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. 19-622-EL-RDR

DIRECT TESTIMONY OF

TRISHA A. HAEMMERLE

ON BEHALF OF

DUKE ENERGY OHIO, INC.

March 29, 2019

TABLE OF CONTENTS

PAGE

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 45230

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 and 18-397-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 achievement 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, and 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 case 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.

Q. HAS DUKE ENERGY UPDATED ANY OF ITS PROGRAMS TO BE OFFERED TO CUSTOMERS IN 2017 - 2019?

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 22, 2017. On September 27, 2017 the amended stipulation was approved by the Commission with modifications. 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 not permit shared savings for 2017. 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. On October 12, 2017 Duke Energy Ohio requested a waiver to permit the Company to exceed the Portfolio

[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).

Plan budget and the waiver was approved on November 21, 2017. Consistent with the amended stipulation that the Commission had approved, until the Company received approval of the 2017 – 2019 portfolio the programs, Duke Energy Ohio continued to operate under the 2016 portfolio guidelines. No additional programs were offered in 2018.

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, under Rider EE-PDR, the Company is 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 are mandated by Ohio law. 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).

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 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. 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 cost incurred for EM&V.

Q. IS THE COMPANY'S SHARED SAVINGS MECHANISM APPROVED FOR 2018?

A. Yes, the Company's Shared Savings mechanism was approved along with the Company's last portfolio in Case No.16-576-EL-POR, consistent with the amended stipulation in that case that was approved by the Commission. However, the Commission's decision to impose a $38.7 million cost cap on the Company's portfolio impacts the actual amount of the shared savings incentive earned by the Company. The current Shared Savings mechanism will continue until the Company's next portfolio plan is approved.

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.

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.

Q. ARE THERE ANY CIRCUMSTANCES THAT COULD CHANGE THE AMOUNT OF REQUESTED RECOVERY ASSOCIATED WITH THE 2018 TRUE-UP COMPONENT OF THE COMPANY FILING?

A. Yes, the revenue amount requested associated with the Company's allowed shared savings incentive could change. The Company's requested shared savings incentive in this application reflects the impact of the Commission's overall cost cap, which effectively reduced the Company's shared savings incentive by over $6 million. The legality of the Commission's imposition of the cost caps has been challenged at the Ohio Supreme Court by the FirstEnergy Companies. Should the Supreme Court find that the Commission's imposition of a cost cap was not permissible, Duke Energy Ohio would seek to modify its revenue request to appropriately reflect the shared savings incentive it earned in 2018.

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 2018?

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

- Residential Energy Assessments
- Smart $aver® Residential
- Low Income Services
- 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
- Power Manager® for Business
- Low Income Neighborhood Program
- Low Income Pay for Performance

- o Small Business Energy Saver

Q. HAS DUKE ENERGY UPDATED ANY OF ITS PROGRAMS TO BE OFFERED TO CUSTOMERS IN 2018?

A. Yes. Duke Energy Ohio filed a new portfolio in 2016 for program years 2017 – 2019. Duke Energy Ohio added Power Manager® for Business which is a demand response program for small and medium non-residential customers. The program began in 2018. Various measures were added and changed within the portfolio. Other programs and measures were approved but due to program funding limits created by the Commission imposed portfolio cost cap, in 2018, the program operations have been designed to stay within defined spending limitations resulting in certain programs and measures to be removed from the portfolio.

Q. DID DUKE ENERGY OHIO OFFER ANY OTHER PROGRAMS DURING 2018 THAT WERE NOT INCLUDED IN CASE NO. 16-576-EL-POR?

A. Yes. Consistent with Rule 4901:1-39-05(G) O.A.C., and the Commission's Opinion and Order in Case No. 10-834-EL-POR, 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[2] and cost effective[3], PJM approved MW resources were bid into the 2021/2022 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 program based on percentage of MWs clearing each auction and customer class and the net offset will be shared with the Company at its approved shared savings percentage as applicable. Duke Energy Ohio kept the Duke Energy Community Partnership (the Collaborative) updated throughout 2018 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 2018 statutory mandates for energy efficiency and peak demand of 1,715,529 MWh and its peak reduction mandate of 339.6 MW.

---

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

[3] "Cost effective" is defined as the projected auction revenues 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 zone and "projected costs" are defined as the costs necessary to fully qualify and bid the resources into the PJM capacity auctions.

Q. WHAT PROGRAMS WERE THE PRIMARY CONTRIBUTORS TO THE COMPANY'S SUCCESS DURING 2018?

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 217,000 MWh, 63%, of the total impacts recognized in 2018. These programs continue to flourish in large part due to the attractiveness and expansion of LED lighting options available to customers.

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 2018?

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 Mercantile Self-Direct Rebate Program are included for recovery in the calculation of Rider EE-PDR.

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 OPINION AND ORDER IN THE 16-0576-EL-POR CASE?

A. Yes. Duke Energy Ohio has complied with the directives set forth in that Opinion and Order. 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 03/27/18, 06/13/18, 08/30/18, and 11/28/18.

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 and 19-621-EL-EEC[4]. Finally, the Company is filing this true-up in accordance with the Stipulation and Recommendation and the Commission's Order in Case No. 16-0576-EL-POR.

[4] To be filed by May 15, 2019

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 2018, (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. WHAT PROGRAMS RECEIVED EVALUATION, MEASUREMENT & VERIFICATION IN 2018?

A. The table below provides the detailed, completed EM&V reports for 2018:

Attachment	Program	Evaluation Type	Report Date
1	Power Manager®	Process and Impact	July 2018
2	PowerShare®	Process and Impact	May 2018
3	Small Business Energy Saver	Process and Impact	August 2018
4	My Home Energy Report (MyHER)	Process and Impact	October 2018
5	Energy Efficiency Education for Schools Program	Process and Impact	October 2018
6	Smart $aver® Non-residential Custom Program	Process and Impact	September 2018
7	Residential Assessments Program Evaluation	Process and Impact	October 2018
8	Free LED and Online Savings Store Evaluation	Process and Impact	September 2018

Additionally, the Company will provide the reports presented here as Appendices D - K as appendices in its annual energy efficiency status report, Case No. 19-621-EL-EEC, to be filed later this year.

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

A. Yes, the Company is operating under the new 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[5] 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

[5] Per Sec. 4928.662(B)

higher than the deemed savings, are applied to the rider in the month[6] following the completion of the EM&V report. When applicable, these results will also be used to estimate future target achievement levels for development of estimated incentives and in future cost-effectiveness evaluations[7].

Q. WHAT 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 – 8 PREPARED BY YOU OR AT YOUR DIRECTION?

A. The EM&V reports were prepared by Nexant, Navigant, and Opinion Dynamics, all of which are Duke Energy Ohio's independent third-party evaluators.

---

[6] Impacts for demand response programs are applied at the beginning of the next program cycle.
[7] For demand response programs, the contracted amounts of kW reduction capability from participants are considered to be components of actual participation.

V. CONCLUSION

Q. PLEASE DESCRIBE THE COMPANY'S OVERALL ENERGY EFFICIENCY AND PEAK DEMAND REDUCTION PORTFOLIO PERFORMANCE IN 2018.

A. Duke Energy Ohio's portfolio of programs continued to perform exceptionally well in 2018 and delivered cost effective energy savings that exceeded the projected impacts included in Case No. 18-397-EL-RDR by over 19%. The success has allowed customers that participated in its 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 2018 energy and capacity achievements from its portfolio of programs is over four times the program cost incurred to achieve the impacts.

Q. HAS DUKE ENERGY PROPOSED ANY NEW PROGRAMS TO ASSIST IN MEETING THE INCREASING ANNUAL BENCHMARK?

A. Duke Energy Ohio filed a new portfolio of programs for the 2017 – 2019 program years which included updated measures, as well as, Power Manager® for Business. Other programs and measures were approved but due to program funding limits created by the Commission imposed portfolio cost cap, in 2018, the program operations have been designed to stay within defined spending limitations.

Q. DOES THIS CONCLUDE YOUR TESTIMONY?

A. Yes, it does.

REPORT

Nexant
Reimagine tomorrow.

Duke Ohio 2017 Power Manager Evaluation

July 2, 2018

Eric Bell, Ph.D.
Ankit Jain, M.P.P.
Greg Sidorov, M.S.

Figures

Tables

1 Executive Summary

This report presents the results of the 2017 Power Manager impact evaluation for the Duke Energy Ohio territory. 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. During normal events, the signal to load control devices to reduce air conditioner use is phased in over the first half hour and the reduction is sustained through the remainder of the event and phased out over the half hour immediately after the event. During emergency operations, all devices are instructed to instantaneously shed loads and deliver larger demand reductions (66% and 75% cycling for moderate and high control option customers, respectively).

1.1 Impact Evaluation Key Findings

The impact evaluation is based on a randomized control trial. Each customer who had an addressable load control device at the start of the summer was randomly assigned to one of six groups—a primary group with 75% of the population and five research groups, each with 5% of the population. During each event, a control group of approximately 2,200 households was withheld to provide an estimate of energy load profiles absent activation of Power Manager. During the summer of 2017, over 45,000 households were actively participating in Power Manager and had load control devices.

Table 1-1 summarizes the reductions attained during each event in 2017, as estimated using the randomized control trial. The June 12, 2017 event included a side-by-side test of demand reduction under different dispatch hours during which 75% of customers were dispatched for the 4pm to 6pm event and four research groups were dispatched at different times. The July 20, 2017 event included side-by-side tests 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 0.65 kW per household for the average general population event.
- Peak day impacts under normal operations averaged 0.61 kW per household over the course of the two hour dispatch window on July 20, 2017 (the day emergency operations were tested side by side with normal operations), when the daily maximum temperature was 90˚F.
- Emergency operations on July 20 produced larger impacts than normal operations, 0.90 kW vs. 0.60 kW per household for the same hour on the hottest day in 2017. Reductions from emergency operations exceeded those from normal operations by 50%.
- The magnitude of impacts varied slightly by dispatch window in absolute terms, but not so much as a percentage of available load. Demand reductions ranged from 0.43 to 0.73 kW per household on June 12, with larger impacts generally occurring later in the day. As a percentage of loads, the demand reductions varied less, ranging from 17.1% to 21.4%, suggesting that most of the differences by event window are a function of the underlying amount of air conditioner load.

- Demand reductions grow larger in magnitude when temperatures are hotter and resources are needed most.[1]
- The difference in impacts between customers who signed up for the lower and higher load control options was minimal and within the range of uncertainty.

Table 1-1: Randomized Control Trial Demand Reductions for Individual Events[2]

Event Date	Start Time	End Time	Load without DR	Impact	Std. error	90% Confidence Interval		% Impact	90% Confidence interval		Daily Max	Avg. Temp 24 Hours Prior to Event
						Lower bound	Upper bound		Lower Bound	Upper Bound		
6/12/2017	11:30 AM	1:00 PM	2.49	-0.43	0.05	-0.35	-0.51	-17.1%	-13.9%	-20.3%	90	79
	12:30 PM	2:00 PM	2.66	-0.45	0.05	-0.36	-0.53	-16.8%	-13.7%	-19.9%	90	79
	1:30 PM	4:00 PM	2.94	-0.55	0.05	-0.47	-0.63	-18.7%	-16.0%	-21.4%	90	80
	3:30 PM	6:00 PM	3.35	-0.72	0.04	-0.65	-0.78	-21.4%	-19.5%	-23.2%	90	80
	5:30 PM	8:00 PM	3.43	-0.73	0.05	-0.65	-0.81	-21.3%	-19.0%	-23.6%	90	80
7/12/2017	3:30 PM	6:00 PM	3.25	-0.67	0.04	-0.61	-0.73	-20.6%	-18.7%	-22.4%	89	76
7/20/2017	3:30 PM	6:00 PM	3.18	-0.61	0.04	-0.55	-0.66	-19.1%	-17.2%	-20.9%	90	81
7/20/2017	4:00 PM	5:00 PM	3.06	-0.90	0.05	-0.82	-0.98	-29.5%	-26.9%	-32.0%	90	81
7/21/2017	2:30 PM	5:00 PM	2.78	-0.44	0.03	-0.39	-0.50	-15.9%	-13.9%	-17.8%	90	82
8/16/2017	3:30 PM	5:00 PM	3.33	-0.76	0.03	-0.71	-0.81	-22.8%	-21.2%	-24.4%	91	76
8/16/2017	3:30 PM	6:00 PM	3.41	-0.72	0.03	-0.66	-0.77	-21.0%	-19.5%	-22.5%	91	76
9/21/2017	2:30 PM	5:00 PM	2.31	-0.24	0.03	-0.19	-0.30	-10.6%	-8.4%	-12.8%	89	75
9/22/2017	2:30 PM	5:00 PM	2.95	-0.78	0.04	-0.72	-0.85	-26.6%	-24.5%	-28.6%	89	77
9/25/2017	2:30 PM	5:00 PM	2.58	-0.45	0.03	-0.39	-0.51	-17.4%	-15.2%	-19.6%	89	77
9/26/2017	2:30 PM	5:00 PM	2.79	-0.53	0.03	-0.47	-0.58	-18.8%	-16.8%	-20.9%	89	77
Average General Population Event			**3.02**	**-0.59**	**0.01**	**-0.57**	**-0.60**	**-19.4%**	**-18.9%**	**-20.0%**	**90**	**78**

1.2 Time-Temperature Matrix and Demand Reduction Capability

A key objective of the 2017 evaluation was to quantify the relationship between demand reductions, temperature, hour of day, and cycling strategy—referred to as the time-temperature matrix. By design, a large number of events were called under different weather conditions, for different dispatch windows, using various cycling strategies so that demand reduction capability could be estimated for a wide range of operating and planning conditions. Because weather conditions did not vary significantly during the 2017 events, data from the 2016 evaluation was also used in the development of this time-temperature matrix.

1 This observation is based on results from the 2016 Power Manager evaluation.

2 Emergency operations noted with red text.

Figure 1-1: Demand Reduction Capability on a day with an 85˚F Average Temperature for the previous 24 hours with Emergency Dispatch

INPUTS	
Dispatch Type	Emergency Dispatch
Option	Overall
Event start (excludes phase in)	4 PM
Event duration (hours)	1
Previous 24 hr Avg Temp (F)	85
Homes	45,000

Event Window Avg. Impacts		
Load without DR	3.51	kW per house
Load with DR	2.28	kW per house
Impact per house	-1.23	kW per house
Impact (MW)	-55.3	MW
% Impact	-35%	%

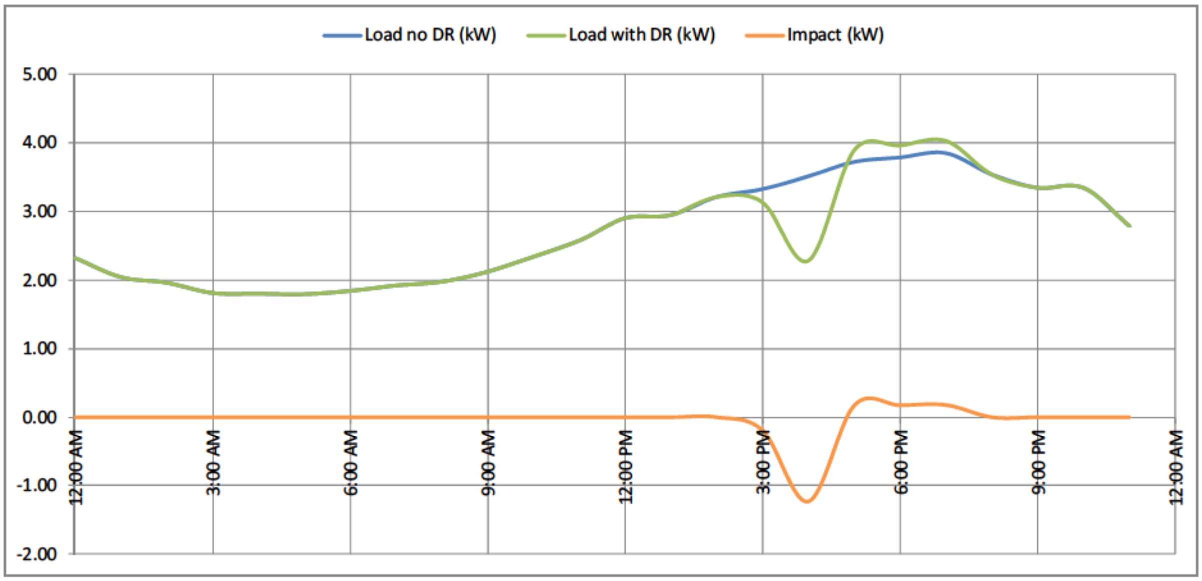


Figure 1-1 shows the demand reduction capability of the program if emergency shed becomes necessary on a day in which the previous 24 hours prior to the event have an 85˚F average temperature (which reflects the weather conditions experienced on the 2016 emergency shed test day) for a single hour. Individual customers are expected to deliver 1.23 kW of demand reduction. Because there are approximately 45,000 devices, the expected aggregate reductions total is 55.3 MW.

