https://energy.gov/sites/prod/files/2014/12/f19/gsfl_final_rule.pdf

Lamp Type	Correlated Color Temperature (K)	Minimum Average Lamp Efficacy (lm/W)
	>4,500 and <7,000	81
Eight-Foot Slimline	<4,500	97
	>4,500 and <7,000	93
Eight-Foot High Output	<4,500	92
	>4,500 and <7,000	88
Four-Foot Miniature Bipin Standard Output	<4,500	86
	>4,500 and <7,000	81
Four-Foot Miniature Bipin High Output	<4,500	76
	>4,500 and <7,000	72

The following are the exemptions from the rule:

- General Service Fluorescent Lamps: Lamps with Color Rendering Index (CRI) rating 87 or better, lamps designed for cold-weather applications, ultraviolet lamps, and some other specialty lamps.
- Incandescent Reflector Lamps: 50W and lower-wattage BR30, ER30, ER40 lamps, 45W and lower-wattage R20 lamps, and 65W BR30, BR40, and ER40 lamps.

The 2009 Fluorescent Lamps Rule also sets updated efficiency standards for certain linear lighting products as of January 1, 2018. Table 4.provides these updated standards.

Table 4. Incandescent Reflector Lamp Standards (40W-205W)

Lamp Type	Covered Wattages	Correlated Color Temperature (K)	Minimum Average Lamp Efficacy (lm/W)	Percent Increase Over Current Standards
Four-Foot Medium Bipin	> 25 W	<4,500	92.4	3.8%
		>4,500 and <7,000	88.7	0.8%
Two-Foot U-Shaped	> 25 W	<4,500	85.0	1.2%
		>4,500 and <7,000	83.3	2.8%
Eight-Foot Slimline	> 49 W	<4,500	97.0	0.0%
		>4,500 and <7,000	93.0	0.0%
Eight-Foot Recessed Double Contact High Output	All	<4,500	92.0	0.0%
		>4,500 and <7,000	88.0	0.0%
Four-Foot Miniature Bipin Standard Output	> 25 W	<4,500	95.0	10.5%
		>4,500 and <7,000	89.3	10.2%
Four-Foot Miniature Bipin High Output	> 44 W	<4,500	82.7	8.8%
		>4,500 and <7,000	76.9	6.8%

Department of Energy (DOE) Energy Conservation Standards for Fluorescent Lamp Ballasts (2012 Ballast Rule)

The 2012 Ballast Rule[3] is the current standard for fluorescent lamp ballasts manufactured after November 14, 2014. Table 8 provides a summary of the efficiency standards covered by the 2012 Ballast Rule.

Table 5. Current Efficiency Standards for Ballasts

Fluorescent lamp ballasts shall have a ballast luminous efficiency of no less than A/(1+B*total lamp arc power^-C) where A, B, and C are as follows:				Percent Improvement Over Current Standard or Baseline**
Product Class	A	B	C	
Instant start and rapid start ballasts (not classified as residential) that are designed to operate: 4- foot medium bipin lamps 2 foot U-shaped lamps 8-foot slimline lamps	0.993	0.27	0.25	5.7%
Programmed start ballasts (not classified as residential) that are designed to operate: 4-foot medium lamps 2 foot U-shaped lamps 4-foot miniature bipin standard output lamps 4-foot miniature bipin high output lamps	0.993	0.51	0.37	10.8%
Instant start and rapid ballasts (not classified as sign ballasts) that are designed to operate 8-foot high output lamps	0.993	0.38	0.25	26.5%
Programmed start ballasts (not classified as sign ballasts) that are designed to operate 8-foot high output lamps	0.973	0.70	0.37	26.2%
Sign ballasts that operate 8-foot high output lamps	0.993	0.47	0.25	15.1%
Instant start and rapid start residential ballasts that operate: 4-foot medium bipin lamps 2-foot U-shaped lamps 8-foot slimline lamps	0.993	0.41	0.25	7.2%
Programmed start residential ballasts that are designed to operate: 4-foot medium bipin lamps 2-foot U-shaped lamps	0.973	0.71	0.37	5.8%

* Fluorescent ballasts that are exempt from these standards are listed below.
** Percent improvement is applicable to the average ballasts directly analyzed.

[3] Code of Federal Regulations 10 CFR Part 430: Energy Conservation Standards for Fluorescent Lamp Ballasts: https://www1.eere.energy.gov/buildings/appliance_standards/pdfs/flbstandards_finalrule_frnotice.pdf

The following ballasts are exempt from coverage:

- Ballasts designed for dimming to 50 percent or less of its maximum output.
- Ballasts designed for use with two F96T12 high output (HO) lamps at ambient temperatures of -20 degrees Fahrenheit (F) or less and for use in an outdoor sign.
- Ballasts that have a power factor of less than 0.90 and are designed and labeled for use only in residential building applications.

Energy Independence and Security Act of 2007 (EISA 2007)

This legislation sets efficiency standards for most general service products. EISA legislation deployment is two-phased. Phase 1 of the legislation went into effect in 2012 and gradually phased out general service incandescent products replacing them with halogen and making them a new baseline. The EISA regulations affected 100-watt incandescent products in January 2012, 75-watt incandescent products in January 2013, and 60-watt and 40-watt incandescent products in January 2014. Manufacturers and retailers were allowed to sell existing inventory of incandescents, so products did not immediately disappear from the market. Halogen is the baseline in the market given this legislation. Table 3 provides a summary of the efficiency standards under the first phase of EISA.

Table 6. Phase 1 EISA Efficiency Standards

Rated Lumen Range	Typical Current Lamp Wattage	Maximum Rated Wattage	Minimum Rated Lifetime	Effective Date
1,490-2,600	100	72	1,000 hrs	1/1/2012
1,050-1,489	75	53	1,000 hrs	1/1/2013
750-1,049	60	43	1,000 hrs	1/1/2014
310-749	40	29	1,000 hrs	1/1/2014

A range of products were exempt from this legislation, including small base lamps, low-wattage (<40 watt) lamps, high wattage lamps (>100 watt), rough service lamps, three-way lamps, appliance lamps, and other products.

Phase 2 of the legislation was to take effect on January 1, 2020, setting an efficiency standard of 45 lumens per watt across most screw-based products. However, through a series of rules and determinations issued over the course of 2019, DOE effectively rolled back the EISA standards, leaving halogens and incandescent technologies as the minimum efficiency standards.

Department of Energy (DOE) Energy Conservation Standards for Incandescent Reflector Lamps

DOE published updated energy conservation standards on January 26, 2015. According to the standards, certain incandescent reflector lamps manufactured after July 14, 2012, shall meet or exceed the lamp efficacy standards shown in Table 4.

Table 7. Incandescent Reflector Lamp Standards (40W-205W)

Lamp Spectrum	Lamp Diameter	Rated Voltage	Minimum Average Efficacy
Standard	>2.5 inches	≥125 V	6.8*$p^{0.27}$ lumens per watt
		<125 V	5.9*$p^{0.27}$ lumens per watt
	≤ 2.5 inches	≥125 V	5.7*$p^{0.27}$ lumens per watt
		<125 V	5.0*$p^{0.27}$ lumens per watt
Modified	>2.5 inches	≥125 V	5.8*$p^{0.27}$ lumens per watt
		<125 V	5.0*$p^{0.27}$ lumens per watt
	≤ 2.5 inches	≥125 V	4.9*$p^{0.27}$ lumens per watt
		<125 V	4.2*$p^{0.27}$ lumens per watt

Certain reflector products are exempt from the above-mentioned standards. Those products include:

- Lamps rated at 50 watts or less that are ER30, BR30, BR40, or ER40 lamps;
- Lamps rated at 65 watts that are BR30, BR40, or ER40 lamps; or
- R20 incandescent reflector lamps rated 45 watts or less.

For all reflector products not covered by the legislations above, incandescent light bulbs are the minimum efficiency product on the market.

All nominated program discounted products are CFLs or LEDs, which exceed minimum efficiency standards.

1.7 Nominated and Verified Values by EE Resource

Table 8 below shows the claimed nominated EE and CP values by installation period (IP) and overall. Note that CP values were set to not to exceed the EE value per PJM guidance for nominating savings under CP. The Excel spreadsheet provided alongside this M&V report, titled "2020-2021 Delivery Year_Detailed Non-Residential Nomination Results", contains a summary as well as a detailed account of the energy efficient equipment distributed through DEO's non-residential programs from which demand reduction was nominated into the 2020-2021 DY.

Table 8. Claimed Nominated EE and CP Values by Installation Period

Type of EE Installation	Installation Period	Transmission Zone	Claimed Nominated EE Value (MW)	Claimed Nominated CP Value (MW)
Lighting	6/1/2016-5/31/2017	DEOK	21.52	15.80
Lighting	6/1/2017-5/31/2018	DEOK	15.16	11.23
Lighting	6/1/2018-5/31/2019	DEOK	9.23	6.77
Lighting	6/1/2019-5/31/2020	DEOK	9.92	7.03
Total			**55.84**	**40.83**

Table 9 summarizes the nominated, cleared, and claimed nominated EE and CP values along with the overall one-tailed relative precision at 90% confidence around the verified values.

Table 9. EE and CP Values by Installation Period

Value Type	Nominated Values (MW)	Cleared Value (MW)	Claimed Nominated Value (MW)	Relative Precision
EE value	44.47	0	55.84	4.0%
CP Value	39.09	35.18	40.83	5.0%

1.8 Capacity Rights to Use an Energy Efficiency Installation as Capacity Resource

By submitting this Post-Installation Measurement & Verification Report to PJM, Duke Energy Ohio affirms and acknowledges that it has the legal authority to claim the demand reduction associated with the EE installation(s) that constitute the Energy Efficiency Resource for the applicable Delivery Year (DY).

2. Site Documentation to Support Installed EE Resource

The Excel spreadsheet provided alongside this M&V report, titled "2020-2021 Delivery Year_Detailed Non-Residential Nomination Results", contains a detailed account of the energy efficient equipment distributed through DEO's non-residential programs.

3. Measurement and Verification Results

3.1 Methodology Used

Opinion Dynamics relied on the Partially Measured Retrofit Isolation M&V option (Option A) to measure and verify nominated savings. This option is recommended for non-residential lighting applications in the International Performance Measurement & Verification Protocol (IPMVP). The use of this M&V option conforms with the Manual 18B M&V guidelines.

Under the Partially Measured Retrofit Isolation option of the IPMVP, savings are determined by partial field measurement of the energy use of the system(s) to which an energy conservation measure (ECM) was applied, separate from the energy use of the rest of the facility. Savings are calculated using engineering calculations as well as short term or continuous post-retrofit measurements and stipulations.

On the measurement side, we leveraged the results from the lighting metering study conducted as part of the 2018 evaluation of the DEO Smart $aver Non-Residential Prescriptive Program to derive coincidence factors (CF). Section 3.2 details measurement activities. Our verification work focused on establishing the share of lighting products installed and operational, through participant survey research. Section 3.3 details verification activities.

All other assumptions to support the calculation of the nominated EE values are either stipulated or derived from detailed program tracking data. Section 3.4 of this report provides details around the nominated EE value calculation.

3.2 Measurement Activity Details

Measurement activities aim at establishing coincidence factors (CFs). In conjunction with the impact evaluation of DEO's Non-Residential Prescriptive Program, Opinion Dynamics conducted a lighting logger study across a representative sample of participating facilities in the summer of 2018. The study included customers who participated in DEO's Non-Residential Prescriptive Program from January 2016 through December 2017. We drew a stratified random sample of 35 projects. We contacted customers and scheduled on-site visits with customers interested in the study. When on site, site visit technicians verified program-discounted lighting products and placed loggers on a representative sample of fixtures. To capture lighting usage, we used DENT loggers. DENT loggers are routinely used in the M&V industry to measure lighting usage, and they meet all applicable standards set forth in Section 12 of Manual 18B, including logger synchronization to the accuracy of +/- 2 minutes per month, proper logger calibration, and maintenance. Appendix B of this report contains a detailed description of the metering equipment used for this study.