2 Introduction

This report presents the results the 2017 Power Manager impact evaluation for the Duke Energy Ohio (DEO) territory. Power Manager is a voluntary demand response program that provides incentives to residential customers who allow DEO to reduce the use of their central air conditioner's outdoor compressor and fan on summer days with high energy usage.

Because DEO has full deployment of smart meters and 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 was withheld to serve as a control group and provide an estimate of customer's energy profiles absent activation of Power Manager. The randomized control trial was employed during normal Power Manager operations and during specific tests designed to address key research questions.

In addition to estimating load impacts during 2017 events, this study determined the program capability under a range of weather and dispatch conditions. Average customer load reductions were calculated as a function of customer type, event type, event start time, event duration, and average temperature during the 24 hours preceding the event start.

2.1 Key Research Questions

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

Impact Evaluation Research Questions

- What demand reductions were achieved during each event called in 2017?
- Did impacts vary for customers on moderate and high load control options?
- Do impacts vary based on the hours of dispatch and/or weather conditions? If so, how?
- What magnitude of load reduction is the program capable of delivering during extreme conditions?

2.2 Program Description

Power Manager is a voluntary demand response program that provides incentives to residential customers who allow DEO 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 cycling switch 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. DEO initiates events by sending a signal to all participating devices through a corporate paging network. The signals instruct the switch devices to cycle the air conditioning system on and off, reducing the run time of the unit during events.

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

Power Manager events typically occur between May and September in DEO territory, but are not limited to these months. Participants receive financial incentives for their participation that depend on the amount of load control they experience during an event. At enrollment, Power Manager customers elect one of two load control options that are available—moderate or high load control. Approximately 84% of Power Manager devices in DEO are enrolled in the moderate option and the remaining 16% are enrolled in the higher load control option.[3] The payments received by participants include a one-time installation credit of $25 for the moderate load control option ($35 for high load control) plus bill credits for each cycling event that occurs. The minimum bill credit for 2017 participation was $12 for customers enrolled in the moderate option and $18 for customers enrolled in the high load control option.

Starting in 2017, DEO began using a new cycling algorithm known as *true cycle algorithm*. The algorithm uses learning days to estimate the run time (or duty cycle) of air conditioners as a function of hour of day and temperature at each specific site and aims to curtail use by a specified amount. In general, Power Manager events fall into two categories: economic events during which customers are cycled at 48% and 75% for moderate and high control customers, respectively, and emergency events during which customers are cycled at 66% and 75% for moderate and high control customers, respectively.

2.3 Participant Characteristics

The Duke Energy Ohio service territory is in the Southern portion of Ohio and centered in the Cincinnati area. By the end of summer 2017, over 47,000 air conditioner units were part of Power Manager. Of those units, 16% enrolled in the higher load control option. On average, customers enroll 1.06 air conditioner units per site.

DEO serves approximately 760,000 residential customers. To enroll on Power Manager, customers must be in DEO territory, own their single family home, and have a functional central air conditioning unit with an outside compressor. Based on the program rules and a residential appliance saturation survey Duke Energy implemented in 2016, approximately 54.7% of customers meet the eligibility criteria.[4] To date, DEO has enrolled approximately 10.9% of eligible customers. Figure 2-1 visualizes enrollment in Power Manager over time.

[3] Customers who ask to de-enroll are offered a low load control option to minimize attrition. Less than 1/15th of one percent of devices are enrolled in the low load control option.

[4] 77.3% of residential customer in the territory own single family homes and, of those, 82.7% have central air conditioners. The estimate does not include heat pumps.

Figure 2-1: Power Manager Participation Over Time

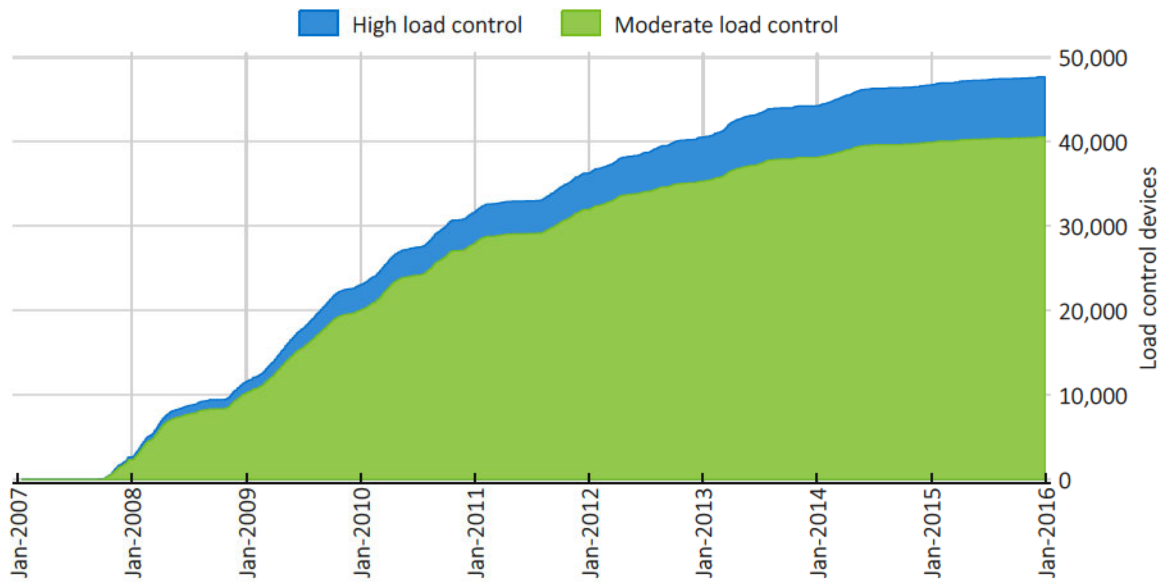


Figure 2-2: Distribution of Air Conditioner Peak Period Loads Amongst Power Manager Customers

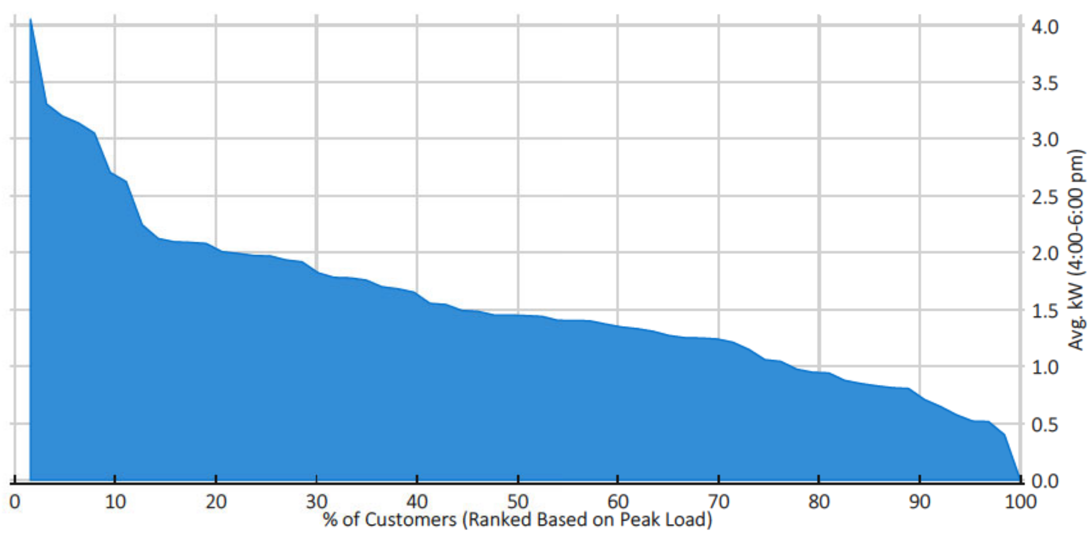
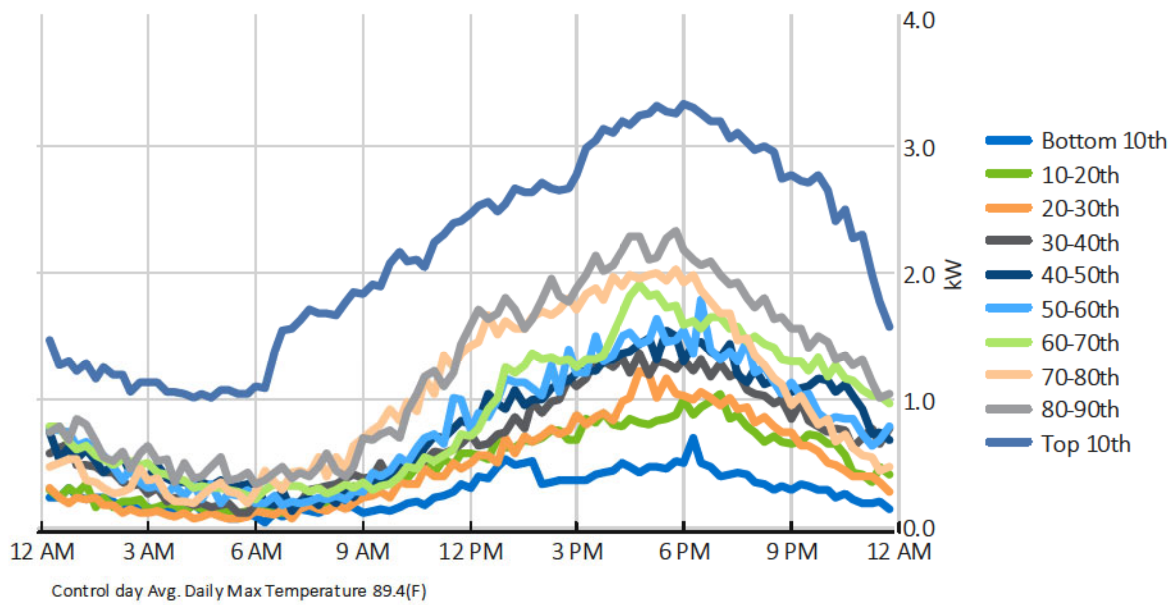


Figure 2-2 shows the distribution of air conditioner demand across customers on hot nonevent days, based on end use load data that was collected in 2016. We isolated the 4 to 6pm period because it aligns with the time period for most Power Manager events. Air conditioner use by Power Manager participants varied substantially, reflecting different occupancy schedules, comfort preferences, and thermostat use and settings. Roughly 40% of air conditioner loads exceeded 1.5 kW. As with any program, some customers who enrolled use little or no central air conditioners during late afternoon hours on hotter days. They 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.

Figure 2-3 provides additional detail and shows the hourly air conditioner end use loads for different customer groups. The customers were classified into 10 equally sized groups, known as deciles, based on their air conditioner use during hot nonevent days. Each line represents the hourly air conditioner loads for the average customer in each decile.

Figure 2-3: Air Conditioner End-use Hourly Loads by Size Decile



2.4 2017 Event Characteristics

In 2017, DEO dispatched Power Manager eight times for general population events in addition to the PJM test event, two research events, and an emergency operations test. The general population events all occurred either between 3:30 and 6:00pm or 2:30 and 5:00pm. DEO bids Power Manager resources into the PJM market during those time periods. The PJM event was prescheduled well in advance and happened to land on a cooler day with a daily maximum temperature of only 69˚F. During a PJM event, Power Manager customer loads needed to be less than the peak load contribution (PLC) minus the magnitude of DR resources bid into the capacity market.

Table 2-1: 2017 Event Operations and Characteristics

Event Date	Start Time	End Time	Daily Max (ºF)	Type of Event	# of Customers	Customer dispatch	Control group	Notes
6/12/2017	11:30 AM	1:00 PM	90	Research	45,600	2,280	2,280	Group 1 dispatched
	12:30 PM	2:00 PM				2,280	2,280	Group 2 dispatched
	1:30 PM	4:00 PM				2,280	2,280	Group 3 dispatched
	3:30 PM	6:00 PM				34,200	2,280	Group 0 dispatched
	5:30 PM	8:00 PM				2,280	2,280	Group 5 dispatched
7/12/2017	3:30 PM	6:00 PM	89	GP Event	45,600	43,320	2,280	Group 1 held back
7/20/2017	3:30 PM	6:00 PM	90	GP and Shed Test	45,600	43,320	2,280	Group 3 held back; Group 5 shed test
7/21/2017	2:30 PM	5:00 PM	90	GP Event	45,600	43,320	2,280	Group 4 held back
8/16/2017	3:30 PM	6:00 PM	91	Research	45,600	4,560	41,040	Group 4 dispatched until 5pm; Group 2 dispatched until 6pm
9/7/2017	4:00 PM	5:00 PM	69	PJM Test	45,600	45,600	0	No control
9/21/2017	2:30 PM	5:00 PM	89	GP Event, then Emergency	45,200	42,940	2,260	Group 1 held back; Emergency Shed during 2nd hour w/ no Control
9/22/2017	2:30 PM	5:00 PM	89	GP Event, then Emergency	45,600	43,320	2,280	Group 2 held back; Emergency during 2nd hour
9/25/2017	2:30 PM	5:00 PM	89	GP Event	45,600	43,320	2,280	Group 2 held back
9/26/2017	2:30 PM	5:00 PM	89	GP Event	45,600	43,320	2,280	Group 4 held back

DEO overlaid three research experiments alongside the general population events on June 12, July 20, and August 16. On June 12, DEO implemented a side-by-side test of five groups to assess if and how demand reductions varied for different dispatch periods. On July 20, a research group was dispatched using emergency shed operations side-by-side with a control group and a group that experienced normal operations. The objective was to assess how the magnitude of the emergency shed compares to traditional operations. Emergency operations reflect the full demand reduction capability of the program, but are employed judiciously. On August 16, a group was dispatched from 3:30 to 5pm alongside a group that was dispatched from 3:30 to 6pm, to test how impacts are affected by event duration.

With the exception of emergency shed tests, the control of the air conditioner units is phased in, at random, over the first 30 minutes. Likewise, at the end of an event, instructions to resume normal operations are gradually sent to individual air conditioners. The demand reductions reported in this study are for the time period when units' full load reduction were achieved—that is, the phase in and phase out periods are excluded since they do not reflect the demand reduction capability.

3 Methodology and Data Sources

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

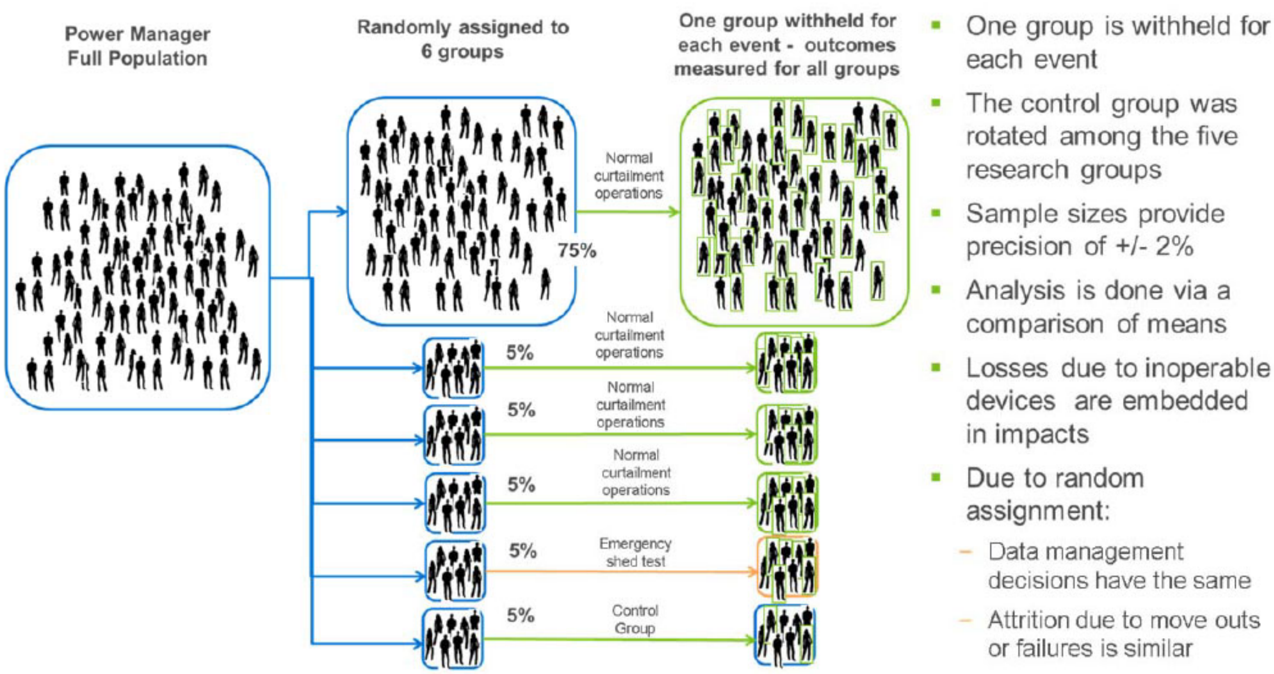
3.1 Randomized Control Trial Design and Analysis

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 any kind of model specification error; and
- They are guaranteed to produce accurate and precise impact estimates with proper randomization and large sample sizes.

The RCT design randomly separated the DEO Power Manager population into two groups—treatment and control—for each event day. On an event day, all load control devices in the treatment group were activated, while none of the devices in the control group were activated. Because of random assignment, the only systematic difference between the two groups is that one set of customers was curtailed and the other group was not. During research events, distinct operation strategies were employed to enable side-by-side testing, but in all instances a control group was withheld. Figure 3-1 shows the conceptual framework of the random assignment.

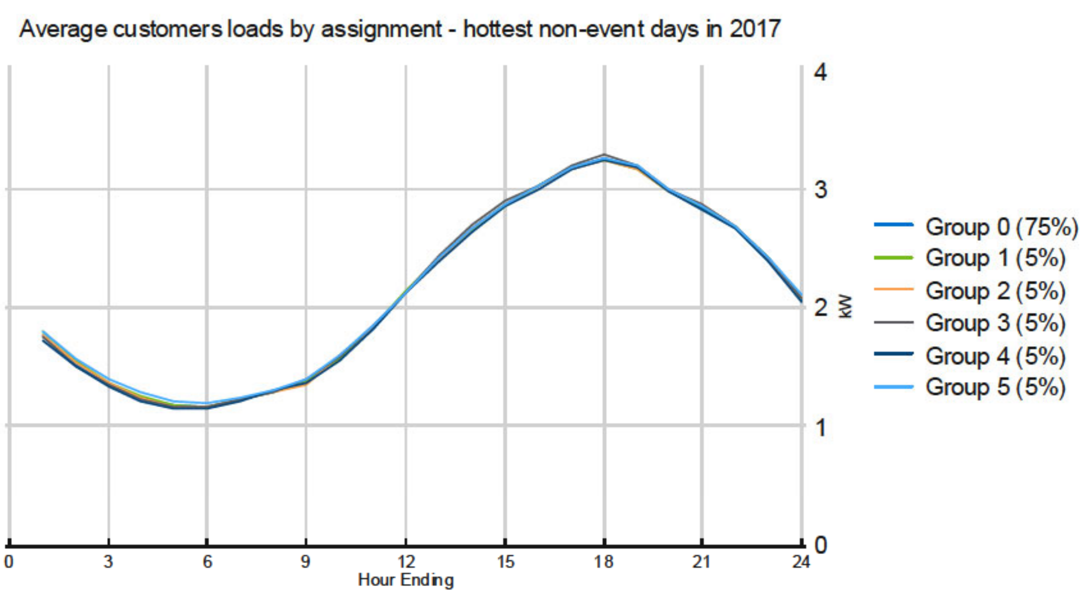
Figure 3-1: Randomized Control Trial Design



The Power Manager participant population with addressable load control devices was randomly assigned into six distinct groups prior to the 2016 summer based on the last two digits of the device serial number, with the randomization maintained for existing customers in 2017 and new customers similarly assigned to an experimental group.[5] At the beginning of the summer, the main general population group includes 75% of participants – approximately 34,000 participants. The remaining five research groups each include 5% of participants, or roughly 2,200 customers each. Before implementation, Nexant conducted simulation based power analysis using smart meter data for load control participants and concluded the sample sizes were sufficient to provide a ±2% Margin of Error with 90% confidence. The purpose of creating six distinctive randomly assigned groups was twofold. First, it allowed side-by-side testing of cycling strategies, event start times, or other operation aspects to help optimize the program. Second, it also allowed DEO to alternate the control group, increasing fairness but also helping avoid exhausting individual customers by dispatching them too often solely for research purposes.

To ensure the randomization was properly implemented, the loads for each of the six groups were compared to each other on all days when none of the groups experienced an event. Figure 3-2 shows average hourly loads for each group on the hottest, nonevent days (July 22, September 23, and September 27). The customer loads are nearly identical, which provides strong evidence that the assignment of devices into the six different groups was indeed random. It also reflects the precision of control group as a method for estimating the counterfactual.

Figure 3-2: Validation of Random Assignment and Precision — Loads on the Hottest Nonevent Day



5 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.

For each event, one of the five research groups was withheld to serve as a control group and establish the counterfactual or baseline—the electricity load patterns in the absence of curtailment. 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. Because of this, estimating the load impacts for an event requires simply calculating the difference in loads between the treatment and control groups during each interval, including the event period and hours following the event when snapback can occur. The demand reductions reflect net impacts and account for customer use of fans to compensate for curtailment of air conditioners, device failures, and paging network communication issues.

The standard error, used to calculate the confidence bands, is calculated using the formula shown in Equation 1.

Equation 1: Standard Error Calculations 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* is the stand deviation, *n* is the sample size, *t* and *c* are the treatment and control groups respectively, and *i* refers to individual time intervals.

4 Randomized Control Trial Results

The goals of this study include understanding the load impacts associated with the Power Manager program under a variety of conditions. General population event dates were selected to understand the available load reduction capacity under a variety of temperature conditions during normal operations, while emergency shed events demonstrated the available capacity for short-duration events during extreme conditions. In addition, one test day was used to understand how load reduction capacity varied as a function of dispatch window by signaling different customer groups at different times of day. This section presents the results for these event days. A comparison of load impacts by dispatch option (moderate versus high load control) is also presented.

4.1 Overall Program Results

The load impact estimates derived from the randomized control trial analysis for the general population events, as well as the research events that occurred side-by-side with normal operation of the program, are presented in Table 4-1. Results for the July 20 emergency event and the August 16 event duration test are presented as separate events from the general population event. The load impacts presented here, along with the accompanying confidence intervals, are the average changes in load during the indicated dispatch windows, excluding the first 30 minutes of dispatch for the normal operation events since this is the time period when devices are phased-in at random.

Table 4-1: Randomized Control Trial per Customer Impacts[6]

Event Date	Start Time	End Time	Load without DR	Impact	Std. error	90% Confidence Interval		% Impact	90% Confidence interval		Daily Max	Avg Temp 24 Hours Prior to Event
						Lower bound	Upper bound		Lower Bound	Upper Bound		
6/12/2017	11:30 AM	1:00 PM	2.49	-0.43	0.05	-0.35	-0.51	-17.1%	-13.9%	-20.3%	90	79
	12:30 PM	2:00 PM	2.66	-0.45	0.05	-0.36	-0.53	-16.8%	-13.7%	-19.9%	90	79
	1:30 PM	4:00 PM	2.94	-0.55	0.05	-0.47	-0.63	-18.7%	-16.0%	-21.4%	90	80
	3:30 PM	6:00 PM	3.35	-0.72	0.04	-0.65	-0.78	-21.4%	-19.5%	-23.2%	90	80
	5:30 PM	8:00 PM	3.43	-0.73	0.05	-0.65	-0.81	-21.3%	-19.0%	-23.6%	90	80
7/12/2017	3:30 PM	6:00 PM	3.25	-0.67	0.04	-0.61	-0.73	-20.6%	-18.7%	-22.4%	89	76
7/20/2017	3:30 PM	6:00 PM	3.18	-0.61	0.04	-0.55	-0.66	-19.1%	-17.2%	-20.9%	90	81
7/20/2017	4:00 PM	5:00 PM	3.06	-0.90	0.05	-0.82	-0.98	-29.5%	-26.9%	-32.0%	90	81
7/21/2017	2:30 PM	5:00 PM	2.78	-0.44	0.03	-0.39	-0.50	-15.9%	-13.9%	-17.8%	90	82
8/16/2017	3:30 PM	5:00 PM	3.33	-0.76	0.03	-0.71	-0.81	-22.8%	-21.2%	-24.4%	91	76
8/16/2017	3:30 PM	6:00 PM	3.41	-0.72	0.03	-0.66	-0.77	-21.0%	-19.5%	-22.5%	91	76
9/21/2017	2:30 PM	5:00 PM	2.31	-0.24	0.03	-0.19	-0.30	-10.6%	-8.4%	-12.8%	89	75
9/22/2017	2:30 PM	5:00 PM	2.95	-0.78	0.04	-0.72	-0.85	-26.6%	-24.5%	-28.6%	89	77
9/25/2017	2:30 PM	5:00 PM	2.58	-0.45	0.03	-0.39	-0.51	-17.4%	-15.2%	-19.6%	89	77
9/26/2017	2:30 PM	5:00 PM	2.79	-0.53	0.03	-0.47	-0.58	-18.8%	-16.8%	-20.9%	89	77
Average General Population Event			**3.02**	**-0.59**	**0.01**	**-0.57**	**-0.60**	**-19.4%**	**-18.9%**	**-20.0%**	**90**	**78**

[6] Emergency operations noted with red text.

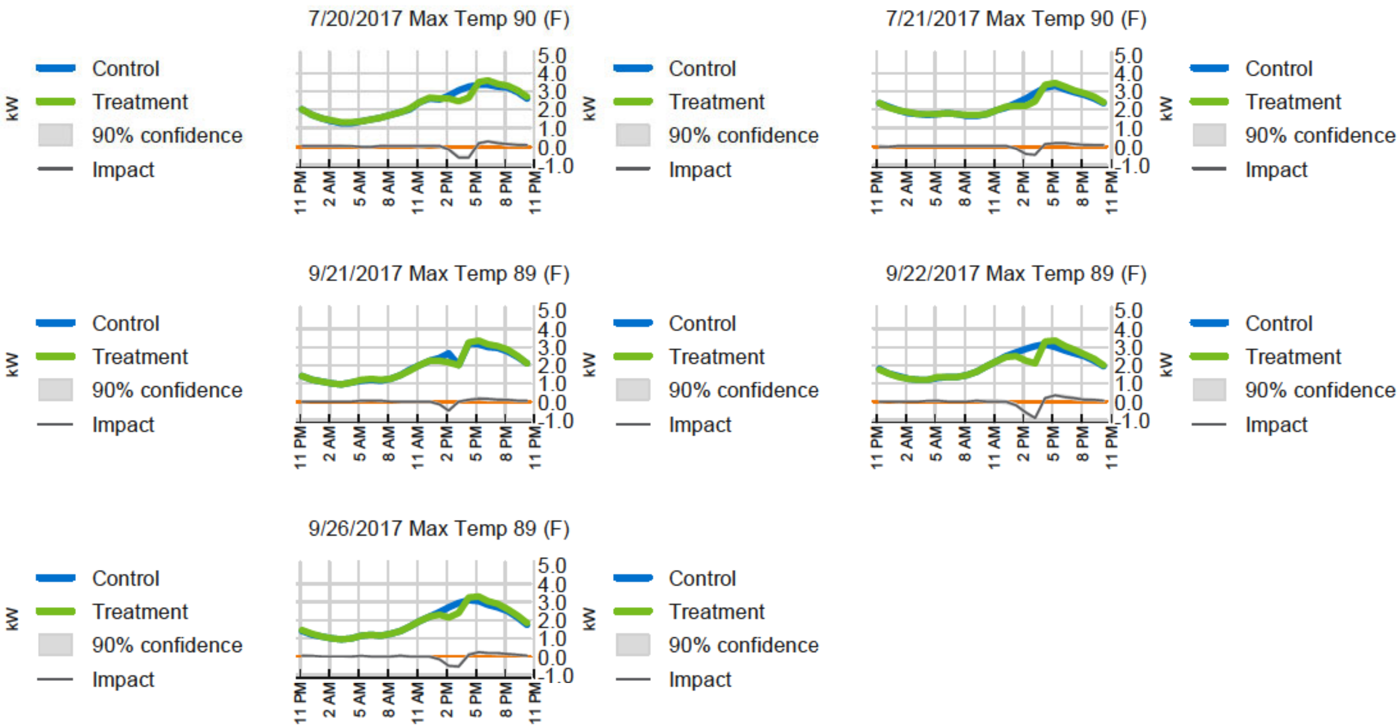
Overall load impacts for the average customer in the test group ranged between 0.24 kW and 0.78 kW during normal operations, though most events saw reductions of at least 0.45 kW. These impacts are considerably lower than what was observed in the prior year, likely due to cooler weather conditions. Although the aim was to call events during a range of temperature conditions, most event days saw very similar maximum daily temperatures which were overall cooler than what was experienced in 2016. The emergency shed event had a much higher load impact of 0.90 kW.

Except for the PJM test, at most, 95% of the sites were dispatched since at least 5% of the population was withheld to serve as a control group and establish the baseline. Had all resources been dispatched under normal operation on July 20, the emergency event day, the program would have delivered 27.5 MW. If instead, all resources had been dispatched using emergency operations, reduction would have been 40.5 MW, despite a relatively cool weather year.

Since all of the analysis included customers with inoperable devices, the results implicitly take device inoperability into account. Because we used random assignment, each of the test groups accurately represent the percentage of customers with inoperable devices among the entire population and the estimated load impacts are appropriately de-rated by the nonworking devices included in the test groups.

These same impacts are shown graphically in Figure 4-1, along with the average customer load profiles for the test and control groups. Compared to the control group load profile, there is a clear drop in test group load during the dispatch period, along with a small snapback in energy usage immediately after the events.