The site visits began with an initial walk-through of the facility to record the number of unique space types containing program fixtures and bulbs. We deployed up to 12 loggers per site, with at least one in each distinct space type. For sites with more than 12 unique space types, we randomly selected 12 space types to place loggers in. We deployed more than one logger per space type if there were fewer than 12 unique space types. This helped increase the overall precision as well as to act as a backup loggers(s). If there were multiple spaces within a unique space type, we randomly selected a space to place the logger in. Within each space and space type, we randomly selected the light switch to log. For each logger, we recorded the switch it was placed on and the count of lamps and fixtures, by technology, it controls. We also recorded a detailed description of the logger placement to aid in subsequent retrieval visits (e.g., light above reception area).

Prior to deployment, all loggers were cleaned of extraneous data and reset. Logger clocks were reset to the correct time zone and time using the SMARTware™ Windows® software package. Loggers were placed as close to the fixture as possible to eliminate any ambient light interference. Where needed, site visit technicians used a fiber optic eye to get as close to the source of light as possible. Technicians calibrated and tested each logger for proper operation in accordance with stringent logger state tests as specified by the manufacturer.

Loggers remained in place for 4 weeks, after which site technicians returned to the site and retrieved the loggers. We completed logger deployment site visits between June 25, 2018 and June 29, 2018, and retrieval visits between July 23, 2018 and July 27, 2018.

Table 10 provides a summary of the sampling and recruitment process. As can be seen in the table, from the sample of 35 DEO customers, we recruited 29 customers, and completed site visits with 27 of those customers. We retrieved loggers from all 27 facilities where we deployed them.

Table 10. Summary of Sampling and Recruitment

Sampling Step	DEO
Population	3,936
Sample	35
Unable to reach site contact	3
Site contact declined site visit	3
Recruited but unable to complete deployment	2
Completed deployment site visits	27
Completed logger retrieval	27

In total, we deployed 214 loggers across 27 commercial facilities. We were unable to retrieve 1 logger. To prepare the logger data for analysis, we performed a series of data-cleaning steps to ensure that only loggers with proper and reasonable data are included in our analysis. Based on the cleaning steps, we used 202 of the 214 deployed loggers in our analysis (94%). This represents an attrition rate of 6%.

CFs represent the fraction of time during the performance period that the light is on. We used the following performance period definitions:

- The EE Performance Hours (summer peak CF) are between the hour ending 15:00 Eastern Prevailing Time (EPT) and the hour ending 18:00 EPT during all days June 1 through August 31, inclusive, of such delivery year that is not a weekend or a federal holiday.
- The Winter Performance Hours (winter peak CF) are between the hour ending 8:00 EPT and the hour ending 9:00 EPT, and between the hour ending 19:00 EPT and the hour ending 20:00 EPT all days from January 1 through February 28, inclusive, of such delivery year that is not a weekend of federal holiday.

We calculated summer peak CF by summing, for each logger, the time the light was on during the summer performance hours and dividing the result by the number of hours within the performance period. We did not annualize the results because lighting usage was stable and consistent over the observed period.

We did not log lighting usage during the winter performance hours. To determine winter peak CFs, we used lighting usage data collected over the metering period and calculated, for each logger, the time the light was on during the winter performance hours and divided the result by the number of hours within the performance period. Commercial facilities generally tend to exhibit stable lighting usage across the year. We verified consistency of lighting usage by comparing operating schedules reported by facility contacts for the EE performance period, and winter performance period. The results revealed high degrees of consistency of space usage in terms of operating hours between the winter and summer months.

We aggregated CF results across individual loggers in stages. First, we aggregated individual loggers to space-type CF estimates within each facility in the sample, weighting the results by fixture count associated with each logger. We then weighted space type-level CF estimates to the individual facility level using total fixture counts across space types as the weighting parameter. Finally, we aggregated facility-level estimates to the overall estimates of summer and winter CF by applying facility fixture count weights.

Table 11 presents coincidence factors for the EE and winter performance hours to support the energy efficiency resource nomination into PJM's forward capacity markets. The overall EE (Summer) CF is 0.745, while the overall winter CF is 0.628. The relative precision of both coincidence factors exceeds PJM requirements (as detailed in Manual 18B, Section 9) of 10% one-tailed at 90% confidence (equivalent to two-tailed at 80% confidence). The team used the following equation to estimate relative precision from the study sample size:

Equation 1. Lighting Metering Study Relative Precision Calculation

$$e = \sqrt{\frac{(z * z) * (cv * cv)}{n}}$$

Where:

e=relative precision
z=confidence level (1.28 for 90% one-tailed confidence level)
cv=observed population coincident peak coefficient of variation
n=sample size

Table 11. Coincidence Factors and Relative Precision

Metric	EE Performance Hours (Summer CF)	Winter Performance Hours (Winter CF)
Installation type	Lighting	Lighting
Sample size	202	202
Coincidence factor	0.745	0.628
Standard deviation	0.337	0.367
Coefficient of variation	0.453	0.584
Relative precision	4.1%	5.3%

The Excel spreadsheet provided alongside this M&V report, titled "2020-2021 Delivery Year_Detailed Non-Residential Nomination Results", contains a detailed account of the key measurement activity parameters.

3.3 Verification Activity Details

Verification activities focused on confirming lighting installation (i.e., that the lighting products were installed and were operational at the time of the inquiry) and consisted of survey efforts with a representative sample of participants from each installation period (IP) nominated into the 2020-2021 DY. The results of the participant survey research were used to develop an estimate of the in-service rate (ISR).

3.3.1 Sampling and Fieldwork

Opinion Dynamics performed verification research for the 2016-2017 IP, 2017-2018 IP, and 2018-2019 IP. For the 2019-2020 IP, where only part of the year had elapsed prior to development of the M&V report, no verification research was performed. Instead, we relied on the verification results from the prior installation period.

The sample frame for the verification research for the 2016-2017 IP consisted of program participants from the three non-residential programs from which Duke Energy nominated demand reduction into the 2020-2021 DY (i.e., the Non-Residential Prescriptive, Custom, and SBES programs). Opinion Dynamics stratified the sample by program to ensure adequate representation of participants from each program. For the Custom program, the number of participants in the sample frame was small. As a result, we did not draw a sample, but rather included all participants in the verification survey (census attempt). For the Prescriptive and SBES programs we drew a random sample of program participants, stratified by project size to ensure adequate representation of larger projects.

The verification research sampling approach for the Custom and SBES programs for the 2017-2018 IP was similar to that of the 2016-2017 IP and consisted of a census attempt of all custom projects. To determine ISR for Prescriptive program projects, we relied on the verification work conducted as part of the 2018 impact evaluation of the DEO Non-Residential Prescriptive Program. Verification efforts consisted of engineering desk reviews and on-site verification visits for a representative sample of projects.[4]

The sampling approach for 2018-2019 IP was also similar to that of the 2016-2017 IP. Opinion Dynamics stratified the sample by program to ensure adequate representation of participants. We attempted a census of all custom projects and drew a random sample of participants for the Prescriptive and SBES programs, stratified by project size to ensure adequate representation of larger projects.

For all verification efforts with the exception of 2017-2018 IP Prescriptive program, we administered surveys over the phone. As part of these surveys, we verified project completion, measure installation, and measure persistence. We asked installation verification and persistence questions at the measure category level. For the 2017-2018 IP Prescriptive program, Opinion Dynamics conducted desk reviews for a random sample of lighting projects in which we reviewed all available project documentation (i.e., applications, calculations, invoices, specification sheets, inspection forms, and any other project-specific data made available) to verify measure information and quantities and conducted site visits with a subset of participants included in the desk reviews to verify installation and exact measure specifications.

Table 12 below provides a summary of the target and achieved sample and survey fielding period for each IP.

Table 12. Sample Design and Fieldwork

Installation Period	Target Sample	Achieved Sample	Verification Method	Survey Fielding Period
2016-2017	75	78	Phone survey	September-November 2017
2017-2018	75	40	Desk review/site visits	Prescriptive: June-July 2018
		35	Phone survey	Custom and SBES: July-August 2018
2018-2019	75	78	Phone survey	August 2019

3.3.2 In-Service Rate Estimation

We calculated ISR as the number of bulbs installed and operational at the time of the survey divided by the number of bulbs that participants received (see Equation 2). For each survey respondent, we calculated ISR for each lighting measure covered in the survey. We aggregated measure-level ISRs to the participant level weighting by savings. We then further aggregated participant-level ISRs to the program level, applying savings weights. Finally, we aggregated program-level ISRs to the IP level weighting by savings associated with each program for that year.

Equation 2. ISR Formula

$$ISR = \frac{Total\ Number\ of\ Lamps\ or\ Fixtures\ Installed\ and\ Operational}{Total\ Number\ of\ Lamps\ or\ Fixtures\ Delivered}$$

[4] Opinion Dynamics. *Duke Energy Ohio Non-Residential Smart $aver® Prescriptive Program Evaluation Report*. Prepared for Duke Energy. December 7, 2018.

Table 13 shows ISR results by IP. As can be seen in the table, the ISR estimates range from 99.3% to 100.0%. The error bounds around each ISR estimate are narrow and relative precision is robust. We applied the IP-specific ISRs presented in the table below to the installations from that IP. ISR values for the 2018-2019 IP incorporate results from research conducted since the submission of 2019-2020 DY nominated savings, which accounts for a very slight difference between 2018-2019 IP values applied to the 2019-2020 DY and 2020-2021 DY. For the 2019-2020 IP, we used program-specific ISR values from the 2018-2019 IP reweighted by the savings associated with each program in the 2019-2020 IP.

Table 13. ISR Results

Installation Period	Sample Size (Respondents)	ISR	Relative Precision
2016-2017	78	99.3%	0%
2017-2018	75	99.8%	0%
2018-2019	78	100.0%	0%
2019-2020[a]	78	99.6%	0%

[a] No survey was conducted; the ISR is based on savings-weighted program-level ISR results from the 2018-2019 IP.

The Excel spreadsheet provided alongside this M&V report, titled "2020-2021 Delivery Year_Detailed Non-Residential Nomination Results", contains a detailed account of the key verification activity parameters.

3.4 Nominated EE Value Calculation

We calculated the EE and CP savings values using the equation below. This equation is an industry-accepted, standard approach to estimating peak demand saving from lighting installations.

Equation 3. Savings Equation

$$\Delta kW = Bulbs * \left(\left(\frac{Watts_{base} - Watts_{ee}}{1000}\right) * ISR * CF * HVAC_d\right)$$

Where:

ΔkW = Gross coincident peak demand savings
Bulbs = number of bulbs/lamps distributed through the programs
$Watts_{base}$ = Baseline bulb wattage
$Watts_{ee}$ = Program bulb wattage
ISR = In-service rate
CF = Peak coincidence factor
$HVAC^d$ = HVAC system interactive effect for demand

Fixtures

We used detailed program tracking data to determine the number of lamps/fixtures distributed through the program.

$Watts_{base}$

We used the "Standard Baseline" approach to determine baseline wattages. Per Section 8 of Manual 18B, the "standard" baseline is appropriate for projects in which equipment (whether failed or not) is replaced by a more efficient equivalent or by an alternative strategy for delivering comparable output. For each program measure we determined minimum efficiency baseline wattages adjusted by applicable federal standards.

$Watts_{ee}$

We used detailed program tracking data to determine program fixture wattages. All non-residential programs keep detailed records of the manufacturer rated wattage for each unique product.

ISR

We relied on the participant survey to estimate ISR. Section 3.3 above details the verification approach that Opinion Dynamics used and the ISRs that we applied.

CF

We relied on the lighting metering study to determine the CFs for both EE Performance Hours and Winter Performance Hours. This study is described in detail in Section 3.2 above. We used the CF for the EE Performance Hours to calculate EE savings and the CF for the Winter Performance Hours to calculate CP savings.

$HVAC_d$

When lighting equipment converts electrical energy to light, a significant amount of that energy is dissipated in the form of heat. Energy efficient lighting measures convert more electrical energy to light and less to heat, which helps reduce the need in energy use from cooling required to mitigate heat emitted from lighting. Interactive effects help account for this reduction in the savings formula. Accounting for interactive effects when estimating savings from energy efficient lighting installation is standard practice in the energy efficiency evaluation industry, which is supported by the Ohio Technical Reference Manual (TRM) and other TRMs across the country.