1: Load Profiles of Average Test and Control Group Customers on General Population Event Days



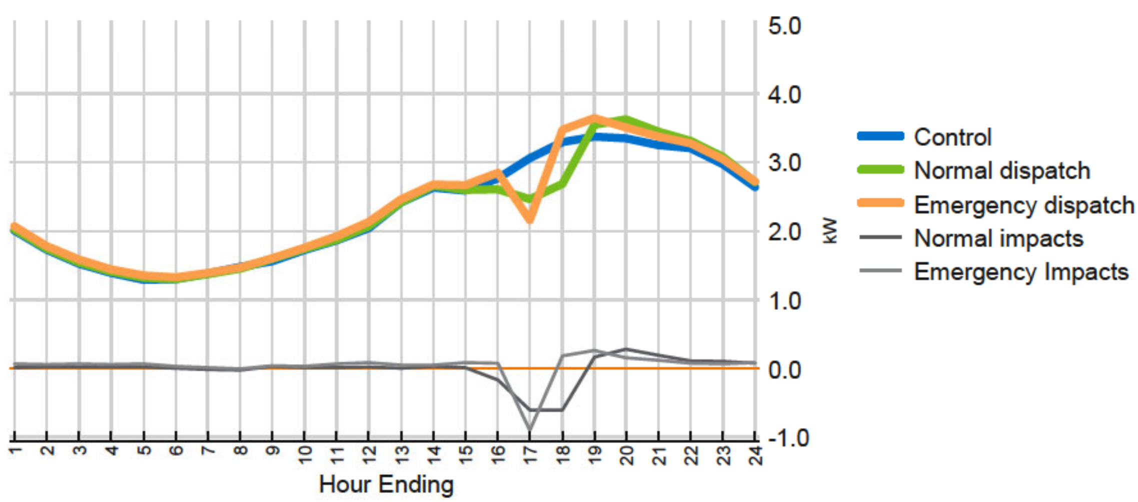
4.2 Normal Operations Versus Emergency Shed Test

Impacts for the July 20 event are presented in Figure 4-2 for both normal and emergency operations. As shown in the graph, the group that was dispatched via normal operations had a 30 minute period (3:30 to 4pm) during which devices were phased in randomly, whereas all of the devices in the emergency shed test group were dispatched simultaneously at the start of the 4pm event and instructed to implement 66% and 75% cycling for the moderate and high control customers, respectively. As a result, the magnitude of the overall load reduction was much greater for customers in the emergency shed group.

Emergency operations produced larger impacts than normal operations, 0.90 kW vs. 0.60 kW per household for the common dispatch hour from 4 to 5pm (average load reduction for normal operations during the entire two hour event window was 0.61 kW). Reductions from emergency operations exceeded those from normal operations by 50%.

The emergency shed event ended at 5pm, after which time the load for this dispatch group returned to nearly the same level as the control group, with some additional snapback. The normal operation group continued to show steady load drop until the end of its dispatch window at 6pm.

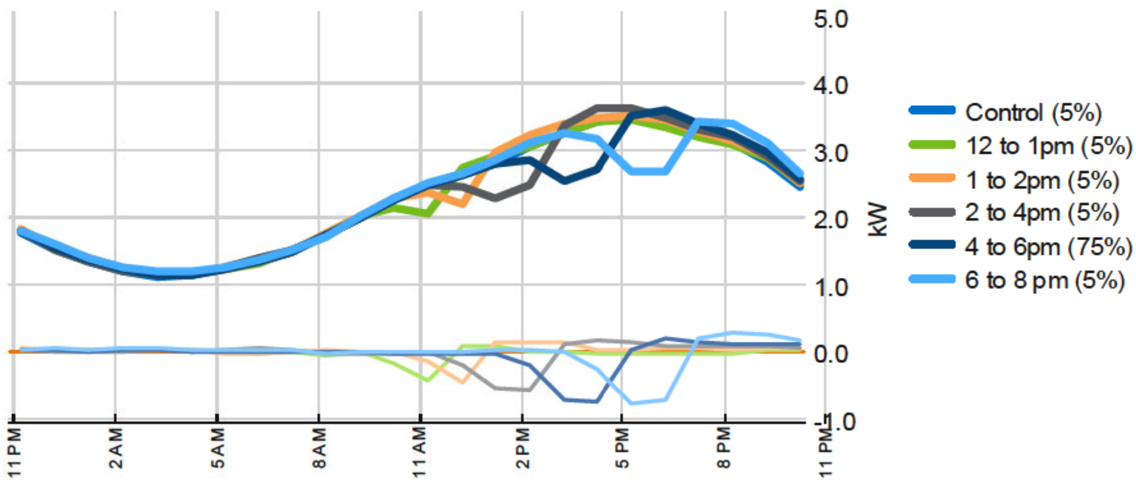
Figure 4-2: Load Profiles for Emergency and Normal Operations on July 20 Event



4.3 Impacts by Dispatch Period

Load profiles for the various test groups for the June 12 cascading event test are presented in Figure 4-3, along with the load profile for the control group. The plot shows the load reduction and accompanying snapback associated with each group's dispatch, as compared to the control group. As can be seen from the plot and from the prior table, there were slight differences in the estimated load impacts with larger per customer impacts occurring in the late afternoon hour, up to the last event which began at 6pm (excluding the 30 minute ramp-in period at the beginning of the event). Impacts during all dispatch windows were fairly steady throughout the events. While the magnitude of impacts varied by dispatch window (between 0.43 and 0.73 kW per household), the percent load reduction was actually fairly similar for each group. As a percentage of loads, the demand reductions varied less, ranging from 17.1% to 21.4%, suggesting that most of the differences by event window are a function of the underlying amount of air conditioner load.

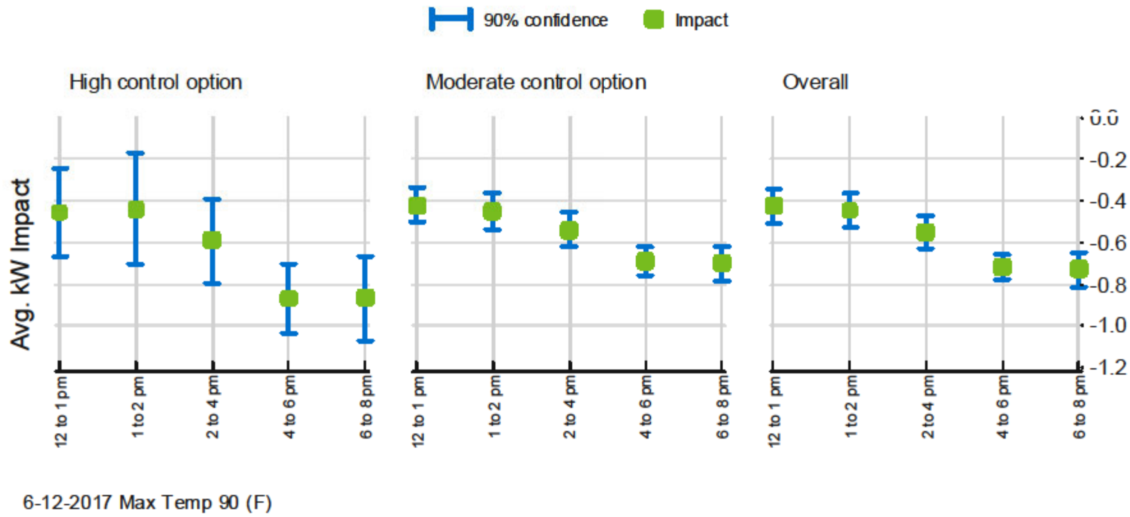
Figure 4-3: Load Profiles for June 12 Dispatch Window Test



The point estimates for the load impacts, along with the 90% confidence intervals, for each test group is presented in Figure 4-4. The results are broken down by program option (moderate versus high load control), as well as for program participants in general. Note that the width of the confidence intervals are largely driven by the sample sizes, and thus the confidence intervals for the higher load control option customers are much wider because only 15% of customers sign up for it and, as a result, treatment and control group sample sizes were smaller.

In all cases, the load impacts show the same pattern with average load reduction increasing for later dispatch windows. However, the difference in impacts between the first three event windows and the last two event windows is not great enough to rule out the possibility that it could be explained by estimation error, as indicated by the overlapping confidence intervals for the various dispatch windows.

Figure 4-4: Point Estimates and Confidence Intervals for June 12 Cascading Events



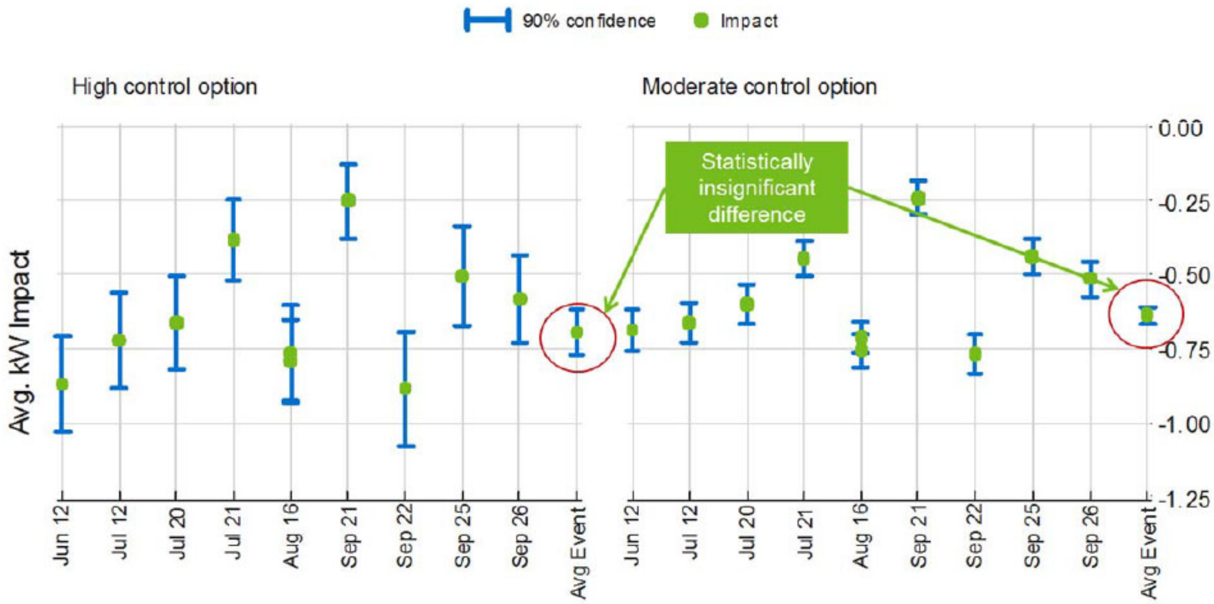
4.4 Weather Sensitivity of AC Load and Demand Reductions

Weather sensitivity analysis was not conducted this year due to the uniformity of the temperature conditions seen on event days. The weather sensitivity analysis from the previous evaluation has been placed in Appendix A for reference.

4.5 Impacts by Customer Load Control Option

Figure 4-5 compares the load impact estimates for customers enrolled in the moderate versus high load control option, along with the 90% confidence intervals for each event. In general, point estimates for load reduction are similar for high and moderate load control option customers on any given event day. In addition, because there were relatively fewer customers in the high load control option subgroup, the confidence intervals for these point estimates are quite wide. 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 4-5: Comparison of Load Impact Results by Control Option for all Events



4.6 Key Findings

A few key findings are worth highlighting:

- Demand reductions were 0.65 kW per household for the average general population event.
- Peak day impacts under normal operations averaged 0.61 kW per household over the course of the two hour dispatch window on July 20, 2017, when the daily maximum temperature was 90˚F.
- Emergency operations produced larger impacts than normal operations, 0.90 kW vs. 0.60 kW per household for the same hour on the hottest day in 2017. Reductions from emergency operations exceeded those from normal operations by 50%.
- The magnitude of impacts varied slightly by dispatch window in absolute terms, but not so much as a percentage of available load. Demand reductions ranged from 0.43 to 0.73 kW per household on June 12, with larger impacts generally occurring later in the day. As a percentage of loads, the demand reductions varied less, ranging from 17.1% to 21.4%, suggesting that most of the differences by event window are a function of the underlying amount of air conditioner load.
- Demand reductions grow larger in magnitude when temperatures are hotter and resources are needed most.[7]
- The difference in impacts between customers who signed up for the lower and higher load control options was minimal and within the range of uncertainty.

[7] This observation is based on results from the 2016 Power Manager evaluation.

5 Demand Reduction Capability – Time-Temperature Matrix

A key objective of the 2017 evaluation was to quantify the relationship between demand reductions, temperature, hour of day, and cycling strategy—referred to as the time-temperature matrix. By design, plans called for a large number of events to be called under different weather conditions, for different dispatch windows, using various cycling strategies so that demand reduction capability could be estimated for a wide range of operating and planning conditions. Because weather conditions did not vary significantly during the 2017 events, data from the 2016 evaluation was also used in the development of this time-temperature matrix.

Weather conditions vary substantially from year to year. Because 2017 conditions did not approach the weather conditions experienced on the emergency event day in 2016, the reductions capability had to be estimated based on conditions experienced on the 2016 emergency event day. It was also found that relying on maximum daily temperature to estimate demand reductions does not reflect heat buildup and its impact on AC usage. Rather than estimating load reductions and defining emergency weather conditions based on maximum daily temperature, this study relies on average temperature over the 24 hour period preceding an event. Using this weather metric, the weather conditions experienced on the 2016 emergency event day was an average of 85˚F during the 24 hours prior to the event.

5.1 Methodology

Figure 5-1 illustrates the essential trends and challenges associated with time-temperature matrix development. Not only do Power Manager demand reductions grow on a percentage basis with hotter weather and with deeper cycling, but so do the air conditioner loads available for curtailment. The implication is that larger percent reductions are attainable from larger loads when temperatures are hotter.

Figure 5-1: Both Air Conditioning Loads and Percent Demand Reductions are Weather Sensitive

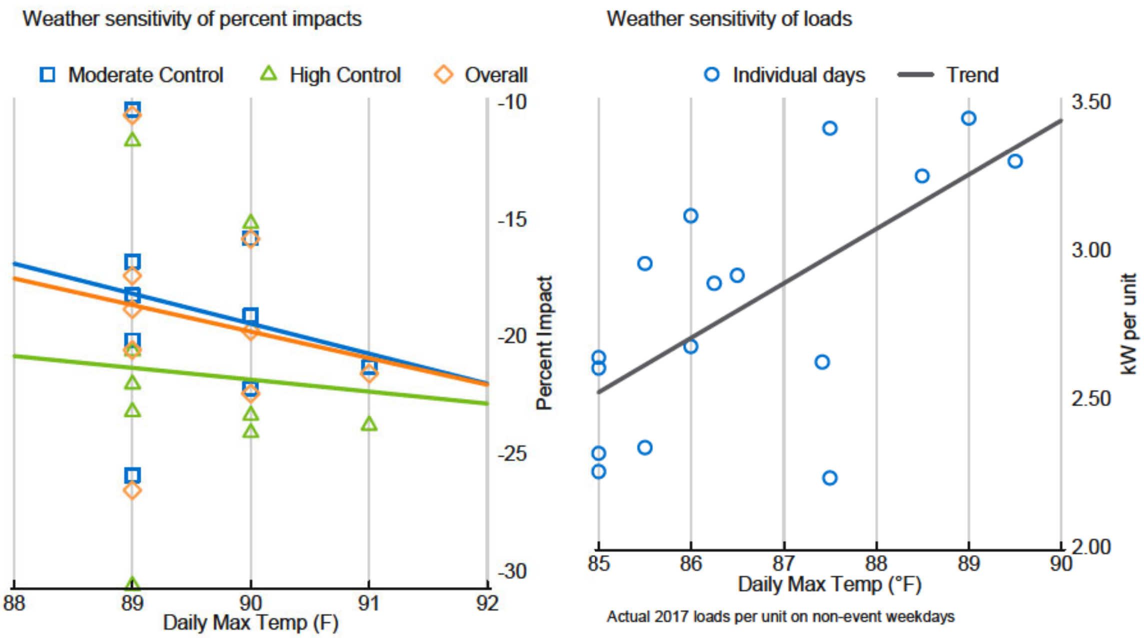


Figure 5-2: Time Temperature Matrix Development Process

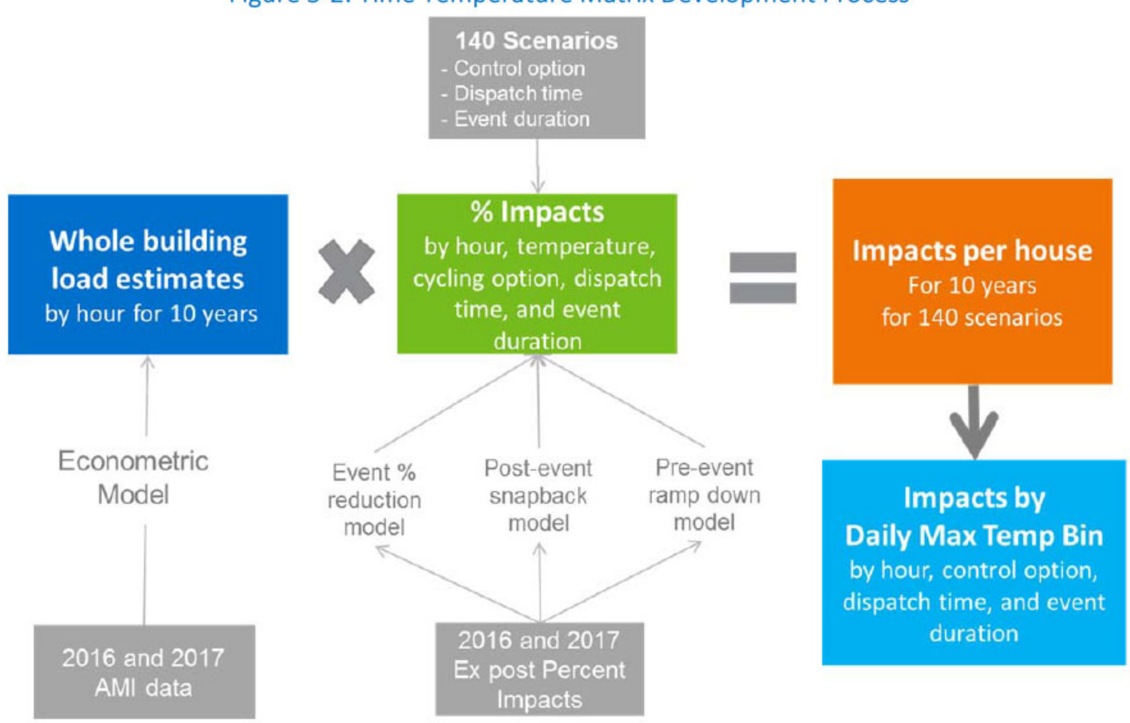


Figure 5-2 illustrates the process used to estimate the demand reduction capability under various conditions:

- Estimates of air conditioner loads were developed using the 2016 and 2017 AMI data and using the same regression models used to estimate impacts. All weekdays with daily maximum temperatures above 75˚F were included in the models. The models were used to estimate air conditioner load patterns for 1,314 days in 10 years. Because the models were based on 2016 and 2017 data, they reflect current usage patterns and levels of efficiency. The 2016 and 2017 air conditioner patterns were applied to actual weather patterns experienced in past 10 years and not 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 2016 and 2017 events.
- A total of 140 scenarios were developed to reflect various cycling/control strategies, event dispatch times, and event lengths.
- Estimated impacts per device were produced. This was done by combining the estimated air conditioner loads, estimated percent reductions, and dispatch scenarios. The process produced estimated hourly impacts for each of 1,314 hotter weekdays in 2007-2017 under 140 scenarios each.
- Multiple days in narrow temperature bins were averaged to produce an expected reduction profile. Days with the similar daily maximum temperature can have distinct temperature profiles and the heat buildup influenced the amount of air conditioner load.

5.2 Demand Reduction Capability for Emergency Conditions

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

Figure 5-3: Demand Reduction Capability for an event with an 85˚F Average Temperature 24 hours prior to the Emergency Dispatch

INPUTS	
Dispatch Type	Emergency Dispatch
Option	Overall
Event start (excludes phase in)	4 PM
Event duration (hours)	1
Previous 24 hr Avg Temp (F)	85
Homes	45,000

Event Window Avg. Impacts		
Load without DR	3.51	kW per house
Load with DR	2.28	kW per house
Impact per house	-1.23	kW per house
Impact (MW)	-55.3	MW
% Impact	-35%	%

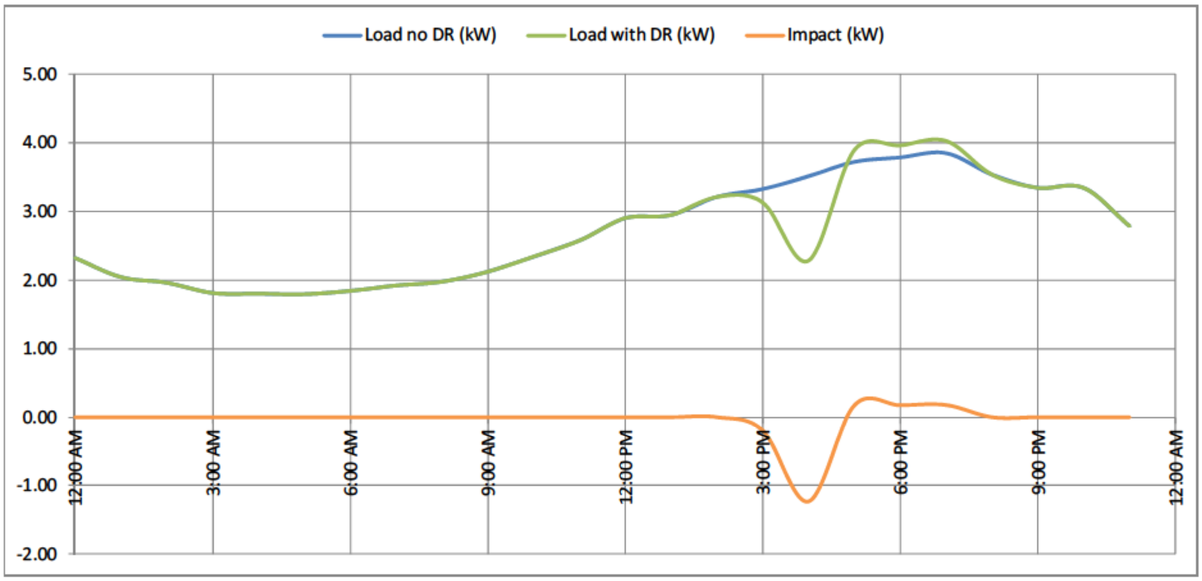


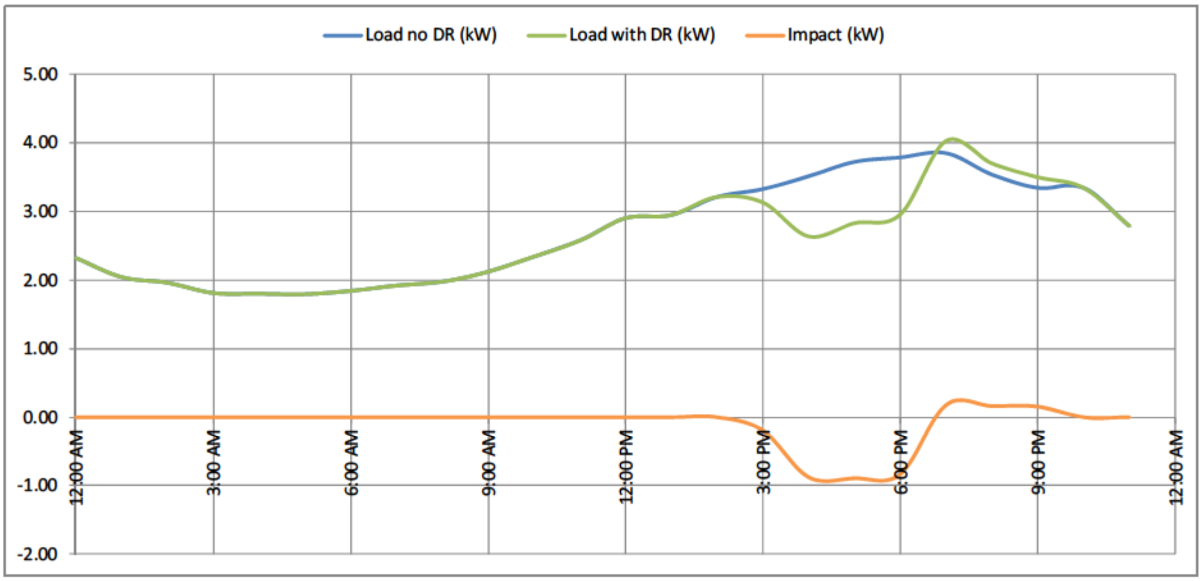
Figure 5-3 shows the demand reduction capability of the program if emergency shed becomes necessary when there is an 85˚F average temperature 24 hours prior to the event. Individual customers are expected to deliver 1.23 kW of demand reduction for the hour. Because there are approximately 45,000 customers, the expected aggregate reductions total is 55.3 MW.

Power Manager can deliver substantial demand reductions under emergency conditions, even if emergency shed operations are not employed and economic dispatch is employed. With a three hour economic dispatch event, demand reductions average 39.0 MW across the dispatch hours, as shown in Figure 5-4. With longer events, reductions vary slightly across each hour but are generally larger when air conditioner use is highest.

Figure 5-4: Demand Reduction Capability for an event with an 85˚F Average Temperature 24 hours prior to the Economic Dispatch

INPUTS	
Dispatch Type	Economic Dispatch
Option	Overall
Event start (excludes phase in)	4 PM
Event duration (hours)	3
Previous 24 hr Avg Temp (F)	85
Homes	45,000

Event Window Avg. Impacts		
Load without DR	3.67	kW per house
Load with DR	2.81	kW per house
Impact per house	-0.87	kW per house
Impact (MW)	-39.0	MW
% Impact	-24%	%



5.3 State 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 in additional to achieving an additional .75% of 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 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 2017 Power Manager evaluation, which was associated with cooler events and lower impacts relative to the 2016 evaluation, the “deemed” approach will be applied with the 2016 results being incorporated into the time-temperature matrix to support estimation of the deemed values. The relevant language for SB310 is provided in Appendix B.

Table 5-1 provides the deemed peak demand reductions that DEO will claim per SB 310 for the Power Manager 2017 program year.

Table 5-1: SB 310 Compliance Peak Demand Reductions

Event Conditions	Number of Customers	Average Impact per Customer	Aggregate Impact	Source
Emergency Shed	45,000	1.23 kW	55.3 MW	Time-Temperature Matrix based on 2016 and 2017 impacts

5.4 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;
- Not only do Power Manager demand reductions grow on a percentage basis with hotter weather and with deeper cycling, but so do the air conditioner loads available for curtailment;
- If emergency shed becomes necessary on an 85˚F average temperature day, Power Manager can deliver 1.23 kW of demand reductions per household;
- Because there are approximately 45,000 Power Manager customers, the expected aggregate reductions total 55.3 MW;
- Reductions are larger with hotter temperatures and more aggressive load control operations; and
- The event start time also influences the magnitude of reductions which, generally, are larger during hours when air conditioner loads are highest.

Appendix A Weather Sensitivity of AC Load and Demand Reductions

Replicated from the 2016 evaluation- the load reduction capacity of Power Manager is dependent on weather conditions, as shown in Figure A-1. The plot shows the estimated average customer impact for each event as a function of daily maximum temperature. There is a clear correlation between higher temperatures and greater load reduction capacity, with the greatest load reductions occurring on the hottest day. Both emergency and normal operation impacts are displayed on this plot for that day, with the greater magnitude impacts attributable to the emergency operations customers.

While the weather correlation is clear, the question remains: How much of the bigger reduction capacity is due to larger air conditioners loads versus larger demand reductions? Both percent reduction and air conditioner loads grow with hotter temperatures. The whole house reductions were 18.9% on the coolest event day (87°F) and 26.1% on the hottest day (93°F). Figure A-2 shows the weather sensitivity of whole house load for the average customer in Power Manager. All nonevent weekdays with a daily high above 70°F were classified into two degree temperature bins. The plot shows how the loads vary by hour as temperatures grow hotter.

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 conditioner loads available for curtailment grows in parallel with the need for resources. Not only are air conditioner loads higher, but the program performs at its best when it is hotter.

Figure A-1: Weather Sensitivity of Load Reduction based on Randomized Control Trial Analysis

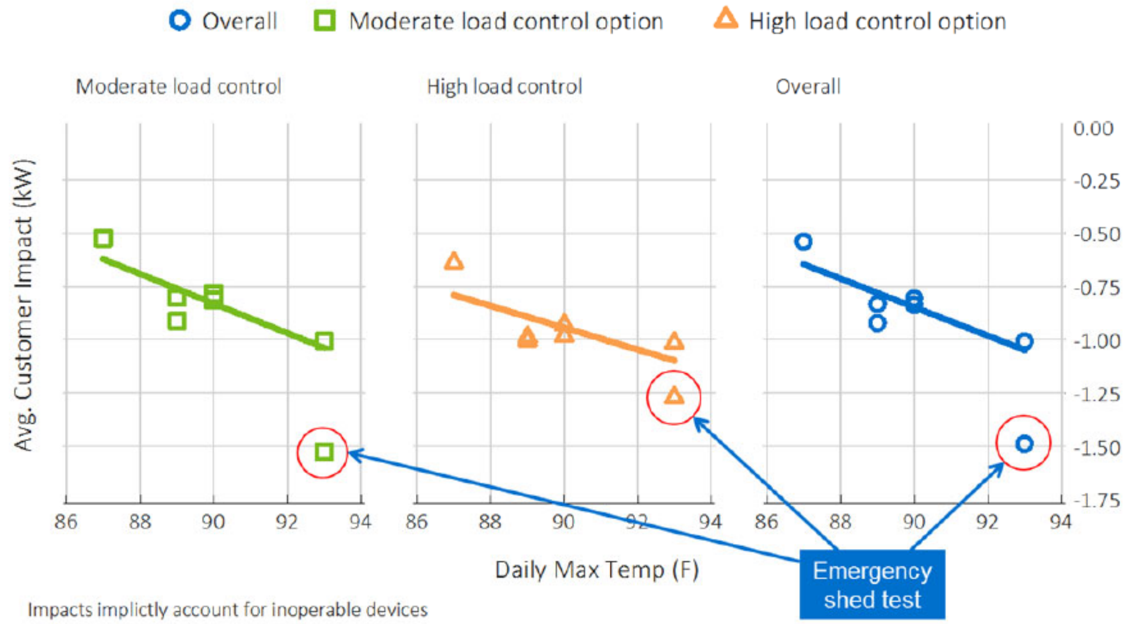
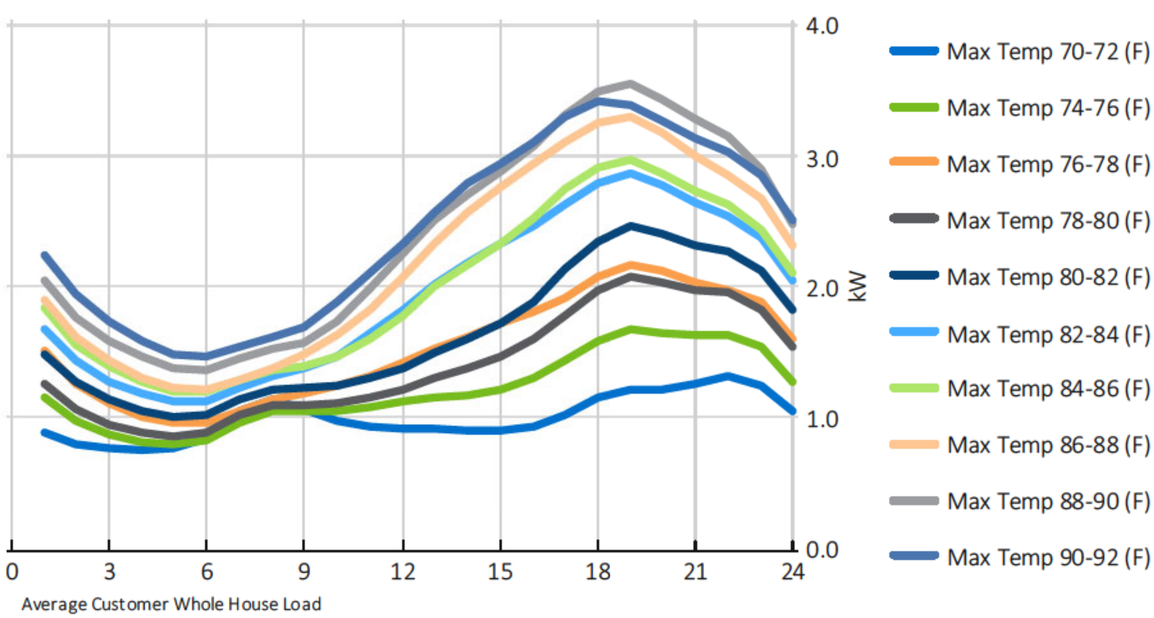


Figure A-2: Weather Sensitivity of Average Customer Loads



Appendix B 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.