To estimate EE savings, Opinion Dynamics used an interactive effects factor of 1.200 for interior fixtures and 1 for exterior fixtures from Ohio TRM.[5] The interactive effect was developed based on a series of prototypical small commercial building simulation runs. The prototypes are based on the California DEER study prototypes, modified for local construction practices. Simulations were run using TMY3 weather data for the following Ohio cities: Cincinnati, Cleveland, Columbus, and Dayton.

To estimate CP savings, we did not apply any interactive effects. Given a relatively small share of commercial facilities in the East North Central Division of the Midwest that are electrically heated (12%), we anticipate interactive effects to be negligible.[6]

[5] http://s3.amazonaws.com/zanran_storage/amppartners.org/ContentPages/2464316647.

[6] Based on the 2012 Commercial Building Energy Consumption Survey. https://www.eia.gov/consumption/commercial/data/2012/bc/cfm/b28.php

Appendix A. Data Collection Instrument – Installation Periods 2016-2017, 2017-2018, and 2018-2019

Opinion Dynamics

Duke Energy Ohio

Commercial Energy Efficiency Programs

Participant Survey

FINAL

August 21, 2019

Background

The purpose of this survey is to verify the installation and continued operation of lighting equipment that was incentivized through one of Duke Energy Ohio commercial energy efficiency programs. This survey will be administered as a phone survey with participants of one or more of the following programs:

- Smart $aver Prescriptive Incentive Program
- Smart $aver Custom Program
- Small Business Energy Saver Program

We will draw a random sample of program participants across the three commercial programs and we will stratify the sample by program and lighting equipment type, as needed, to ensure adequate representation of participants across all programs and equipment types.

Sample Variables

<PROGRAM1>	IF Prescriptive: Smart Saver Prescriptive Incentive Program IF Custom: Smart Saver Custom Program IF Small Business: Small Business Energy Saver Program
<PROGRAM2>	IF Prescriptive or Custom: Smart Saver Program IF Small Business: Energy Saver Program
<COMPANY>	Company name
<ADDRESS>	Address of project installation
<CITY>	City of project installation
<STATE>	State of project installation
<DATE>	Month and year of incentive
<QTYX>	Measure quantity
<MEASX>	Measure category installed as part of the project

Introduction

Hello, my name is ________ calling on behalf of Duke Energy, and we're speaking with customers who have participated in Duke Energy's <PROGRAM1>. May I please speak with the person most familiar with your company's recent energy efficiency project in <CITY>, <STATE>?

[TRY TO REACH CORRECT CONTACT: Is there someone else at your company that is more knowledgeable about the lighting equipment <COMPANY> received through the <PROGRAM2> in <DATE>? May I please speak to that person?] [TERMINATE IF DID NOT PARTICIPATE IN PROGRAM]

[READ WHEN CORRECT CONTACT IS ON THE PHONE]
I have a few questions about an energy efficiency project that <COMPANY> completed through Duke Energy's <PROGRAM1> at <ADDRESS> and for which you received an incentive in <DATE>.

(IF NEEDED: As a part of your participation, <COMPANY> received a financial incentive for the installation of the lighting equipment through Duke Energy's <PROGRAM2> at <ADDRESS> in <CITY>, <STATE>.)

(IF NEEDED: This survey should only take 5 minutes of your time.)

Installation Verification

First I'd like to verify some information from our records. For the purpose of this survey, we may not ask about all of the improvements made through the program, so please try and focus just on the ones that I specify.

[ASK IF MEASCOUNT=1]
PV0a. Our records indicate that you received an incentive from Duke Energy's <PROGRAM2> for installing<MEAS1> at <ADDRESS> in <DATE>.

[ASK IF MEASCOUNT>1]
PV0b. Our records indicate that you received an incentive from Duke Energy's <PROGRAM2> for installing the following energy efficient lighting products at <ADDRESS> in <DATE>.

- <MEAS1>
- <MEAS2>
- <MEAS3>]

For each, I'd like to confirm the quantity of lighting products that were a part of the lighting project for which you received an incentive through the <PROGRAM2>.

[REPEAT LOOP FOR EACH MEASURE]
PV1. Our records indicate that <QTYX> <MEASX> were a part of the lighting project, is that correct?
(IF NEEDED: I don't have the exact specifications in front of me, but our records indicate <QTYX> <MEASX>. Does that sound like it could describe some of the lighting included in this project?)

1. Yes
2. No
8. (Don't know)
9. (Refused)

[ASK IF PV1=2,8]
PV2. Approximately, how many <MEASX> were a part of the project? [NUMERIC OPEN END 0-9997; 9998=DON'T KNOW, 9999=REFUSED]

[CALCULATE RECEIVED=QTYX IF PV1=1, RECEIVED=PV2 IF PV1=2,8 AND PV2<9998, ELSE RECEIVED=MISSING]

[ASK IF RECEIVED<>0]
PV3. I would like now to ask you whether the <MEASX> were installed. Were all of the <RECEIVED> <MEASX> installed, just some, or none?
1. All
2. Some
3. None
8. (Don't know)
9. (Refused)

[ASK IF PV3=2]
PV4. How many of the <RECEIVED> <MEASX> were installed? [NUMERIC OPEN END 0-9997; 9998=DON'T KNOW, 9999=REFUSED]

[ASK IF PV4=9998]
PV5. Approximately, what percentage of the <RECEIVED> <MEASX> were installed? [NUMERIC OPEN END 0-100; 998=DON'T KNOW, 999=REFUSED]

[CALCULATE MEAS_INSTALLED=RECEIVED IF PV3=1, MEAS_INSTALLED=0 IF PV3=3, MEAS_INSTALLED=PV4 IF PV3=2 AND PV4<998, MEAS_INSTALLED=PV5*RECEIVED IF PV4=998 AND PV5<998, ELSE MEAS_INSTALLED=MISSING]

[READ IF PV5<998] <PV5> percent of <RECEIVED> <MEASX> is about <MEAS_INSTALLED>. I will refer to this number in my follow-up questions.
[ASK IF MEAS_INSTALLED>0]
PV6. And were all <MEAS_INSTALLED> <MEASX> installed at <ADDRESS> or were they installed someplace else?
1. All at <ADDRESS>
2. All someplace else
3. Some at <ADDRESS> and some elsewhere

[SKIP PV7B IF PV6A=1 & PV6B=1]
[SKIP PV7C IF (PV6A=1 & PV6C=1) OR (PV6B=1 & PV6C=1)]
[ASK IF MEAS_INSTALLED > 0]
PV7. Does Duke Energy provide electric services at the facility or facilities where you installed <MEASX>?
1. Yes
2. No
8. (Don't know)
9. (Refused)

[ASK IF PV3=2 OR 3]
PV8. Why have [READ IF PV3=2 "not all"; READ IF PV3=3 "none"] of the <MEASX> been installed? [MULTIPLE RESPONSE UP TO 4]
- 01. Products were purchased as spares for our business location
- 02. Haven't had time to install the products
- 03. Returned products to distributor
- 04. Products were broken
- 05. Threw products away
- 06. Gave products away
- 07. Products are not compatible with existing fixtures
- 00. Other, specify
- 98. (Don't know)
- 99. (Refused)

[ASK IF MEAS_INSTALLED>0]
PV9. Are all <MEAS_INSTALLED><MEASX> still installed, or have any of them been removed?
- 1. All are still installed
- 2. Removed some
- 3. Removed all
- 8. (Don't know)
- 9. (Refused)

[ASK IF PV9=2]
PV10. How many of the <MEAS_INSTALLED> <MEASX> have been removed? [NUMERIC OPEN END 0-9997; 9998=DON'T KNOW, 9999=REFUSED]

[ASK IF PV10=9998]
PV11. Approximately, what percentage of the <MEAS_INSTALLED> <MEASX> have been removed? [NUMERIC OPEN END 0-100; 998=DON'T KNOW, 999=REFUSED]

[ASK IF PV9=2,3]
PV12. Why did you remove the <MEASX>? [MULTIPLE RESPONSE UP TO 4]
- 01. Burned out, stopped working, or broke
- 02. Did not like the light color
- 03. Light not bright enough
- 04. Didn't like the way the product looked
- 05. Moved to another location
- 06. Product not compatible with existing fixtures
- 00. Other, specify
- 98. (Don't know)
- 99. (Refused)

Firmographics

I now have just a few general questions about your company and then we will be done.

F1. What is the business type of the facility located at <ADDRESS>? (PROBE, IF NECESSARY)

(NOTE: CLARIFY WITH RESPONDENT IF SECTOR OVERLAPS IN CATEGORIES BELOW, FEEL FREE TO READ LIST IF NEEDED)

01. (K-12 School)
02. (College/University)
03. (Grocery)
04. (Medical)
05. (Hotel/Motel)
06. (Light Industry)
07. (Heavy Industry)
08. (Office)
09. (Restaurant)
10. (Retail/Service)
11. (Government)
00. (Other, specify)
98. (Don't know)
99. (Refused)

F2. What would you estimate is the total square footage of your facility where the discounted lighting products are/will be installed?

1. (Less than 2,500 square feet)
2. (2,500 to less than 5,000 square feet)
3. (5,000 to less than 10,000 square feet)
4. (10,000 to less than 20,000 square feet)
5. (20,000 to less than 50,000 square feet)
6. (50,000 to less than 100,000 square feet)
7. (Agricultural/Outdoors)
98. (Don't know)
99. (Refused)

F3. What is the primary heating fuel for your facility?

1. (Electricity)
2. (Gas)
00. (Other – specify)
98. (Don't know)
99. (Refused)

F4. Which of the following best describes the ownership of this facility?

1. Company owns and occupies this facility
2. Company owns this facility but it is rented to someone else
3. Company rents this facility
8. (Don't know)
9. (Refused)

F5. In what year was your facility built? [OPEN END NUMERICAL; 8=DK; 9=RF]

F6a. How many employees, full plus part-time, are employed at this facility? [NUMERIC OPEN END, 0 TO 2000; 9998=Don't know, 9999=Refused]

[ASK IF F6a=9998]
F6b. Do you know the approximate number of employees? Would you say it is…?
1. Less than 10
2. 10-49
3. 50-99
4. 100-249
5. 250-499
6. 500 or more
8. (Don't know)
9. (Refused)

Those are all the questions I have. Thank you so much for your time!

Appendix B. Logger Equipment Specifications

DENT INSTRUMENTS

SMARTLOGGERS™

ON/OFF TIME-OF-USE INSTRUMENTS

MEASURE TOTAL-ON TIME AND ON/OFF TRANSITIONS OF ALMOST ANY DEVICE

FEATURES

- Instantly see what your logger has recorded. All **SMART***loggers*™ come with a 5-digit LCD showing On-Time (in hours) and Percent On.
- With a storage capacity of over 32,000 records, **SMART***loggers*™ can record unattended for months or years.
- Simple mounting using power rare earth magnets, Velcro®, or screw hole easily secures the instruments out of sight.
- Interfaces with **SMART***ware*™ Windows® software package for easy data retrieval and simple, sophisticated data analysis.
- Compact and rugged, the **SMART***loggers*™ are designed for provide many years of service in a variety of operating conditions.
- Five-year battery life.
- **Three-year warranty.**

APPLICATIONS

- Lights
- Motors
- Water Heaters
- Gas Valves
- Switches & Relays
- Virtually any electric load

CE

For more information, please contact:

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Duke Energy 2020-2021 Delivery Year

EE Post-Installation Measurement and Verification Final Report – Residential Lighting

May 7, 2020

Opinion Dynamics

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Opinion Dynamics

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1. Executive Summary

1.1 Submission Date

May 7, 2020

1.2 Applicable Delivery Year

2020-2021 Delivery Year (DY)

1.3 Company Name

Duke Energy Ohio – Energy Efficiency Resource Provider

Opinion Dynamics – Measurement and Verification Contractor

1.4 Company Address and Contact Information

Table 1 contains Duke Energy's contact information of the person associated with this project.

Table 1. Duke Energy Address and Contact Information

Company Name:	Duke Energy Ohio, Inc
Company Shortname in eSuite:	DEOEFR
Name of Company Contact:	Lisa Ehrichs
Phone Number:	513-287-1915
Email Address:	lisa.ehrichs@duke-energy.com

Table 2 contains Opinion Dynamics' contact information of the person associated with this project.