ATTACHMENT 2-
PowerShare Evaluation

NAVIGANT

2017 Evaluation Report for the Duke Energy Ohio PowerShare® Program

Prepared for:

Duke Energy

May 8, 2018

Submitted by:
Navigant Consulting, Inc.
1375 Walnut St.
Suite 200
Boulder, CO 80302

303.728.2500
navigant.com

NAVIGANT

CONTENTS

NAVIGANT

EXECUTIVE SUMMARY

This document presents Navigant's evaluation for the Duke Energy Ohio (DEO) PowerShare Program for Program Year 2017. PowerShare is a demand response (DR) program offered to commercial and industrial customers that is part of the portfolio of demand side management and energy efficiency (DSM/EE) programs offered by Duke Energy. PowerShare offers participating companies and agencies a financial incentive to reduce their electricity consumption when called upon by Duke Energy.

The DEO program offers customers two options to choose between: CallOption and QuoteOption.

- **CallOption:** In exchange for a monthly availability bill credit and event performance credits[1], participants reduce and maintain a predetermined load level during Emergency Curtailment events.
- **QuoteOption:** Customers nominate amounts of curtailable load based on upon price and timing offers from Duke Energy. Customers receive bill credits for actual load curtailed during the event. QuoteOption is not addressed further in this report because no QuoteOption events were called during this evaluation period.

Participants enrolled in CallOption must further select one of three seasonal participation periods[2]:

1. **Summer Only** – A maximum of 10 emergency events may occur from June 1 to September 30. Events may only be called on non-holiday weekdays from 12 noon to 8 pm and events may be a maximum of 6 hours in length.
2. **Extended Summer** – No limit is placed on the number of emergency events that may occur from June 1 to October 31, 2017 plus May of 2018. Events may be called on any day during those months and an event may last no more than 10 hours.
3. **Annual** – No limit is placed on the number of events, and events may occur any day through the year (June 1, 2017 to May 31, 2018). Events may last no more than 10 hours.

CallOption participants may choose between one of two compliance options: that of having curtailment evaluated based on a "Firm" demand level ("down to") or a "Fixed" demand reduction ("down by"). CallOption participants must further choose between one of two energy options: "Capacity Only" (may also participate in PJM energy markets) and "Emergency Full" (Duke acts as the participant's sole curtailment service provider).

In the period of analysis, DEO PowerShare participants were subject to only test events. Participants are only required to respond to a single test event per season, and most of the participants elected to participate in the first test event on September 7, 2017.

Evaluation Objectives

The research objectives of this evaluation are as follows:

[1] Event performance energy credits are provided only to participants that select the "Emergency Full" energy option. See body of report for more details.
[2] Participation periods shown are specific to a given calendar period, as specified in the program literature.

NAVIGANT

- Review updates to the SAS code used by Duke Energy to estimate baseline as well as monthly and seasonal capability.
- Audit the hourly kW DR event load shed for participating customers by replicating the Schneider Electric Energy Profiler Online™ (EPO) methods used to calculate the energy (kWh) and demand (kW) impacts used to determine settlement payments.

To complete the first objective, Navigant reviewed updates to the SAS code used by Duke Energy to determine participant baselines and monthly and seasonal capability. To complete the second objective, Navigant replicated the EPO energy and demand calculations used by Duke Energy to determine settlement payments.

Key Findings

This section presents Navigant's key evaluation findings for the two principal evaluation objectives:

Duke Energy Baseline SAS Code Audit

Duke Energy Applied Updates Per Navigant's Recommendations. During the 2016 PowerShare evaluation, Navigant performed a detailed audit of the SAS code used by Duke Energy to calculate settlement baselines, as well as monthly and seasonal capabilities. As an outcome of this audit, Navigant provided Duke Energy with several recommendations to improve the functionality and organization of the SAS code. For 2017, Navigant again reviewed the SAS code and found that Duke Energy appropriately implemented the changes recommended by Navigant.

Verification and Validation of Settlement Energy and Demand Calculations

Settlement calculations verified as correct. Duke Energy uses EPO to determine the energy (kWh) and capacity (kW) values that are the basis for calculating monthly settlement amounts. Navigant replicated the calculations for all of the participants in the period from June through October of 2017. Because no customers were enrolled in the QuoteOption program, this report only includes results for CallOption participants.

Initially, Navigant found a number of discrepancies between its energy and capacity settlement calculations and those provided by Duke Energy. After several discussions with Duke Energy, Navigant identified the following causes of discrepancies:

- Interval data issues related to power outages (caused most of the discrepancies)
- Missing usage data

Upon resolving those discrepancies, Navigant found that all of Duke Energy's estimates are accurate per the settlement algorithms defined by the program literature. A summary of the validation results, by credit type, may be found in Table E- 1 below. The program-level energy and demand impacts are shown in Table E- 2 and Table E- 3, respectively.[3]

[3] A total of 13 participants were enrolled for the Extend Summer option that includes October. However, no events were called in October so it is omitted from Table E-3.

NAVIGANT

Table E- 1. Verification of EPO Calculations

Program Option	Credit Type	Customers	# of Unique Account Numbers	# of EPO Results Replicated[a]	Average % Absolute Error[b]
CallOption	Energy	41	41	41	0.00%
CallOption	Capacity	41	41	164	0.00%

a. *The number of calculations reproduced by Navigant for this analysis. For energy there is one credit calculated per participating account per event. For capacity there is one credit calculated per participating account per month. The period of analysis for this evaluation included four months and three test curtailment events.*

b. *The absolute error represents the difference between Navigant's replicated settlement results and the EPO estimates used by Duke Energy. The near-zero error demonstrates that Navigant was able to replicate settlement calculations using the algorithms provided by Duke Energy.*

Source: EPO Settlement Data and Navigant analysis

Table E- 2. Summary of 2017 Event Energy Impacts at the Meter (Total Program MWh per Event)

Program Name	September 7th	September 21st	September 26th	Total
Total Energy Curtailed (MWh)	54	0.4	0.5	55
# of Participants	38	2	1	41

Source: EPO Settlement Data and Navigant analysis

Table E- 3. Total Monthly Capacity for 2017 at the Meter (MW)

Program Name	June	July	August	September	Average
CallOption	45	47	50	49	48

Source: EPO Settlement Data and Navigant analysis

NAVIGANT

1. INTRODUCTION

This document presents Navigant's evaluation for the Duke Energy Ohio (DEO) PowerShare® Program for Program Year 2017. The PowerShare Program is a demand response program offered to commercial and industrial customers that is part of Duke Energy's portfolio of demand side management and energy efficiency (DSM/EE) programs. PowerShare offers participating customers a financial incentive to reduce their electricity consumption when called upon by Duke Energy.

1.1 Program Overview

The customer contracts for DEO's PowerShare Program commence on the first day of the month and the initial contract term varies between four months (CallOption – Summer Only) to one year (all other options).

The DEO program offers customers two options to choose between: CallOption and QuoteOption.

- **CallOption:** In exchange for a monthly availability bill credit and event performance credits[4], participants reduce and maintain a predetermined load level during Emergency Curtailment events.
- **QuoteOption:** Customers nominate amounts of curtailable load based on upon price and timing offers from Duke Energy. Customers receive bill credits for actual load curtailed during the event. QuoteOption is not addressed further in this report because no QuoteOption events were called during this evaluation period.

Participants enrolled in CallOption must further select one of three seasonal participation periods[5]:

1. **Summer Only** – A maximum of 10 emergency events may occur from June 1 to September 30. Events may only be called on non-holiday weekdays from 12 noon to 8 pm and events may be a maximum of 6 hours in length.
2. **Extended Summer** – No limit is placed on the number of emergency events that may occur from June 1 to October 31, 2017 plus May of 2018. Events may be called between 10:00am and 10:00pm on any day during those months and an event may last no more than 10 hours.
3. **Annual** – No limit is placed on the number of events, and events may occur any day through the year (June 1, 2017 to May 31, 2018). Events may last no more than 10 hours.

In the period of analysis, DEO PowerShare participants were subject to only test events. Participants are only required to respond to a single test event per season, and most of the participants elected to participate in the first test event on September 7, 2017.

The PowerShare Program is designed to encourage participating customers to reduce their electricity consumption on days of high electric demand and/or high energy market prices. Duke Energy contracts with Schneider Electric to calculate monthly customer settlements for the PowerShare Program. Schneider Electric is a specialized firm providing services in energy management and automation. The PowerShare settlements are calculated with the use of Schneider Electric's EPO, a hosted software application designed to assist utilities with energy data analysis. EPO uses participant interval data,

[4] Event performance energy credits are provided only to participants that select the "Emergency Full" energy option. See body of report for more details.
[5] Participation periods shown are specific to a given calendar period, as specified in the program literature

Duke Energy-generated participant baselines, and a set of program option-specific formulas to calculate the event energy (kWh) and monthly capacity (kW) values that determine participant settlement payments.

1.2 Evaluation Objectives

The research objectives of this evaluation are:

1. Review updates to the SAS code used by Duke Energy to estimate baseline as well as monthly and seasonal capability.
2. Audit the hourly kW DR event load shed for participating customers by replicating the Schneider Electric EPO methods used to calculate the energy (kWh) and demand (kW) impacts that are used to determine settlement payments.

1.2.1 Review Updates to SAS Code Used for DR Baseline and Capability Calculations

During the 2016 PowerShare evaluation, Navigant performed a detailed audit of the SAS code used by Duke Energy to calculate settlement baselines, as well as monthly and seasonal capabilities. As an outcome of this audit, Navigant provided Duke Energy with several recommendations to improve the functionality and organization of the SAS code. For 2017, Navigant again reviewed the SAS code and found that Duke Energy appropriately implemented the changes recommended by Navigant. Navigant reviewed about 70 files as part of this process, which included code scripts and extracts. Navigant did not execute the code; however the Navigant analyst performed a detailed assessment of output extracts from each section of the code, and coordinated closely with the Duke Energy SAS code author throughout the review process.

1.2.2 Verify Energy and Demand Calculations Used for Settlement

To complete the second objective, Navigant replicated Duke Energy's energy and demand calculations to determine settlement payments, and compared these with the energy and demand values reported in the program's operational tracking database containing settlement reports exported from EPO.

Schneider Electric's EPO outputs a settlement report for each participant (monthly capacity and event energy settlements). Each report contains the data (including the Duke Energy baseline and the participant actuals) used and the arithmetic applied to calculate the settlement payment.

To fulfill this task, Duke Energy directed Navigant to replicate the settlement arithmetic for all PowerShare participants from June through October of 2017. The purpose of this replication was to audit the process and ensure that all algorithms were applied as specified in the program literature. A detailed methodology and findings are presented later in this report.

1.3 Program Rules

This sub-section provides some additional detail regarding the program rules, specifically, those rules that define how much DR participants are required to provide, and a summary of the participant credits.

This information is a summary of the DEO PowerShare Program brochure to which interested readers should refer for additional detail.[6]

As noted earlier, there are two PowerShare program options in DEO territory, but no QuoteOption events were called during the period covered by this evaluation so only CallOption is addressed further.

The CallOption has, itself, a high degree of optionality for participants. Participants enrolled in CallOption must select:

- A compliance plan ("Fixed" or "Firm");
- A participation period ("Summer Only", "Extended Summer", or "Annual"), and;
- An energy option ("Capacity Only" or "Emergency Full").

Details of each of these options are discussed in the text immediately below, and in Table 1, which follows.

Compliance Plan. Participants in the CallOption must select one of two compliance plans:

- Fixed. A "Fixed" compliance plan is a "down by" requirement (i.e., when called participants must reduce demand by X kW).
- Firm. A "Firm" compliance plan is a "down to" requirement (i.e., when called participants must reduce demand to X kW).

Participation Period. The participation period selected determines the contract term, potential periods of interruption and the payment schedule. Details of these differences are presented in Table 1, below.

Energy Option. CallOption participants may choose either the:

- "Capacity Only" option, in which case they may participate in the PJM energy markets but do not receive any energy payments from Duke Energy; or,
- "Emergency Full" option which precludes the participant from participating in other curtailment programs.

All PowerShare options, compliance plans, participation periods and energy options require participants to commit to curtailing a minimum of 100kW per event.

CallOption curtailment may only be called as required by PJM capacity constraints.

Table 1, below, presents some additional detail regarding the program rules for the three PowerShare options in DEO territory with enrolled participants.

[6] Duke Energy Ohio, *PowerShare Ohio 2016 - 2017* (Program Brochure), Accessed 2017 https://www.duke-energy.com/business/products/powershare

NAVIGANT

Table 1: Detailed PowerShare Option Rules

	CallOption – Summer Only	CallOption – Extended Summer	CallOption – Annual
Eligibility	Available to customers served on rate schedules DS, DP, and TS.	Available to customers served on rate schedules DS, DP, and TS.	Available to customers served on rate schedules DS, DP, and TS.
Notice	30 Minutes	30 Minutes	30 Minutes
Curtailment Frequency and Timing	Curtailment may occur between noon and 8pm for up to 6 hours on non-holiday weekdays from June through September. No more than 10 emergency events may be called during the summer.	Curtailment may occur between 10am and 10pm for up to 10 hours on any day from June through October 2017, and May 2018. There is no limit on the number of events that may be called.	Curtailment may occur between 10am and 10pm for up to 10 hours on any day from June through October 2017, and May 2018. Curtailment may also occur between 6am and 9pm on any day from November through April. There is no limit on the number of events that may be called.
Energy Payment	Emergency Full option participants receive credit at a rate equivalent to 85% of the real-time LMP observed during the event.	Emergency Full option participants receive credit at a rate equivalent to 85% of the real-time LMP observed during the event.	Emergency Full option participants receive credit at a rate equivalent to 85% of the real-time LMP observed during the event.
Capacity Payment	$36 per kW/year	$48 per kW/year	$54 per kW/year
Penalty	Failure to reduce to Firm Demand levels incurs a penalty of the Real-Time cost of energy (LMP + 10%). All penalties charged by PJM and include potential for removal from the program.	Failure to reduce to Firm Demand levels incurs a penalty of the Real-Time cost of energy (LMP + 10%). All penalties charged by PJM and include potential for removal from the program.	Failure to reduce to Firm Demand levels incurs a penalty of the Real-Time cost of energy (LMP + 10%). All penalties charged by PJM and include potential for removal from the program.

Source: Duke Energy program literature

2. EVALUATION METHODS

This section of the PowerShare evaluation outlines the methods employed by the evaluation team to complete the evaluation.

This section is divided into two sub-sections:

- **Duke Energy Baseline SAS Code Audit.** This sub-section describes Navigant's approach to auditing the SAS code developed by Duke Energy to estimate participant baselines and calculate capabilities.
- **Replication of EPO Calculations**. This sub-section describes the approach and data used to replicate the EPO calculations that deliver the energy and demand used by Duke Energy to determine settlement payments.

2.1 Duke Energy Baseline SAS Code Audit

Navigant's approach to reviewing the SAS code was to focus on the changes implemented to the code based on the recommendations provided by Navigant during the 2016 evaluation. Navigant requested and reviewed a number of files containing SAS coding script and other extracts from the code. Navigant did not run the code.

2.2 Replication of EPO Calculations

This sub-section describes the approach and data used by Navigant to replicate the EPO calculations for energy and demand used by Duke Energy to determine settlement payments.

It is divided in two parts:

- **Input Data** - This section lists the key data and documents used as inputs for this analysis.
- **Description of EPO calculations** - This section provides the algebraic descriptions of the calculations replicated by Navigant.

2.2.1 Input Data

Navigant used the following key input data and documents to replicate the EPO settlement calculations:

1. EPO settlement results data
2. DEO PowerShare participants' interval consumption data
3. DEO PowerShare Program brochure[7]
4. The Schneider Electric summary of data required to complete settlement algorithms, provided to Navigant by Duke Energy.
5. PowerShare program guidelines, provided to Navigant by Duke Energy.

[7] The DEO PowerShare Program brochure can be found at https://www.duke-energy.com/business/products/powershare

NAVIGANT

2.2.2 Description of EPO Calculations

This section summarizes Navigant's replication of the EPO calculations that estimate the energy and demand values used by Duke Energy to determine settlement. There are several key terms that are worth formally defining in order to clarify their use in equations that follow. These terms are:

- **Proforma Demand**: Demand level specified in CallOption participants' agreement
- **Firm Demand Compliance Option**: CallOption participants may choose one of two compliance options. For the Firm demand option, participants agree to reduce load **by** a certain kW level when called.
- **Fixed Demand Compliance Option**: CallOption participants may choose one of two compliance options. For the Fixed demand option, participants agree to reduce load **to** a certain kW level when called.

Navigant applied the equations in this section to the interval consumption data resulting in the relevant energy or capacity credits. Navigant then compared the calculated credits to the EPO settlement data and verified that the results were essentially identical for each calculation.[8]

Event Energy Credits (Applies to "Emergency Full" CallOption Participants)

$$LR = \sum_h [MAX(0, MIN(1000, P_h - A_h))]$$

Where:

LR	=	Load reduction,
P_h	=	Proforma demand in hour h,
A_h	=	Actual demand in hour h

Monthly Capacity Credits (Applies to CallOption Participants)

The calculation of monthly capacity differs by compliance option.

Firm Demand Compliance Option

$$NEOL = MAX(0, A_i - F)$$
$$EOL = MAX(0, P - F)$$

Where:

NEOL	=	Non-event option load, used for months in which no event occurred,
EOL	=	Event option load, used for months in which an event occurred,
A_i	=	Average demand for month i during the exposure period,
F	=	Firm demand,
P	=	Average proforma demand during curtailment period

[8] Some small insignificant differences in individual calculations were found due to rounding effects.

Fixed Demand Compliance Option

$$NEOL = MAX(0, MIN(A_i, FDR))$$

$$EOL = MIN(P, FDR)$$

Where:

NEOL	=	Non-event option load, used for months in which no event occurred,
EOL	=	Event option load, used for months in which an event occurred,
A_i	=	Average demand for month i during the exposure period,
FDR	=	Fixed demand reduction,
P	=	Average proforma demand during curtailment period

NAVIGANT

3. EVALUATION FINDINGS AND RESULTS

This section describes the findings and results of Navigant's evaluation. It is divided into two sections:

- **Duke Energy Baseline SAS Code Audit.** This section describes Navigant's findings and recommendations based on our audit of the Duke Energy baseline SAS code.
- **PowerShare Impacts and Findings from Navigant's Replication of EPO Calculations.** This section describes Navigant's findings based on our analysis of the program tracking database[9] and the replication of the EPO calculations that deliver the energy and demand impacts used by Duke Energy to determine settlement payments.

3.1 Duke Energy Baseline SAS Code Audit

Navigant found that Duke Energy addressed all recommendations from the 2016 PowerShare EM&V reports. This resulted in improvements to the code that should enhance the usability and mitigate the potential for errors.

3.2 PowerShare Impacts and Findings from Navigant's Replication of EPO Calculations

Navigant replicated the EPO calculations for all of the participants in the period from June through October of 2017. Initially, Navigant found a number of discrepancies between its energy and capacity settlement calculations and those provided by Duke Energy. After several discussions with Duke Energy, Navigant identified the following causes of discrepancies:

- Interval data issues related to power outages (caused most of the discrepancies)
- Missing data

Upon resolving those discrepancies, Navigant found that all of Duke Energy's estimates are accurate per the settlement algorithms defined by the program literature. A comparison of Navigant's replicated calculations with the output of the EPO revealed no deviations beyond what could be expected as a result of rounding error, meaning that Duke Energy's estimates are accurate. A summary of the validation results, by credit type may be found in Table 2 below.

[9] The "program tracking database" refers to the documentation provided by Duke Energy outlining the reported capacity and energy values used by Duke Energy for settlement payment.

NAVIGANT

Table 2. Verification of EPO Calculations

Program Option	Credit Type	Customers	# of Unique Account Numbers	# of EPO Results Replicated[a]	Average % Absolute Error[b]
CallOption	Energy	41	41	41	0.00%
CallOption	Capacity	41	41	164	0.00%

a. *The number of calculations reproduced by Navigant for this analysis. For energy there is one credit calculated per participating account per event. For capacity there is one credit calculated per participating account per month. The period of analysis for this evaluation included four months and three test curtailment events. CallOption participants are required only to participate in one test event per season.*

b. *The absolute error represents the difference between Navigant's replicated settlement results and the EPO estimates used by Duke Energy. The near-zero error demonstrates that Navigant was able to replicate settlement calculations using the algorithms provided by Duke Energy.*

Source: EPO Settlement Data and Navigant analysis

Navigant calculated verified values according the EPO algorithms described above using Duke Energy's participant baselines and participant interval data. Only CallOption Emergency events (as opposed to test events) were called in the period of analysis. Since participants are required to participate only in a single test event during the DR season, most only participated in the first event. This resulted in most energy impacts being observed in that event. The total energy impacts per event for the summer of 2017 by PowerShare option are summarized in Table 3, below.

Table 3: Summary of 2017 Event Energy Impacts at the Meter (Total Program MWh per Event)

Program Name	September 7th	September 21st	September 26th	Total
Total Energy Curtailed (MWh)	54	0.4	0.5	55
# of Participants	38	2	1	41

Source: EPO Settlement Data and Navigant analysis

The PowerShare Program paid out capacity credits to participants for an average monthly capacity of approximately 48 MW during the summer of 2017. This value is calculated according the EPO algorithms described above using Duke Energy's participant baselines and participant interval data. The total DR capacity per month for the summer of 2017 for PowerShare CallOption participants is summarized in Table 4, below.[10]

[10] A total of 13 participants were enrolled for the Extend Summer option that includes October. However, no events were called in October so it is omitted from Table 4.

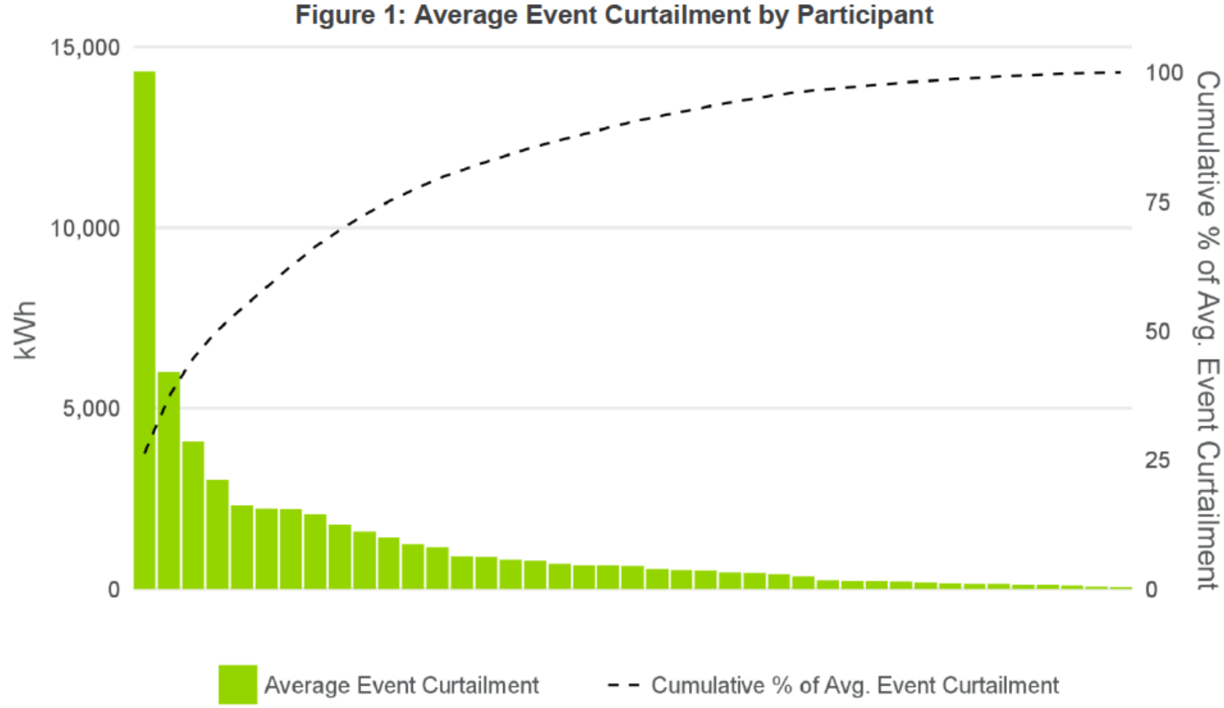
NAVIGANT

Table 4: Total Monthly Capacity for 2017 at the Meter (MW)

Program Name	June	July	August	September	Average
CallOption	45	47	50	49	48

Total program impacts are driven by curtailment for individual meters. Figure 1 shows each meter's average event energy reduction across the analysis period with a single accout driving much of the curtailment.

Figure 1: Average Event Curtailment by Participant

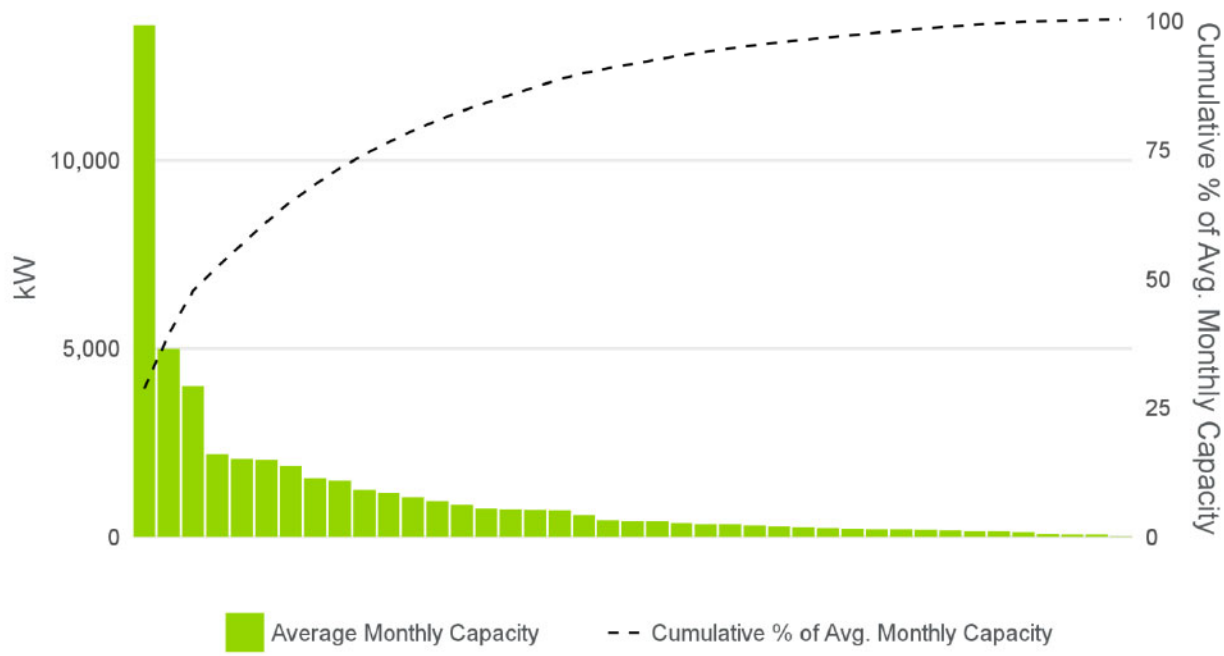


Source: EPO Settlement Data and Navigant analysis

Average monthly capacity is driven by a small percentage of meters. Figure 2 shows that the top three meters in terms of average monthly capacity account for 48% of total average monthly capacity. The ranking of participants by their average monthly capacity is nearly identical to that of their average event reduction.

NAVIGANT

Figure 2: Average Monthly Capacity by Participant[11]



Source: EPO Settlement Data and Navigant analysis

[11] The bar chart shows each participant's average capacity only across the months in which they participated in events.

4. CONCLUSIONS AND RECOMMENDATIONS

4.1 Duke Energy Baseline SAS Code Audit

Navigant's detailed review of Duke Energy's SAS code determined that Duke Energy addressed all recommendations from the 2016 EM&V report for improving the organization and functionality of the code. The evaluation team believes the code is functioning correctly and does not need further review or updates at this time.

4.2 Verification and Validation of Settlement Energy and Demand Calculations

Although Navigant initially encountered some discrepancies when replicating Duke Energy's settlement calculations, these discrepancies were eventually resolved, and Navigant found that Duke Energy's settlement calculations were accurate per the algorithms defined in Section 2.2. This finding confirms that Duke Energy's procedure for calculating impacts is functioning in accordance with the program definitions, and therefore there will be limited value in continuing to audit settlement calculations using the methods described in this report.

If future evaluation efforts include similar efforts to replicate the settlement calculations, Navigant recommends that Duke Energy implement a detailed process for tracking all outages such that it can easily be determined when missing interval data was replaced with pro forma figures to minimize the initial discrepancies and expedite the evaluation.

ATTACHMENT 3-
Small Business Energy Saver Evaluation

EM&V Report for the Small Business Energy Saver Program

Duke Energy Ohio

Prepared for:

Duke Energy

Submitted by:
Navigant Consulting, Inc.
1375 Walnut Street
Suite 100
Boulder, CO 80302

303.728.2500
navigant.com

August 29, 2018

TABLE OF CONTENTS

1. EVALUATION SUMMARY

1.1 Program Summary

The Small Business Energy Saver (SBES) Program is part of a portfolio of energy efficiency programs operated by Duke Energy. Duke Energy selected SmartWatt Energy to implement the SBES program in the Duke Energy Ohio (DEO) jurisdiction. The program caters specifically to small business customers and offers a performance-based incentive up to 80 percent of the total project cost, inclusive of both materials and installation, on high-efficiency lighting and refrigeration equipment.

The SBES Program generates energy savings and peak demand reductions by offering eligible customers a streamlined service including marketing outreach, technical expertise, and performance incentives to reduce equipment and installation costs from market rates on high-efficiency lighting, refrigeration, and HVAC equipment. The SBES Program seeks to bundle all eligible measures together and offer them as a single project in order to maximize the total achievable energy and demand savings, while working with customers to advise equipment selection to meet their unique needs.