Table 2. Opinion Dynamics Address and Contact Information

Company Name:	Opinion Dynamics
Company Shortname in eSuite:	N/A
Name of Company Contact:	Evan Tincknell
Phone Number:	617-301-4648
Email Address:	etincknell@opiniondynamics.com

1.5 Type(s) of Energy Efficiency (EE) Installation(s)

Energy efficiency installations include energy efficient lighting products delivered to DEO residential customers through a variety of programs. Opinion Dynamics attests that the definition of an Energy Efficiency (EE) Resource meets the one outlined in Section 1.1 of Manual 18B, which describes an EE Resource as:

> *A project that involves the installation of more efficient processes/systems, exceeding then-current building codes, appliance standards, or other relevant standards, at the time of the*

installation, as known at the time of commitment, and meets the requirements of Section 6 (section M)[1] of the Reliability Assurance Agreement. The EE Resource must achieve a permanent, continuous reduction in electric energy consumption (during the defined EE Performance Hours and during winter performance hours if such EE Resource is a Capacity Performance Resource) that is not reflected in the peak load forecast used for the Auction Delivery Year (DY) for which the EE Resource is proposed. The EE Resource must be fully implemented at all times during the Delivery Year (DY), without any requirement of notice, dispatch, or operator intervention.

Below are descriptions of the programs whose lighting EE Resources are nominated into the 2020-2021 DY.

Free LED Program

Duke Energy Ohio (DEO) launched the Free LED program in January 2016 as the successor to the Free CFL program. The program's goal is to reduce energy consumption and peak demand through increased awareness and adoption of energy efficient lighting technologies. As part of the Free LED program, DEO offered a variety of free LED kits that consisted of 3, 6, 8, 12, or 15 LEDs. Customers could request a total of 15 LEDs online or over the phone.[2] To better manage program budgets, program marketing and outreach is focused on business reply cards (BRCs). To ensure that only DEO customers receive the LEDs, customers had to provide their account number or the phone number associated with their account, as well as the last four digits of their social security number. Once requested, program bulbs were shipped to the billing address associated with the customer's account.

Energy Efficiency Online Store Program

Duke Energy's Energy Efficiency Online Store offers residential customers discounts on a variety of general service and specialty CFL and LED products, including three-way, candelabra, torpedo, globe, flood light, and reflector products, in a variety of wattages.[3] All DEO electric customers are eligible to participate. Customers must provide a valid DEO account number and the last four digits of their social security number to shop the Online Store. Customers can purchase up to 36 discounted CFLs or LEDs per account. Once the bulb limit is reached, customers can order additional CFLs and LEDs but without the program discounts. To further the adoption of energy efficient lighting, DEO offers discounted shipping to customers who purchase CFLs and LEDs through the Online Store.

Residential Energy Assessments

Duke Energy's Residential Energy Assessments program is an in-home assessment program offered at no direct cost to the customers. Duke Energy Ohio partners with Franklin Energy to administer the program in which an energy specialist completes a walk-through assessment of the home and analyzes energy usage to identify energy saving opportunities. At the end of the visit, customers receive a customized report with energy saving recommendations. Customers also receive an energy efficiency starter kit that contains two energy efficient bulbs and other lower-cost energy efficiency measures such as a low-flow showerhead, outlet seals, faucet aerators, and weather stripping that the auditor can install free of charge as well as up to six additional LEDs. Energy specialists also encourage behavioral changes (such as turning off vampire load equipment

[1] While Manual 18B refers to Section M in Section 6 of the Reliability Assurance Agreement, we believe that the reference is in correct and should be to Section L in Section 6 of the Reliability Assurance Agreement. http://www.pjm.com/media/documents/merged-tariffs/raa.pdf

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

[3] As part of the program, customers could request a lighting catalog and make an order over the phone. The program also ran a mail-order offering where customers could order program discounted products via mail

when not in use or turning off lights when not in the room) and inform customers of higher cost investments (such as adding insulation and air sealing the home).

The Residential Energy Assessments program targets owner-occupied, single-family residences with at least 4 months of billing history. Program participation continues to be driven through a multi-channel approach including targeted mailings to pre-qualified residential customers, bill inserts, online promotions, and online videos. The core messaging continues to be simple and focused on key benefits (a free energy assessment from Duke Energy can help save energy and money while also increasing comfort) and three easy steps: you call, we come over, you save. In 2020, they will begin offering rebated blower door tests and smart thermostats. The program also upgraded its assessment scheduling tool to allow for customer-driven appointment scheduling and management online.

Low Income Neighborhoods (Neighborhood Energy Saver)

Duke Energy's Neighborhood Energy Saver (NES) program provides one-on-one energy education, on-site energy assessments, and the direct installation of appropriate packages of low-cost energy conservation measures to customers in income-qualified neighborhoods – including energy efficient bulbs. The program transitioned from CFLs to LEDs in 2017.

The program is available to active Duke Energy electric account holders who are individually metered homeowners or tenants living in predetermined low-income communities. Neighborhoods targeted for this program are eligible to participate if the income of at least 50% of the households within the community is equal to or less than 200% of the federal poverty level, corresponding with the eligibility requirements set for the federal Weatherization Assistance Program (WAP). Once Duke Energy determines that a neighborhood is eligible according to this criterion, all residential customers in that neighborhood are eligible to receive energy efficiency measures through the NES program regardless of their individual household income. Participating households are limited to one-time receipt of energy efficiency measures through the NES program and up to 15 free energy efficient bulbs from any Duke Energy program.

Property Manager Lighting Channel

The Property Manager Lighting Channel (Multifamily Energy Efficiency Program) allows DEO to use an alternative delivery channel to target multi-family apartment complexes. The program helps property managers upgrade lighting with energy efficient bulbs, and tenants also save energy by offering water measures such as bath and kitchen faucet aerators, water-saving showerheads, and pipe wrap. The quantity of lighting measures installed is based on apartment size with up to 12 energy efficient bulbs in a one-bedroom apartment, up to 15 bulbs in a two-bedroom apartment, and up to 18 bulbs in a three-bedroom apartment. In January 2018, the program transitioned from CFLs to LEDs. Property managers can choose to install program products by themselves or leverage the direct installation services of the implementation contractor. After installations are completed, Quality Assurance (QA) inspections are conducted on 20% of properties that completed installations in a given month. The QA inspections are conducted by an independent third party. The implementation contractor is responsible for all marketing and outreach for the program. This is primarily done through outbound calls and on-site visits to solicit initial interest in the program from property managers in the Duke Energy Ohio jurisdiction. The program also utilizes local Apartment Association memberships to obtain contact information for local properties and attends Association trade shows and events to promote the program.

Eligible properties must have four or more units and must be served on an individually metered residential rate schedule.

Energy Education Program for Schools

The Energy Efficiency Education Program for Schools is available to K-12 students enrolled in public and private schools. The current curriculum, administered by The National Theatre for Children ("NTC"), targets kindergarten through 8th grade students. The program provides principals and teachers with an innovative curriculum that educates students about energy, resources, how energy and resources are related, ways energy is wasted, and how to be more energy efficient. The centerpiece of the curriculum is a live theatrical production – focused on concepts such as energy, renewable fuels, and energy efficiency – which is performed by two professional actors. Teachers receive supportive educational materials for the classroom and students take home materials such as workbooks, assignments, and activities that meet state curriculum requirements. School principals are the main point of contact and schedule the performance at their convenience for the entire school. Once the principal has confirmed the performance date and time, two weeks prior to the performance, all materials are delivered to the principal's attention for classroom and student distribution. Materials include school posters, teacher guides, and classroom and family activity books. Students are encouraged to complete a home energy survey with their family (found in their classroom and family activity book), to receive an Energy Efficiency Starter Kit. The kit contains specific energy efficiency measures, including LEDs, to reduce home energy consumption. It is available at no cost to all student households at participating schools, including Duke Energy customers and non-customers. Eligible participants include residential customers who reside in households with school-age children enrolled in public and private schools.

Retail Lighting Program

Duke Energy launched the DEO Retail Lighting program in August 2018 with the goal of reducing electric energy consumption and peak demand through increased awareness and adoption of energy-efficient lighting technologies. As part of the Retail Lighting program, Duke Energy partners with retailers and manufacturers across the DEO service territory to provide point-of-sale price markdowns on customer purchases of LED products. The program promotes customer awareness and purchase of program-discounted products through a range of marketing and outreach strategies, including in-store collateral and events, mail and email marketing, and community events. The program also provides training to store staff. The product mix includes a wide range of standard and specialty ENERGY STAR® LED bulbs and fixtures. Notably, 60-watt equivalent standard LEDs are not a part of the product mix, as these products are offered through the Free LED program. Participating retailers include a variety of store types.

1.6 Applicable Energy Efficiency Performance Standards

There are currently two regulations guiding lighting efficiency standards in the market: [4]

Energy Independence and Security Act of 2007 (EISA 2007)

This legislation sets efficiency standards for most general service products. EISA legislation deployment is two-phased. Phase 1 of the legislation went into effect in 2012 and gradually phased out general service incandescent products replacing them with halogen and making them a new baseline. The EISA regulations affected 100-watt incandescent products in January 2012, 75-watt incandescent products in January 2013, and 60-watt and 40-watt incandescent products in January 2014. Manufacturers and retailers were allowed to sell existing inventory of incandescents, so products did not immediately disappear from the market.

[4] Code of Federal Regulations at 10 CFR 430.32(x)(1). http://www.ecfr.gov/cgi-bin/text-idx?SID=0656df565fb5d0f6996bfb073b50b36d&mc=true&node=se10.3.430_132&rgn=div8

Halogen is the baseline in the market given this legislation. Table 3 provides a summary of the efficiency standards under the first phase of EISA.

Table 3. Phase 1 EISA Efficiency Standards

Rated Lumen Range	Typical Current Lamp Wattage	Maximum Rated Wattage	Minimum Rated Lifetime	Effective Date
1,490-2,600	100	72	1,000 hrs	1/1/2012
1,050-1,489	75	53	1,000 hrs	1/1/2013
750-1,049	60	43	1,000 hrs	1/1/2014
310-749	40	29	1,000 hrs	1/1/2014

A range of products were exempt from this legislation, including small base lamps, low-wattage (<40 watt) lamps, high wattage lamps (>100 watt), rough service lamps, three-way lamps, appliance lamps, and other products.

Phase 2 of the legislation was to take effect on January 1, 2020, setting an efficiency standard of 45 lumens per watt across nearly all screw-based products commonly used in residential applications. However, through a series of rules and determinations issued over the course of 2019, DOE effectively rolled back the enactment of the Phase 2 EISA standards, leaving halogens and incandescent technologies as the minimum efficiency standards.

Department of Energy (DOE) Energy Conservation Standards for Incandescent Reflector Lamps

DOE published updated energy conservation standards on January 26, 2015. According to the standards, certain incandescent reflector lamps manufactured after July 14, 2012, shall meet or exceed the lamp efficacy standards shown in Table 4.

Table 4. Incandescent Reflector Lamp Standards (40W-205W)

Lamp Spectrum	Lamp Diameter	Rated Voltage	Minimum Average Efficacy
Standard	>2.5 inches	≥125 V	$6.8*p^{0.27}$ lumens per watt
		<125 V	$5.9*p^{0.27}$ lumens per watt
	≤ 2.5 inches	≥125 V	$5.7*p^{0.27}$ lumens per watt
		<125 V	$5.0*p^{0.27}$ lumens per watt
Modified	>2.5 inches	≥125 V	$5.8*p^{0.27}$ lumens per watt
		<125 V	$5.0*p^{0.27}$ lumens per watt
	≤ 2.5 inches	≥125 V	$4.9*p^{0.27}$ lumens per watt
		<125 V	$4.2*p^{0.27}$ lumens per watt

Certain reflector products are exempt from the above-mentioned standards. Those products include:

- Lamps rated at 50 watts or less that are ER30, BR30, BR40, or ER40 lamps;
- Lamps rated at 65 watts that are BR30, BR40, or ER40 lamps; or
- R20 incandescent reflector lamps rated 45 watts or less.

For all reflector products not covered by the legislations above, incandescent light bulbs are the minimum efficiency product on the market.

All nominated program discounted products are CFLs or LEDs, which exceed minimum efficiency standards.

1.7 Nominated and Verified Values by EE Resource

Table 5 below shows the claimed nominated EE and CP values by installation period (IP) and overall. Note that CP values were set to not to exceed the EE value per PJM guidance for nominating savings under CP. The Excel spreadsheet provided alongside this M&V report, titled "2020-2021 Delivery Year_Detailed Residential Nomination Results", contains a summary as well as a detailed account of the energy efficient equipment distributed through DEO's residential programs from which demand reduction was nominated into the 2020-2021 DY.

Table 5. Claimed Nominated EE and CP Values by Installation Period

Type of EE Installation	Installation Period	Transmission Zone	Claimed Nominated EE Value (MW)	Claimed Nominated CP Value (MW)
Lighting	6/1/2016-5/31/2017	DEOK	0.96	0.96
Lighting	6/1/2017-5/31/2018	DEOK	0.90	0.90
Lighting	6/1/2018-5/31/2019	DEOK	5.52	5.52
Lighting	6/1/2019-5/31/2020	DEOK	1.49	1.49
Total			**8.87**	**8.87**

Table 6 summarizes the nominated, cleared, and claimed nominated EE and CP values along with the overall one-tailed relative precision at 90% confidence around the verified values.

Table 6. EE and CP Values by Installation Period

Value Type	Nominated Values (MW)	Cleared Value (MW)	Claimed Nominated Value (MW)	Relative Precision
EE value	4.36	0	8.87	7.3%
CP Value	3.74	3.36	8.87	5.4%

1.8 Capacity Rights to Use an Energy Efficiency Installation as Capacity Resource

By submitting this Post-Installation Measurement & Verification Report to PJM, Duke Energy Ohio affirms and acknowledges that it has the legal authority to claim the demand reduction associated with the EE installation(s) that constitute the Energy Efficiency Resource for the applicable Delivery Year (DY).

2. Site Documentation to Support Installed EE Resource

The Excel spreadsheet provided alongside this M&V report, titled "2020-2021 Delivery Year_Detailed Residential Nomination Results", contains a detailed account of the energy efficient equipment distributed through DEO's residential programs.

3. Measurement and Verification Results

3.1 Methodology Used

Opinion Dynamics relied on the Partially Measured Retrofit Isolation M&V option (Option A) to measure and verify nominated savings. This option is recommended for residential lighting applications in the International Performance Measurement & Verification Protocol (IPMVP).[5] The use of this M&V option conforms with Manual 18B M&V guidelines.

Under the Partially Measured Retrofit Isolation option of the IPMVP, savings are determined by partial field measurement of the energy use of the system(s) to which an energy conservation measure (ECM) was applied, separate from the energy use of the rest of the facility. Savings are calculated using engineering calculations as well as short term or continuous post-retrofit measurements and stipulations.

The focus of the measurement work is on estimating coincidence factors, and the focus of the verification work is on establishing the share of bulbs installed and operational.

All other assumptions to support the calculation of the nominated EE and CP values are either stipulated or derived from detailed program tracking data. Section 3.4 of this report provides details around the nominated EE and CP value calculations.

3.2 Measurement Activity Details

Measurement activities focused on the estimation of the coincidence factors (CF). The definition of the CF is aligned with the PJM EE Performance Hours and Winter Performance Hours.

The EE Performance Hours are between the hour ending 15:00 Eastern Prevailing Time (EPT) and the hour ending 18:00 EPT during all days June 1 through August 31, inclusive, of such delivery year that is not a weekend or a federal holiday.

The Winter Performance Hours are between the hour ending 8:00 EPT and the hour ending 9:00 EPT, and between the hour ending 19:00 EPT and the hour ending 20:00 EPT all days from January 1 through February 28, inclusive, of such delivery year that is not a weekend or federal holiday.

Opinion Dynamics derived the coincidence factor through an onsite lighting metering study in a sample of homes in Duke Energy's Ohio jurisdiction. Opinion Dynamics completed the study as part of the evaluation of the Duke Energy Ohio Free LED and Online Store programs, conducted in 2017.[6] We drew the sample for this study from the population of DEO customers who participated in either the Free LED program or the Online Store program between January 2016 and December 2016.

We recruited customers online as well as over the phone. We sent email invitations to customers for whom we had email addresses and called customers for whom we only had telephone numbers. We followed up with eligible customers to schedule a time for a site visit. As part of each site visit, we took a lighting inventory, sampled fixtures for logging, and placed lighting loggers. We kept the loggers in place for approximately 6 months. After 6 months, we scheduled return visits, during which we removed lighting loggers and collected

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[5] http://www.nrel.gov/docs/fy02osti/31505.pdf

[6] Opinion Dynamics. Duke Energy Ohio Energy Efficient Appliances and Devices Program Final Evaluation Report. Prepared for Duke Energy. September 11, 2018. http://dis.puc.state.oh.us/TiffToPDf/A1001001A19C29B13652F04498.pdf.

updated information on key variables of interest. We completed recruitment and deployment site visits between March 2017 and April 2017, and retrieval visits between September and October 2017.

Table 7 provides a summary of the sampling and recruitment process. As can be seen in the table, from the sample of 2,616 DEO customers, we recruited 294 customers, and completed site visits with 101 of those customers. We retrieved loggers from all 101 homes where we deployed them.

Table 7. Summary of Sampling and Recruitment

Sampling Step	DEO
Population	56,576
Sample	2,616
Recruited customers	294
Completed deployment site visits	101
Completed logger retrieval	101

For logger deployment purposes, during the site visits, technicians classified rooms into nine distinct room types:

- Kitchen
- Living room
- Bedroom
- Bathroom
- Dining room
- Basement
- Hallway
- Exterior
- Other[7]

For each room, technicians collected the information on the total number of switches, switch controls, total number of light sockets controlled by each switch, as well as the lighting technology (CFL, LED, incandescent, halogen, empty socket) and the bulb shape (twist, reflector, globe) in each socket. As part of the site visit, we also interviewed homeowners and collected detailed data on their sociodemographic and household characteristics and their lighting preferences.

To capture lighting usage, we used DENT loggers. Dent loggers are routinely used in the M&V industry to measure lighting usage, and they meet all applicable standards set forth in Section 12 of Manual 18B, including logger synchronization to the accuracy of +/- 2 minutes per month, proper logger calibration, and maintenance. Appendix B of this report contains a detailed description of the metering equipment used for this study.

We deployed up to ten loggers per home, with at least one in each of the distinct room types described above that had an LED installed. For homes with fewer than ten rooms with LEDs, we deployed more than one logger per room (but no more than three loggers per room) to increase the overall precision as well as to act as a

[7] The "Other" category consists of laundry, garage, office, enclosed porch/sunroom/3 season room, storage, closet, attic, crawlspace, and other room types.

backup logger(s). Within each room and room type, we randomly selected the light switch to log. For each logger, we recorded the switch it was placed on and the count of light bulbs, by technology, it controls. We also recorded a detailed description of the logger placement to aid in subsequent retrieval visits (e.g., light above master bathroom mirror).

Prior to deployment, all loggers were cleaned of extraneous data and reset. Logger clocks were reset to the correct time zone and time using the SMARTware™ Windows® software package. Loggers were placed as close to the lamp as possible to eliminate any ambient light interference. Where needed, site visit technicians used a fiber optic eye to get as close to the source of light as possible. Technicians calibrated and tested each logger for proper operation in accordance with stringent logger state tests as specified by the manufacturer.

In total, we deployed 356 loggers across 101 households. We were unable to retrieve a total of 5 loggers. To prepare the logger data for analysis, we performed a series of data-cleaning steps to ensure that only loggers with proper and reasonable data are included in our analysis. Based on the cleaning steps, we used 300 of the 356 deployed loggers in our analysis (84%). This represents an attrition rate of 16%, which is typical for these studies, especially considering the lengthy metering period.

CFs represent the fraction of time during the performance period that the light is on. We used the following performance period definitions:

The EE Performance Hours (summer peak CF) are between the hour ending 15:00 Eastern Prevailing Time (EPT) and the hour ending 18:00 EPT during all days June 1 through August 31, inclusive, of such delivery year that is not a weekend or a federal holiday.

The Winter Performance Hours (winter peak CF) are between the hour ending 8:00 EPT and the hour ending 9:00 EPT, and between the hour ending 19:00 EPT and the hour ending 20:00 EPT all days from January 1 through February 28, inclusive, of such delivery year that is not a weekend of federal holiday.

It is well-known that the number of daylight hours affect hours of lighting use. Lighting logger studies that do not log usage during the entire period of interest must annualize the results so they apply to the entire period and not simply the logged period. Because loggers were in the field for the entire duration of the EE performance period, annualization of the lighting usage was not necessary. Therefore, we relied on the observed usage data to estimate summer peak CFs. We calculated the summer peak CF by summing, for each logger, the time the light was on during the EE performance period and dividing the result by the number of hours within the performance period.

Conversely, we did not log lighting usage during the winter performance hours. To determine winter peak CFs, we annualized lighting usage. We annualized the lighting usage data using an individual ordinary least squares (OLS) regression model. The model specification is provided in the equation below.

Equation 1. Annualization Model Specification

$$Hd = \alpha + \beta \sin(\theta \mathrm{d}) + \varepsilon d$$

Where:

Hd= Hours on during a period, starting with d=1 on January 1.
α= The intercept representing HOU when sin(θd)=0. Since average sin(θd) for the year is equal to zero by design, evaluating the model at the average declination angle leaves only the constant to estimate HOU; therefore, the intercept term is equal to average annualized HOU for each bulb.

β = Sine coefficient, or the difference between the HOU on the solstice and days with the average annual declination angle.

$Sin(\theta d)$ = Sine of the solar declination angle or day d converted to follow the change in the HOU and adjusted to fit the −1 to +1 interval with an average of zero for the year (for ease of analysis). The solar declination angle represents the latitude at which the sun is directly overhead at midday. We used the following formula to calculate the sine of the solar declination angle for each day of the year:

$$\sin(-\pi*2*(284+d)/365)$$

εd = Residual error

We fit sinusoid regression models for each individual logger. We analyzed each regression model for goodness of fit to determine if the individual bulb was sufficiently daylight-sensitive to justify regression-based annualization and to determine if the sinusoid model could provide a reliable estimate (i.e., the sinusoid model accurately represented trends in lighting use over time). In case of poor fitting models, which indicated that the lamp was not daylight-sensitive, we replaced the modeled usage with the observed usage during the metering period.

Similar to the summer peak CF calculation process, we calculated the winter peak CF by summing, for each logger, the time the light was on during the winter performance hours and dividing the result by the number of hours within the performance period.

We aggregated individual logger data in stages. First, we aggregated individual loggers to room-level CF estimates in order to adequately account for the fact that some loggers logged an LED that was on a switch that controlled more than one LED. Therefore, the logged LED represents all LEDs on the same switch. We then further weighted room-level CF estimates by the share of LEDs in each room type. To account for oversampling of Online Store program participants, as well as participants with email addresses, we applied post-stratification weights to align the sample with the participant population.

Table 8 presents coincidence factors for the EE and winter performance hours to support the energy efficiency resource nomination into PJM's forward capacity markets. The overall EE (Summer) CF is 0.089, while the overall winter CF is 0.153. The relative precision of both coincidence factors exceeds PJM requirements (10% one-tailed relative precision at 90% confidence).

Table 8. Coincidence Factors and Relative Precision

Metric	EE Performance Hours (Summer CF)	Winter Performance Hours (Winter CF)
Installation type	Lighting	Lighting
Sample size	300	300
Coincidence factor	0.089	0.153
Standard deviation	0.087	0.104
Coefficient of variation	0.973	0.679
Relative precision	7.0%	5.0%

The Excel spreadsheet provided alongside this M&V report, titled "2020-2021 Delivery Year_Detailed Residential Nomination Results", contains a detailed account of the key measurement activity parameters.

3.3 Verification Activity Details

Verification activities focused on confirming lighting installation (i.e., that the lighting products were installed and were operational at the time of the inquiry) and consisted of survey efforts with a representative sample of participants from each installation period (IP) nominated into the 2020-2021 DY. The results of the participant survey research were used to develop an estimate of the in-service rate (ISR).

3.3.1 Sampling and Fieldwork

Opinion Dynamics performed verification research for the 2016-2017 IP, 2017-2018 IP, and 2018-2019 IP. For the 2019-2020 IP, where only part of the year had elapsed prior to development of the M&V report, no verification research was performed. Instead, we relied on the verification results from the prior installation period.

The sample frame for the verification research for the 2016-2017 IP consisted of program participants from all six of the residential programs operating at that time from which Duke Energy nominated demand reduction into the 2020-2021 DY. To increase sample sizes and therefore relative precision around verification results, Opinion Dynamics leveraged verification survey efforts with participants completed as part of the impact evaluation efforts for the Free LED, Energy Efficiency Online Store, Residential Energy Assessments, and Neighborhoods Energy Saver programs.

The sample frame for the 2017-2018 IP consisted of five programs, excluding participants from the Property Manager program due to insufficient participation within the timeframe needed to support the survey work.[8] To increase sample size and therefore relative precision around verification results for the Neighborhoods Energy Saver program, Opinion Dynamics leveraged the verification survey effort completed as part of the 2018 evaluation of the program.

For the 2018-2019 IP, the sample frame included program participants from five programs and did not include the Neighborhoods Energy Saver program, as we did not have sufficient participation data at the time of the survey effort for the program,[9] In addition, the nature of the Retail Lighting program delivery is such that no participant contact information is collected as part of the process. As such, we are unable to conduct installation verification research for this program. To mitigate this challenge, we relied on the ISR results from the Online Store program.

For each program included in the verification research supporting the 2020-2021 DY, we drew a simple random sample of participants. Opinion Dynamics stratified the samples by program to ensure adequate representation of participants from each program. We administered the surveys over the phone or online after the end of the IP. As part of the surveys, we verified project completion, measure installation, and measure persistence. We asked installation verification and persistence questions at the measure category level. Table 9 below provides a summary of the target and achieved sample and survey fielding period for each IP.

[8] For this program, we used the verification results from the 2016-2017 IP.
[9] For this program, we used the verification results from the 2017-2018 IP.

Table 9. Sample Design and Fieldwork

Installation Period	Target Sample	Achieved Sample	Survey Fielding Period
2016-2017	150	594	Energy Education Program for Schools and Property Manager Lighting Channel: September-October 2017 Free LED Program: December 2016-June 2017 (3 waves) Online Store Program: November 2016-June 2017 (3 waves) Low Income Neighborhoods Program: January 2017 Residential Energy Assessments Program: February 2018
2017-2018	150	254	Free LED, Online Store, Energy Education for Schools, and Residential Energy Assessments Programs: July-August 2018 Low Income Neighborhoods Program: January 2019
2018-2019	150	216	Free LED, Online Store, Energy Education for Schools, Property Manager, and Residential Energy Assessments Programs: August 2019

3.3.2 In-Service Rate Estimation

We calculated ISR as the number of bulbs installed and operational at the time of the survey divided by the number of bulbs that participants received (see Equation 2). For each survey respondent, we calculated ISR for each lighting measure covered in the survey. We aggregated measure-level ISRs to the participant level weighting by savings. We then further aggregated participant-level ISRs to the program level, applying savings weights. Finally, we aggregated program-level ISRs to the IP level weighting by savings associated with each program for that year.

Equation 2. ISR Formula

$$ISR = \frac{Total\ Number\ of\ Bulbs\ Installed\ and\ Operational}{Total\ Number\ of\ Bulbs\ Delivered}$$

Table 10 shows ISR results by IP. As can be seen in the table, the ISR estimates range from 59.6% to 74.6%. The error bounds around each ISR estimates are narrow and relative precision is robust. We applied the IP-specific ISRs presented in the table below to the installations from that IP. ISR values for the 2018-2019 IP incorporate results from research conducted since the submission of 2019-2020 DY nominated savings, which accounts for any difference between 2018-2019 IP values applied to the 2019-2020 DY and 2020-2021 DY. For the 2019-2020 IP, we used program-specific ISR values from the 2018-2019 IP and weighted them to the savings associated with each program for that year.

Table 10. ISR Results

Installation Period	Sample Size (Respondents)	ISR	Relative Precision
2016-2017	594	69.2%	2%
2017-2018	254	72.1%	2%
2018-2019	216	58.8%	3%
2019-2020[a]	216	62.1%	2%

[a] No survey was conducted; the ISR is based on savings-weighted program-level ISR results from the 2018-2019 IP.

The Excel spreadsheet provided alongside this M&V report, titled "2020-2021 Delivery Year_Detailed Residential Nomination Results", contains a detailed account of the key verification activity parameters.

3.4 Nominated EE Value Calculation

We calculated the EE and CP savings values using the equation below. This equation is an industry-accepted, standard approach to estimating peak demand saving from lighting installations.

Equation 3. Savings Equation

$$\Delta kW = Bulbs * \left(\left(\frac{Watts_{base} - Watts_{ee}}{1000}\right) * ISR * CF * HVAC_d\right)$$

Where:

- ΔkW = Gross coincident peak demand savings
- Bulbs = number of bulbs/lamps distributed through the programs
- $Watts_{base}$ = Baseline bulb wattage
- $Watts_{ee}$ = Program bulb wattage
- ISR = In-service rate
- CF = Peak coincidence factor
- $HVAC^d$ = HVAC system interactive effect for demand

Fixtures

We used detailed program tracking data to determine the number of bulbs distributed through the program.

$Watts_{base}$

We used the “Standard Baseline” approach to determine baseline wattages. Per Section 8 of Manual 18B, the “standard” baseline is appropriate for projects in which equipment (whether failed or not) is replaced by a more efficient equivalent or by an alternative strategy for delivering comparable output. For each program measure we determined minimum efficiency baseline wattages adjusted by applicable federal standards.

$Watts_{ee}$

We used detailed program tracking data to determine program fixture wattages. All residential programs keep detailed records of the manufacturer rated wattage for each unique product.

ISR

We relied on the participant survey to estimate ISR. Section 3.3 above details the verification approach that Opinion Dynamics used and the ISRs that we applied.

CF

We relied on the lighting metering study to determine the CFs for both EE Performance Hours and Winter Performance Hours. This study is described in detail in Section 3.2 above. We used the CF for the EE Performance Hours to calculate EE savings and the CF for the Winter Performance Hours to calculate CP savings.

HVAC$_d$

CFLs and LEDs emit less heat than incandescents or halogens, resulting in decreased cooling loads as less energy is needed to compensate for heat given off by incandescents or halogens. Application of interactive effects in the estimation of savings accounts for the changes in cooling load. To estimate EE savings, Opinion Dynamics used an interactive factor of 1.167 from the recent impact and process evaluation of the DEO specialty bulb program. The interactive effect was developed through the DOE-2.2 simulations of a set of prototypical residential buildings. The prototypical simulation models were derived from the residential building prototypes used in the California Database for Energy Efficiency Resources (DEER) study (Itron, 2005), with adjustments made for local building stock and climate leveraging the Duke Energy Home profile database in Ohio, to better represent the Duke Energy Ohio participant population. This estimate of interactive effects is the best available.

To estimate CP savings, we did not apply any interactive effects (interactive effects=1). Given a relatively small share of homes in DEO's service territory that are electrically heated (less than one-third of homes), we anticipate interactive effects to be negligible.

Appendix A. Data Collection Instrument – Installation Periods 2016-2017, 2017-2018, and 2018-2019

Duke Energy Ohio

Residential Energy Efficiency Programs

Participant Survey

FINAL

August 8, 2019

Background

The main goal of this survey is to verify Duke Energy program light bulb receipt, installation, and continued operation. We will administer the survey online and via phone with participants across the following Duke Energy programs:

- Free LED program
- Energy Efficiency Online Store program
- Residential Energy Assessments program
- Low Income Neighborhoods program
- Property Manager Lighting Channel
- Energy Education Program for Schools

We will send a random sample of program participants invitations via mail or email to complete the survey. We will follow invitations by mail and email reminder to increase response rate. Participants who complete the survey will be entered into a drawing for a cash prize.

Sample Fields

INCENTIVE	=Survey drawing incentive
COMPLETES	=Number of anticipated survey completes
PROGRAM	=1 (FREE)/2 (OLS)/3 (HEA)/4 (LI)/5 (PM)/6 (EDU)
TECH	=Standard LED/Reflector LED/Specialty LED
MONTHYEAR	=Month and year of participation
LAST YEAR	=Last full year for income question (2017)
FLDUP	=Flag for multiple Free LED kits in order
FLMULTIORD	=Flag for multiple Free LED orders
FLEDQTY	=Quantity of LEDs through Free LED program
HEALEDQTY	=Quantity of LEDs through HEA program
LILEDQTY	=Quantity of LEDs through Low Income NES program
PMLEDQTY	=Quantity of LEDs through Property Manager program

EELEDQTY =Quantity of LEDs through Energy Education program
STANLED =Quantity of Standard LEDs via Online Store
REFLED =Quantity of Reflector LEDs via Online Store
SPECLED =Quantity of Specialty LEDs via Online Store

Introduction

Thank you very much for taking the time to complete the survey. This survey will take no more than five minutes of your time. As a token of appreciation, once you complete the survey, you will be entered into a drawing to win <INCENTIVE>. You will be one of <COMPLETES> customers eligible to win.

Participation Verification – Free LED Program

[ASK IF PROGRAM=FREE LED]
FLI1. [READ IF <FLMULTIORD>=1: Our records indicate that you have placed multiple orders for free LED bulbs. For the purposes of this survey, we will focus just on your most recent order.] Our records indicate that in <MONTHYEAR>, you received [IF FLDUP=0: a free LED bulb kit] [IF FLDUP>0: free LED bulb kits] with <FLED_QTY> LED light bulbs from Duke Energy. Is that correct?
1. Yes, both quantity and date are correct
2. No, quantity is correct but the date is wrong
3. No, date is correct, but quantity is wrong
4. No, both quantity and date are wrong
5. No, I did not receive any LEDs from Duke Energy
98. Don't know

[ASK IF FLI1=98]
FLI2. Is there someone else knowledgeable about the free LEDs?
1. Yes
2. No [TERMINATE]

[ASK IF FLI2=1]
FLI3. [SHOW FOR PHONE SURVEY] Can I please speak with someone most knowledgeable about the free LEDs that your household received from Duke Energy?
[REDIRECT TO BEGINNING OF SURVEY]

[SHOW FOR WEB SURVEY] For the purposes of this survey, we are looking to gather feedback from the person most knowledgeable about the [IF DUP=0: free LED bulb kit] [IF DUP>0: free LED bulb kits] your household received from Duke Energy. Please have that person complete the survey using the same six-digit PIN that was provided in the survey invitation.
[REDIRECT TO BEGINNING OF SURVEY]

[ASK IF FLI1=3,4]
FLI4. How many LEDs did you receive from Duke Energy?
00. (Numeric Open-end, [ALLOW RESPONSES OF 1-97]
98. (Don't know) [SHOW ON WEB]

[CALCULATE LED_RCVD_QTY=FLI4 IF FLI1=3 OR (FLI1=4 AND FLI4=98); LED_RCVD_QTY=FLED_QTY if FLI1=1,2; 0 IF FLI1=5 OR (IF FLI3=3,4 AND FLI4=0), ELSE LED_RCVD_QTY=999]

[THANK AND TERMINATE IF LED_RCVD_QTY=0]
[SKIP TO DEMOS IF LED_RCVD_QTY=999]

Participation Verification – Online Store Program

[ASK IF PROGRAM=ONLINE STORE]

OSI1. Our records indicate that you purchased bulbs through the Duke Energy Online Store by either ordering online, over the phone, or filling out a mail-back postcard, is that correct?

1. Yes
2. No [TERMINATE]
98. Don't know

[ASK IF OSI1=98]

OSI1A. Is there someone else knowledgeable about LEDs that may have been purchased from the Duke Energy Online Store?

1. Yes
2. No [TERMINATE]

[ASK IF OSI1A =1]

OSI1B. [SHOW FOR PHONE SURVEY] Can I please speak with someone most knowledgeable about the LEDs that your household may have received from Duke Energy?
[REDIRECT TO BEGINNING OF SURVEY]

[SHOW FOR WEB SURVEY] For the purposes of this survey, we are looking to gather feedback from the person most knowledgeable about the LEDs that your household may have received from Duke Energy. Please have that person complete the survey using the same six-digit PIN that was provided in the survey invitation.
[REDIRECT TO BEGINNING OF SURVEY]

OSI2. [SHOW FOR WEB SURVEY] Below is a list of all products that our records show you purchased. For each, please confirm the quantity of light bulbs purchased, tell us how many you installed and how many are still installed today. Please note that the quantity shown is of individual light bulbs, not packages.
[SHOW FOR PHONE SURVEY] I would like to ask you about the specific products that you purchased through the Duke Energy Online Store. For each product, I will tell you what our records show you purchased and ask you to tell me how many products you received, how many you installed, and how many are currently installed.

SHOW FOR WEB SURVEY	Bulb Type	Description	Product Image	Number of Bulbs Purchased (From Duke Energy's Records)	(A) Enter the number of bulbs you received	(B) Enter the number of Duke Energy Online Store bulbs you installed (it can be some or all of the bulbs that you received, but cannot be more than the number of bulbs that you received)	(C) Enter the number of Duke Energy Online Store bulbs that are currently installed" (it can be some or all of the bulbs that you installed, but cannot be more than the number of bulbs you installed)
SHOW FOR PHONE SURVEY			[DO NOT SHOW FOR PHONE SURVEY]	Our records indicate that you purchased this quantity of bulbs	How many bulbs did you receive?	How many bulbs have you installed?	How many bulbs are still installed?
[ASK IF STANLED >0] OSI2_4.	Standard LED	Standard LEDs fit into a regular light socket and can be used to replace your basic general purpose light bulbs. An LED bulb often has a plastic base, sometimes with ridges. LEDs are the newest type of light bulb on the market. They typically cost more than the other types of light bulbs.		[INSERT BULB QUANTITY]	OSI2_A4	OSI2_B4	OSI2_C4
[ASK IF REFLED >0] OSI2_5.	Reflector LEDs or LED flood lights	LED Reflector bulbs are generally used in recessed ceiling fixtures. LED Reflectors include LED flood lights. An LED bulb often has a plastic base, sometimes with ridges. LEDs are the newest type of light bulb on the market. They typically cost more than the other types of light bulbs.		[INSERT BULB QUANTITY]	OSI2_A5	OSI2_B5	OSI2_C5
[ASK IF SPECLED >0] OSI2_6.	Specialty LED	Specialty LED products include light bulbs with a small base, and include bulb shapes like globe, torpedo, three-way and candelabra. An LED bulb often has a plastic base, sometimes with ridges. LEDs are the newest type of light bulb on the market. They typically cost more than the other types of light bulbs.		[INSERT BULB QUANTITY]	OSI2_A6	OSI2_B6	OSI2_C6

[CALCULATE OS_RCVD_QTY=SUM OSI1_A]
[CALCULATE OS_INSTALLED QUANTITY=SUM OSI1_B]
[CALCULATE OS_STILL_INSTALLED=SUM OSI1_C]
[THANK AND TERMINATE IF OS_RCVD_QTY=0]

Participation Verification – Home Energy Assessments Program

[ASK IF PROGRAM=HOME ENERGY ASSESSMENTS]
HEAI1. Our records indicate that on or around <DATE> you participated in Duke Energy's Home Energy House Call Program. As part of the program you registered for a home energy assessment where someone came to your home and provided you with energy saving recommendations and a free energy efficiency kit that included light bulbs, a showerhead, and faucet aerators. Do you remember participating in this program?
1. Yes
2. No

[ASK IF HEAI1=2]
HEAI2. Is there someone else knowledgeable about the Home Energy House Call program?
1. Yes
2. No [TERMINATE]

[ASK IF HEAI2=1]
HEAI3. [SHOW FOR PHONE SURVEY] Can I please speak with someone most knowledgeable about the participation in the Home Energy House Call program?
[REDIRECT TO BEGINNING OF SURVEY]
[SHOW FOR WEB SURVEY] For the purposes of this survey, we are looking to gather feedback from the person most knowledgeable about the Home Energy House Call program. Please have that person complete the survey using the same six-digit PIN that was provided in the survey invitation.
[REDIRECT TO BEGINNING OF SURVEY]

[ASK IF HEAI1=1]
HEAI4. Our records indicate that you received <HEALED_QTY> LED bulbs in your energy efficiency starter kit. Is that correct?
1. Yes, the number is correct
2. No, I received a different number of LEDs

[ASK IF HEAI4=2]
HEAI5. How many LEDs did you receive from Duke Energy? [NUMERIC OPEN END 0-8; 98=DON'T KNOW (SHOW ON WEB)]

[CALCULATE HEA_RCVD_QTY=999 IF HEAI4=2 AND HEAI5=98, ; HEA_RCVD_QTY=HEAI5 IF HEAI4=2 AND HEAI5<>98; HEA_RCVD_QTY=0 IF QHEAI2=2; ELSE HEA_RCVD_QTY=HEALED_QTY]

[THANK AND TERMINATE IF HEA_RCVD_QTY=0]
[SKIP TO DEMOS IF HEA_RCVD_QTY=999]

Participation Verification – Low Income Neighborhoods Program

[ASK IF PROGRAM=LOW INCOME NEIGHBORHOODS PROGRAM]

LII1. Our records indicate that on or around <DATE> you participated in Duke Energy's Residential Neighborhoods program, where representatives from Duke Energy came to your home, gave you information on ways to save energy, and installed energy saving products, is that correct?

1. Yes
2. No

[ASK IF LII1=2]

LII2. Is there someone else knowledgeable about the Residential Neighborhood program?

1. Yes
2. No [TERMINATE]

[ASK IF LII2=1]

LII3. [SHOW FOR PHONE SURVEY] Can I please speak with someone most knowledgeable about the participation in the Residential Neighborhood program?
[REDIRECT TO BEGINNING OF SURVEY]
[SHOW FOR WEB SURVEY] For the purposes of this survey, we are looking to gather feedback from the person most knowledgeable about the Residential Neighborhood program. Please have that person complete the survey using the same six--digit PIN that was provided in the survey invitation.
[REDIRECT TO BEGINNING OF SURVEY]

[ASK IF LII1=1]

LII4. Our records indicate that you received <LILED_QTY> LEDs through the program. Is that correct?

1. Yes, the number is correct
2. No, I received a different number of LEDs

[ASK IF LII4 = 2]

LII5. How many LEDs did you receive from Duke Energy? [NUMERIC OPEN END 0-8; 98=DON'T KNOW [SHOW ON WEB]]

[CALCULATE LI_RCVD_QTY=999 IF LII4=2 AND LII5=98, LI_RCVD_QTY=LII5 IF LII4=2 AND LII5<>98, LI_RCVD_QTY=0 IF QLII2=2, ELSE LI_RCVD_QTY=LILED_QTY]

[THANK AND TERMINATE IF LI_RCVD_QTY=0]
[SKIP TO DEMOS IF LI_RCVD_QTY=999]

Participation Verification – Property Manager Lighting Channel

[ASK IF PROGRAM=PROPERTY MANAGER LIGHTING CHANNEL]

PMI1. Our records indicate that on or around <DATE> you participated in Duke Energy's Multi-Family program where a Duke Energy representative came to your home and installed energy savings products, such as light bulbs, faucet aerators, and low-flow showerheads, is that correct?

1. Yes
2. No

[ASK IF PMI1=2]
PMI2. Is there someone else knowledgeable about your household's participation in this program?
1. Yes
2. No [TERMINATE]

[ASK IF PMI2=1]
PMI3. [SHOW FOR PHONE SURVEY] Can I please speak with someone most knowledgeable about your household's participation in this program?
[REDIRECT TO BEGINNING OF SURVEY]
[SHOW FOR WEB SURVEY] For the purposes of this survey, we are looking to gather feedback from the person most knowledgeable about your household's participation in this program. Please have that person complete the survey using the same six-digit PIN that was provided in the survey invitation.
[REDIRECT TO BEGINNING OF SURVEY]

[ASK IF PMI1=1]
PMI4. Our records indicate that you received <PMLED_QTY> LEDs through the program. Is that correct?
1. Yes, the number is correct
2. No, I received a different number of LEDs

[ASK IF PMI4 = 2]
PMI5. How many LEDs did you receive from Duke Energy? [NUMERIC OPEN END 0-8; 98=DON'T KNOW [SHOW ON WEB]]

[CALCULATE PM_RCVD_QTY=999 IF PMI4=2 AND PMI5=98, PM_RCVD_QTY=PMI5 IF PMI4=2 AND PMI5<>98, PM_RCVD_QTY=0 IF QPMI2=2, ELSE PM_RCVD_QTY=PMLED_QTY]

[THANK AND TERMINATE IF PM_RCVD_QTY=0]
[SKIP TO DEMOS IF PM_RCVD_QTY=999]

Participation Verification – Energy Education Program for Schools

[ASK IF PROGRAM=ENERGY EDUCATION PROGRAM FOR SCHOOLS]
EEI1. Our records indicate that on or around <DATE> your household received an energy efficiency kit through Duke Energy's Education program. The kit contains energy savings measures, such as energy efficient light bulbs, faucet aerators, and low-flow showerheads. Is this correct?
1. Yes
2. No

[ASK IF EEI1=2]
EEI2. Is there someone else knowledgeable about your household's participation in this program?
1. Yes
2. No [TERMINATE]

[ASK IF EEI2=1]
EEI3. [SHOW FOR PHONE SURVEY] Can I please speak with someone most knowledgeable about your household's participation in this program?
[REDIRECT TO BEGINNING OF SURVEY]
[SHOW FOR WEB SURVEY] For the purposes of this survey, we are looking to gather feedback from the person most knowledgeable about your household's participation in this program. Please have that person complete the survey using the same six-digit PIN that was provided in the survey invitation.
[REDIRECT TO BEGINNING OF SURVEY]

[ASK IF EEI1=1]
EEI4. Our records indicate that you received <EELED_QTY> LEDs as part of the kit. Is that correct?
1. Yes, the number is correct
2. No, I received a different number of LEDs

[ASK IF EEI4 = 2]
EEI5. How many LEDs did you receive in the kit? [NUMERIC OPEN END 0-8; 98=DON'T KNOW [SHOW ON WEB]]

[CALCULATE EE_RCVD_QTY=999 IF EEI4=2 AND EEI5=98, EE_RCVD_QTY=EEI5 IF EEI4=2 AND EEI5<>98, EE_RCVD_QTY=0 IF QEEI2=2, ELSE EE_RCVD_QTY=EELED_QTY]

[THANK AND TERMINATE IF EE_RCVD_QTY=0]
[SKIP TO DEMOS IF EE_RCVD_QTY=999]

Installation Verification

[COMPUTE RECEIVED QTY=SUM(LED_RCVD_QTY, OS_RCVD_QTY, HEA_RCVD_QTY, LI_RCVD_QTY, PM_RCVD,_QTY EE_RCVD_QTY)]

[SKIP TO IV3 IF PROGRAM=ONLINE STORE]

[ASK IF RECEIVED QUANTITY=1]
IV1. Did you install the <TECH> that you received from Duke Energy?
1. Yes
2. No

[ASK IF RECEIVED QUANTITY>1]
IV2. Did you install all, some, or none of the bulbs that you received from Duke Energy?
1. All
2. Some
3. None

[ASK IF IV2=2]
IV2A. How many of the <RECEIVED QUANTITY> <TECH>s that you had received from Duke Energy did you install? [NUMERIC OPEN END; 1 TO <RECEIVED QUANTITY>]

[CALCULATE INSTALLED QUANTITY=RECEIVED QUANTITY IF IV2=1 OR IV1=1
INSTALLED QUANTITY=IV2A IF IV2=2 AND IV2A<98
INSTALLED QUANTITY=0 IF IV2=3 OR IV1=2]

[ASK IF INSTALLED QUANTITY>0]
IV3. Where did you install the [IF PROGRAM=ONLINE STORE, READ "bulb(s)", else read "free LED(s)"] that you received from Duke Energy? [FOR WEB SURVEY: Please select all that apply.] [FOR PHONE SURVEY: Did you install the bulb(s) in any of the following places?] [READ LIST]
1. On the inside of my home
2. On the outside of my home (please count garage as outside)
3. Someplace else

[ASK IF IV3=1,2]
IV3A. Does Duke Energy provide service at your home?
1. Yes
2. No
98. Don't know

[ASK IF IV3=3]
IV3B. Where else did you install the bulb(s) that you received from Duke Energy? [MULTIPLE RESPONSE]
01. Where I work
02. In someone else's home
00. Some other place (specify___________)
98. Don't know

[ASK IF IV3=3]
IV3C. Does Duke Energy provide service at the other location(s) that you installed your bulb(s)?
01. Yes
02. No
00. Duke Energy provides service to **some** locations (please specify those locations)
98. Don't know

[ASK IF RECEIVED_QTY<>INSTALLED_QTY, ELSE SKIP TO IV6]
IV4. [READ IF IV2=2] Why haven't you installed all of the <TECH>s you received?
[READ IF IV2=3] Why haven't you installed any of <TECH>s you received?
[READ IF IV1=2] Why haven't you installed the <TECH>you received?
[MULTIPLE RESPONSE UP TO 4, RANDOMIZE]
01. Haven't had the need to install bulbs
02. I am waiting for light bulbs to burn out
03. I don't have a light socket where I use that wattage
04. I don't like LEDs
00. Other, specify

IV5. What did you do with the [IF PRORGAM=ONLINE STORE, READ "bulb(s)", else read "free <TECH>(s)"] you did not install? [MULTIPLE RESPONSE UP TO 4, RANDOMIZE]
01. Placed them in storage for later use
02. Threw them away
03. Gave them away
00. Other, specify

[ASK IF INSTALLED QUANTITY>0; SKIP IF PROGRAM=ONLINE STORE]

IV6. [READ IF INSTALLED QUANTITY=1] Have you removed the free <TECH> that you installed?
[READ IF INSTALLED QUANTITY>1] Have you removed any of the free <TECH>s that you installed?

1. Yes
2. No

[ASK IF IV6=1 AND INSTALLED QUANTITY>1]

IV6A. How many of the <INSTALLED QUANTITY> [IF PRORGAM=ONLINE STORE, READ "bulbs", else read "free <TECH>s"] have you removed? [NUMERIC OPEN END; 1 TO INSTALLED QUANTITY,]

[ASK IF IV6=1 AND INSTALLED QUANTITY=1]

IV7aa. Was the [IF PRORGAM=ONLINE STORE, READ "bulb", else read "free <TECH>"] that you removed working or was it broken?

1. Working
2. Broken

[ASK IF IV6=1 AND INSTALLED QUANTITY>1]

IV7ab. Were the [IF PRORGAM=ONLINE STORE, READ "bulbs", else read "free <TECH>s"] that you removed working or were they broken?

1. All were working
2. All were broken
3. Some were working and some were broken

Replacement Behaviors

[SKIP TO R7 IF PROGRAM=ONLINE STORE]

[ASK IF INSTALLED QUANTITY=1]

R1. What type of bulb was in the socket before you installed the free <TECH>in it?

1. Incandescent/halogen
2. CFL [READ DESCRIPTION IF NEEDED]
3. LED [READ DESCRIPTION IF NEEDED]
4. Nothing, the socket was empty [SKIP TO R6]
98. Don't know
9. (Refused)

[ASK IF INSTALLED QUANTITY>1]

R2. [ASK FOR PHONE SURVEY: I am] [ASK FOR WEB SURVEY: We are] interested in the types of bulbs that were in the sockets before you installed the free <TECH>sin them. Did you have any CFLs or LEDs in any of those sockets?

(READ IF NEEDED FOR INBOUND PHONEY SURVEY: CFLs are “twisty” bulbs that are made with a glass tube bent into a spiral, resembling self-serve ice-cream. They may look just like the bulbs that were installed through the program.

An LED bulb often has a plastic base, sometimes with ridges. LEDs are the newest type of light bulb on the market. They typically cost more than the other types of light bulbs.)

1. Yes
2. No
98. Don’t know

[ASK IF R2=1]

R3. How many of the <INSTALLED QUANTITY> sockets where you installed the free <TECH>s had CFLs or LEDs in them? [NUMERIC OPEN END 1-<INSTALLED QUANTITY>]

[ASK IF INSTALLED QUANTITY>1, ELSE SKIP TO NEXT SECTION]
[SKIP IF R3=INSTALLED QUANTITY]

R4. Were any of the sockets where you installed the free <TECH>s empty at the time you installed the free LEDs in them?

1. Yes
2. No

[ASK IF R4=1]

R5. How many of the sockets where you installed the free <TECH>s were empty? [NUMERIC OPEN END 1-<INSTALLED QUANTITY>]

R6. At the time that you installed the free <TECH> (s), were any of the bulbs you replaced with free LEDs still working or had all of them burnt out? [RANDOMIZE]

1. All were still working
2. Some were still working
3. All of them had burnt out
98. Don’t know

[ASK IF PROGRAM=ONLINE STORE]

R7. [ASK FOR PHONE SURVEY: I am] [ASK FOR WEB SURVEY: We are] interested to learn what was in the sockets before you installed the <INSTALLED QUANTITY> bulbs from the Duke Energy Online Store. [SHOW FOR WEB SURVEY] Please enter how many of the <INSTALLED QUANTITY> bulbs you installed apply to each scenario below. For example, if you installed 4 bulbs and 3 of them replaced incandescents and 1 was placed in an empty socket, then you would enter 1 in the "installed empty sockets" row and 3 in the "replaced incandescents or halogen light bulbs row" and enter zero values in the other cells.
[SHOW FOR PHONE SURVEY] Please tell me where the following bulbs were installed

[SHOW FOR WEB SURVEY]	(A) Enter the number of bulbs that were installed in empty sockets	(B) Enter the number of bulbs that replaced incandescent or halogen light bulbs	(C) Enter the number of bulbs that replaced CFLs or LEDs	(D) Enter the number of bulbs that replaced other type(s) of bulbs
[SHOW FOR PHONE SURVEY]	How many bulbs were installed in empty sockets?	How many bulbs replaced incandescent or halogen light bulbs?	How many bulbs replaced CFLs or LEDs	How many bulbs replaced other types of bulbs?
R7_1. [ASK OSI1_B1>0] <OSI1_B1> Standard CFLs	R7A1	R7B1	R7C1	R7D1
R7_2. [ASK IF OSI1_B2>0] <OSI1_B2> Reflector CFLs or CFL flood lights	R7A2	R7B2	R7C2	R7D2
R7_3. [ASK IF OSI1_B3>0] <OSI1_B3> Specialty CFLs	R7A3	R7B3	R7C3	R7D3
R7_4. [ASK IF OSI1_B4>0] <OSI1_B4> Standard LEDs	R7A4	R7B4	R7C4	R7D4
R7_5. [ASK IF OSI1_B5>0] <OSI1_B5> Reflector LEDs or LED flood lights	R7A5	R7B5	R7C5	R7D5
R7_6. [ASK IF OSI1_B6>0] <OSI1_B6> Specialty LEDs	R7A6	R7B6	R7C6	R7D6

Demographics

These last few questions are about your home and your household.

D1. Which of the following best describes your home/residence? [WEB ANSWER NOT REQUIRED]
- 01. Single-family detached home (If needed: Not a duplex, townhome, or apartment; attached garage is OK)
- 02. Single family attached home (If needed: townhouse)
- 03. Mobile home
- 04. Apartment or condominium (If needed: multifamily)
- 00. Other, specify

[ASK IF D1=1]
D1a. Is your home a factory manufactured or modular home?
1. Yes, factory manufactured or modular
2. No, conventionally built

[ASK IF D1=4]
D1b. How many housing units (If needed: apartments) are in your building? (READ RESPONSES IF NECESSARY) [WEB ANSWER NOT REQUIRED]
1. 1 (Interviewer note: Do not read even if other responses are read)
2. 2-3
3. 4-9
4. 10 or more

D2. Do you own or rent this residence? [WEB ANSWER NOT REQUIRED]
1. Own
2. Rent

[ASK IF D2=2]
D2a. Do you pay your own electric bill or is it included in your rent?
1. Pay bill
2. Included in rent

D3. How long have you lived in this residence? (READ RESPONSES IF NECESSARY)
1. Less than 1 year
2. 1-3 years
3. 4-10 years
4. 11-20 years
5. More than 20 years

D4. Including yourself, how many people currently live in your residence year-round?
[NUMERIC OPEN END 0-97]

[SKIP IF D4=1]
D5. How many people under the age of 18 live in your residence?
[NUMERIC OPEN END 0-97]

D6. Approximately when was your residence first built? (DO NOT READ LIST)
- 01. Before 1950
- 02. 1950-1959
- 03. 1960-1969
- 04. 1970-1979
- 05. 1980-1989
- 06. 1990-1999
- 07. 2000-2005
- 08. 2006-2009
- 09. 2010 or later
- 98. Don't know

D7. Approximately how many square feet is your residence?
[NUMERIC OPEN END 1-50000; 99998=DON'T KNOW]

[ASK IF D7=99998]
D8. Would you estimate the square footage of your residence to be?
[WEB ANSWER NOT REQUIRED]
1. Less than 1,001 sq. ft.
2. Between 1,001 and 2,000 sq. ft.
3. Between 2,001 and 3,000 sq. ft.
4. Between 3,001 and 4,000 sq. ft.
5. Between 4,001 and 5,000 sq. ft.
6. Greater than 5,000 sq. ft.

D9. In what year were you born? [NUMERIC OPEN END 1900-2015] [WEB ANSWER NOT REQUIRED]

D10. What is your highest level of education? [WEB ANSWER NOT REQUIRED]
1. Less than a high school degree
2. High school degree
3. Technical/trade school program
4. Associates degree or some college
5. Bachelor's degree
6. Graduate / professional degree, e.g., J.D., MBA, MD, Ph.D.

D11. What best describes your current employment status? [WEB ANSWER NOT REQUIRED]
1. Employed full-time
2. Employed part-time
3. Retired
4. Not employed, but actively looking
5. Not employed, and not looking

D12. [FOR PHONE SURVEY: Please stop me when I reach the category that best represents your total annual pre-tax household income in <last whole year, i.e., 2015>.]

[FOR WEB SURVEY: Which category best represents your total annual pre-tax household income in <last whole year, i.e., 2015>?] [WEB ANSWER NOT REQUIRED]

1. Less than $25,000
2. $25,000 to just under $50,000
3. $50,000 to just under $75,000
4. $75,000 to just under $100,000
5. $100,000 to just under $150,000
6. $150,000 or more

D13. Thank you for completing our survey! Your name will be entered into our drawing for <INCENTIVE>. [FOR INBOUND PHONE SURVEY: What would be the best phone number and email address to reach you at if you win the drawing?] [FOR WEB SURVEY: Please enter the phone number and email address to contact you at if you win the drawing.]

A. Phone: [OPEN-END NUMERIC REQUIRING 10 DIGITS]
B. Email: [OPEN-END]

Those are all the questions I have. Thank you so much for your participation!

Appendix B. Logger Equipment Specifications

DENT INSTRUMENTS

SMARTLOGGERS™

ON/OFF TIME-OF-USE INSTRUMENTS

MEASURE TOTAL-ON TIME AND ON/OFF TRANSITIONS OF ALMOST ANY DEVICE

FEATURES

- Instantly see what your logger has recorded. All **SMART***loggers*™ come with a 5-digit LCD showing On-Time (in hours) and Percent On.
- With a storage capacity of over 32,000 records, **SMART***loggers*™ can record unattended for months or years.
- Simple mounting using power rare earth magnets, Velcro®, or screw hole easily secures the instruments out of sight.
- Interfaces with **SMART***ware*™ Windows® software package for easy data retrieval and simple, sophisticated data analysis.
- Compact and rugged, the **SMART***loggers*™ are designed for provide many years of service in a variety of operating conditions.
- Five-year battery life.
- **Three-year warranty.**

APPLICATIONS

- Lights
- Motors
- Water Heaters
- Gas Valves
- Switches & Relays
- Virtually any electric load

CE

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