1.2 Evaluation Objectives and High Level Findings

Evaluation, Measurement, and Verification (EM&V) involves the use of a variety of analytic approaches, including on-site verification of installed measures and application of engineering models. EM&V also encompasses an evaluation of program processes and customer feedback, typically conducted through participant surveys and program staff interviews. This report details the EM&V activities that Navigant Consulting, Inc. (Navigant) performed on behalf of Duke Energy for the SBES Program covering the period between March 1, 2016 through June 30, 2017, referenced simply as PY2016.

The primary purpose of the evaluation assessment is to estimate net annual energy and peak demand impacts associated with SBES activity. Net savings are calculated as the reported “gross” savings from Duke Energy, verified and adjusted through EM&V, and netted for free ridership (i.e., savings that would have occurred even in the absence of the program) and spillover (i.e., additional savings attributable to the program but not captured in program records).

- Navigant performed impact and process evaluations for this EM&V assessment. The impact evaluation consists of engineering analysis and on-site field verification and metering to validate energy and demand impacts of reported measure categories, as well as a participant survey to assess net impacts.
- For the process evaluation, Navigant completed online surveys with 110 participants and interviews with program staff and the implementation contractor (IC) to characterize the program delivery and identify opportunities to improve the program design and processes. The evaluation team also used the participant survey data to estimate free ridership and spillover to calculate an NTG ratio.

The evaluation team verified gross energy savings at 104 percent of deemed reported energy savings, and gross summer peak demand reductions at 74 percent. A net-to-gross (NTG) ratio was estimated at 1.02, yielding total verified net energy savings of 27,688 megawatt-hours (MWh), net summer peak demand reductions of 3.4 megawatts (MW), and net winter peak demand reductions of 4.0 megawatts (MW) (Table 1-1 through Table 1-4). It is important to note that although the gross realization rate was

104 percent, there was variability in the verified savings at the individual project level that is explored further in section 4 of this report. The NTG ratio of 1.02 indicates that the program is directly responsible for energy and demand savings, and that savings would not have occurred in the absence of the program.

Table 1-1. Program Claimed and Evaluated Gross Energy Impacts

	Claimed	Evaluated	Realization Rate
Gross Energy Impacts (MWh)	26,021	27,145	1.04

Source: Navigant analysis and Duke Energy tracking data, totals subject to rounding.

Table 1-2. Program Claimed and Evaluated Gross Peak Demand Impacts

	Claimed	Evaluated	Realization Rate
Gross Summer Peak Demand Impacts (MW)	4.5	3.3	0.74
Gross Winter Peak Demand Impacts (MW)	4.7	3.9	0.83

Source: Navigant analysis and Duke Energy tracking data, totals subject to rounding.

Table 1-3. Program Net Energy Impacts

	MWh
Net Energy Impacts (MWh)	27,688

Source: Navigant analysis, totals subject to rounding.

Table 1-4. Program Net Peak Demand Impacts

	MW
Net Summer Peak Demand Impacts (MW)	3.4
Net Winter Peak Demand Impacts (MW)	4.0

Source: Navigant analysis, totals subject to rounding.

Additionally, consistent with Ohio SB310, the higher of the evaluated estimates of energy efficiency impacts or the deemed values are applied prospectively to adjust subsequent impact assumptions until superseded by new EM&V results. The evaluated energy impacts reported for the SBES program were found to be higher than the deemed savings and therefore the evaluated results shall be applied to the rider in the month following the completion of this EM&V report. The evaluated summer demand impact realization rate, however, was found to be lower than the verified realization rate, therefore the deemed results shall be applied. Alternatively, the evaluated winter demand realization rate was found to be higher than the deemed realization rate, therefore the evaluated realization rate will be applied. The evaluated results will also be used to estimate future target achievement levels for development of estimated incentives and in future cost-effectiveness evaluations. Table 1-5 below summarizes the program claimed, deemed, and evaluated values.

Table 1-5. Program Impact Summary

	Energy (MWh)	Summer Demand (MW)	Winter Demand (MW)
Gross Claimed Impacts	26,021	4.5	4.7
Deemed Impacts (1 kWh/kwh)	26,021	4.5	4.7
Deemed Realization Rate	**1.00**	**.77**	**.59**
Evaluated Impacts	27,145	3.3	3.9
Evaluated Realization Rate	**1.04**	**0.74**	**0.83**

Source: Navigant analysis, totals subject to rounding.

1.3 Evaluation Parameters and Sample Period

To accomplish the evaluation objectives, Navigant performed a variety of primary and secondary research activities including:

- Engineering review of measure savings algorithms
- Field verification and metering to assess installed quantities and characteristics
- Participant surveys with customers to assess satisfaction and decision-making processes.

Table 1-6 summarizes the evaluated parameters. The targeted sampling confidence and precision was 90 percent ± 10 percent, and the achieved was 90 percent ± 2.7 percent for energy savings, 11.6 percent for summer and 4.3 percent for winter peak demand reductions.[1]

Table 1-6. Evaluated Parameters

Evaluated Parameter	Description	Details
Efficiency Characteristics	Inputs and assumptions used to estimate energy and demand savings	1. Lighting wattage 2. Operating hours 3. Coincidence factors 4. HVAC interactive effects 5. Baseline characteristics
In-Service Rates	The percentage of program measures in use as compared to reported	1. Measure quantities found onsite
Satisfaction	Customer satisfaction with various stages of their project	1. Overall satisfaction with program 2. Satisfaction with implementation and installation contractors 3. Satisfaction with program equipment

[1] Navigant designed the impact sample to achieve 90/10 confidence and precision using the industry-standard coefficient of variation of 0.5, results from previous (PY2013 through PY2015) SBES program evaluations in other Duke Energy jurisdictions, and Navigant judgement. The final precision was different due to natural variation in individual site level characteristics.

Free Ridership	Fraction of reported savings that would have occurred in the absence of the program	
Spillover	Additional, non-reported savings that occurred as a result of participation in the program	1. Inside spillover (at same facility as program measures) 2. Outside spillover (at different facility as program measures)

Source: Navigant analysis

This evaluation covers program participation from March 2016 through June 2017. Table 1-7 shows the start and end dates of Navigant's sample period for evaluation activities.

Table 1-7. Sample Period Start and End Dates

Activity	Start Date	End Date
Field Verification and metering	September 18, 2017	November 30, 2017
Participant Email Surveys	October 1, 2017	November 30, 2017

Source: Navigant analysis

1.4 Recommendations

The evaluation team recommends six discrete actions for improving the SBES Program, based on insights gained through the evaluation effort. These recommendations, summarized in Table 1-7, provide Duke Energy with a roadmap to fine-tune the DEO SBES Program for continued success.

Table 1-8. Summary of PY2016 SBES Recommendations

Increasing Program Participation and Satisfaction
1. **Increase and improve program communications.** This is the most common challenge or drawback received from participants, with several customers noting specific communication issues regarding the responsibility for and timeline of recycling pickup. Additional education from both SmartWatt and Duke Energy account managers should help customers better understand the program participation process.
2. **Prioritize customer satisfaction training for installation contractors and customer follow-up services.** A minority of customers reported issues with installation and lighting equipment quality. Notably, overall satisfaction was higher for customers that received follow-up inspections from the implementation contractor than those that did not. There appears to be an opportunity to increase satisfaction by performing additional follow-up visits, although this must be balanced against increased cost. Additionally, this helps customers resolve equipment issues in a timely manner.
3. **Phase out T8 fluorescent lighting systems in favor of linear LED kits.** Linear LED lighting offers substantial savings above high-performance/reduced wattage T8 lamps and ballasts, which are increasingly perceived as outdated.
Improving Accuracy of Reported Savings
4. **Track project facility types by using the same list of facility types specified in the Pennsylvania TRM.** This will reduce uncertainty in assigning facility types by the EM&V team based on SIC codes, and facilitate more direct application of HVAC interactive effects and coincidence factors. The Pennsylvania TRM facility types should be used only because the HVAC interactive effects applied by the EM&V team are drawn from this document.

5.	**Track burnout lamps and fixtures during the initial audit.** It is likely that some burnouts were present and tolerated by customers, and may contribute to customers not realizing expected savings on their energy bills.
6.	**Add connected load to occupancy sensor savings estimates.** Occupancy sensor savings were missing details on connected fixture load. This is a key input to the savings estimation, and should be recorded.

Source: Navigant analysis

2. PROGRAM DESCRIPTION

The Small Business Energy Saver (SBES) Program is part of a portfolio of energy efficiency programs operated by Duke Energy. The program launched in the DEO jurisdiction in late 2014, and first claimed energy savings in January 2015. Duke Energy follows best practices from the successful SBES program operating in other Duke Energy jurisdictions since 2013.

2.1 Program Design

The SBES Program is available to qualifying commercial customers with less than 100 kilowatts (kW) demand service. After completing the program application to assess participation eligibility, customers receive a free energy assessment to identify equipment for upgrade. SmartWatt Energy reviews the energy assessment results with the customer, who then chooses which equipment upgrades to perform. Qualified contractors complete the equipment installations at the convenience of the customer.

The SBES Program recognizes that customers with lower savings potential may benefit from a streamlined, one-stop, turnkey delivery model and relatively high incentives to invest in energy efficiency. Additionally, small businesses may lack internal staffing dedicated to energy management and can benefit from energy audits and installations performed by an outside vendor.

The program offers incentives in the form of a discount for the installation of measures, including high-efficiency lighting, and refrigeration and HVAC equipment. These incentives increase adoption of efficient technologies beyond what would occur naturally in the market. In PY2016, the SBES Program achieved the majority of program savings from lighting measures, which tend to be the most cost-effective and easiest to market to potential participants. The SBES program also achieved program savings from refrigeration measures, namely LED case lighting and upgraded motors, and Wifi thermostats.

The program offers a performance-based incentive up to 80 percent of the total project cost, inclusive of both materials and installation. Multiple factors drive the total project cost, including selection of equipment and unique installation requirements.

2.2 Reported Program Participation and Savings

Duke Energy and the implementation contractor maintain a tracking database that identifies key characteristics of each project, including participant data, installed measures, and estimated energy and peak demand reductions based on assumed ("deemed") savings values. In addition, this database contains measure level details that are useful for EM&V activities.

In addition to the aforementioned measure level tracking database, Duke Energy maintains demand savings ratios (kW/kWh) by measure that are used to calculate the final claimed summer and winter demand savings estimates. These ratios are based on the energy savings (kWh) values reported in the implementation contractor tracking database and include average adjustments for coincidence factors and other parameters affecting demand savings. For this report, Navigant based the analysis of verified demand savings on the implementation contractor tracking database, while calculating final demand realization rates by comparing verified demand savings to reported demand savings calculated from these ratios. This was done in an effort to both provide accurate demand realization rates and attempt to reduce sampling uncertainty.

Table 2-1 provides a summary of the gross reported energy and demand savings and participation for PY2016.

Table 2-1. Reported Participation and Gross Savings Summary

Reported Metrics	PY2016
Participants	912
Measures Installed	56,942
Gross Annual Energy Savings (MWh)	26,021
Average Quantity of Measures per Project	62
Average Gross Savings Per Project (MWh)	28.5

Source: SBES Tracking Database

Duke Energy uses assumptions and algorithms primarily from the Pennsylvania Technical Reference Manual[2] (PA TRM) as the basis for reported (deemed) energy and demand savings for all lighting and refrigeration measures. In addition, the Illinois Technical Reference Manual[3] (IL TRM) is used for Wifi thermostat measures because these measures are not detailed in the PA TRM. Both of these TRMs are robust, well-established, and follow industry best practices for the measures found in the SBES program. The team used the PA TRM rather than the draft Ohio TRM because it receives annual updates that reflect ongoing research into energy savings parameters, such as annual hours of use, coincidence factors, HVAC interactive effects, and appropriate baseline wattages, whereas the draft Ohio TRM has not been updated since 2010.The evaluation team believes the PA TRM is an appropriate basis for estimating savings in the DEO jurisdiction based on Navigant's assessment of the underlying energy savings assumptions and similarities in climate, building stock characteristics.

2.2.1 Program Summary by Measure

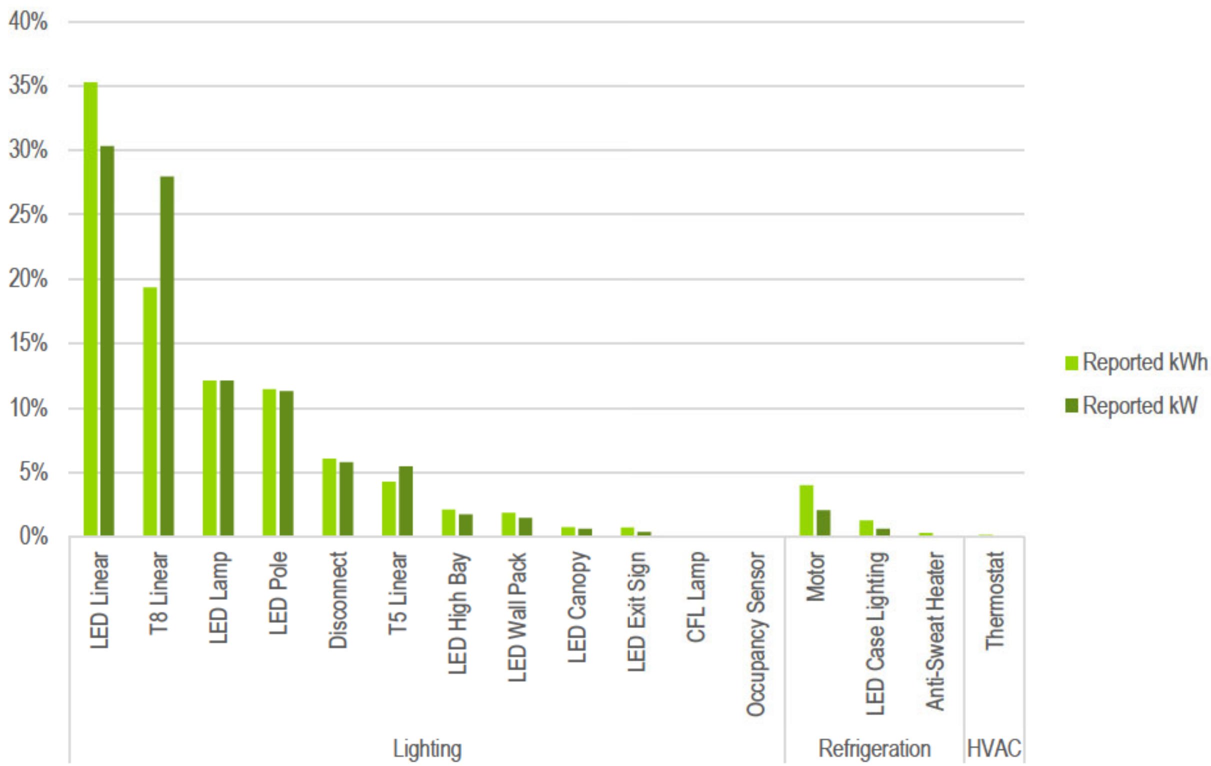
Efficient LED linear lighting retrofits were the highest contributor to program energy and demand savings in PY2016, followed by T8 linear fluorescent lighting measures and a variety of other LED lighting measures. In addition, refrigeration measures (including EC motors, LED case lighting, and anti-sweat heaters), and smart: programmable thermostats also contributed to savings. Overall, lighting measures contribute 94 percent of reported program energy savings, refrigeration measures contribute 6 percent, while HVAC measures contribute less than one percent. Figure 2-1 shows the reported gross savings by measure category as reported by Duke Energy.

---

[2] TECHNICAL REFERENCE MANUAL. State of Pennsylvania Act 129: Energy Efficiency and Conservation Program & Act 213: Alternative Energy Portfolio Standards. June 2015.

[3] Illinois Statewide Technical Reference Manual for Energy Efficiency Version 5.0 Volume 2: Commercial and Industrial Measures. http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_5/Final/IL-TRM_Effective_060116_v5.0_Vol_2_C_and_I_021116_Final.pdf

Figure 2-1. Reported Gross Energy Savings by Measure Category

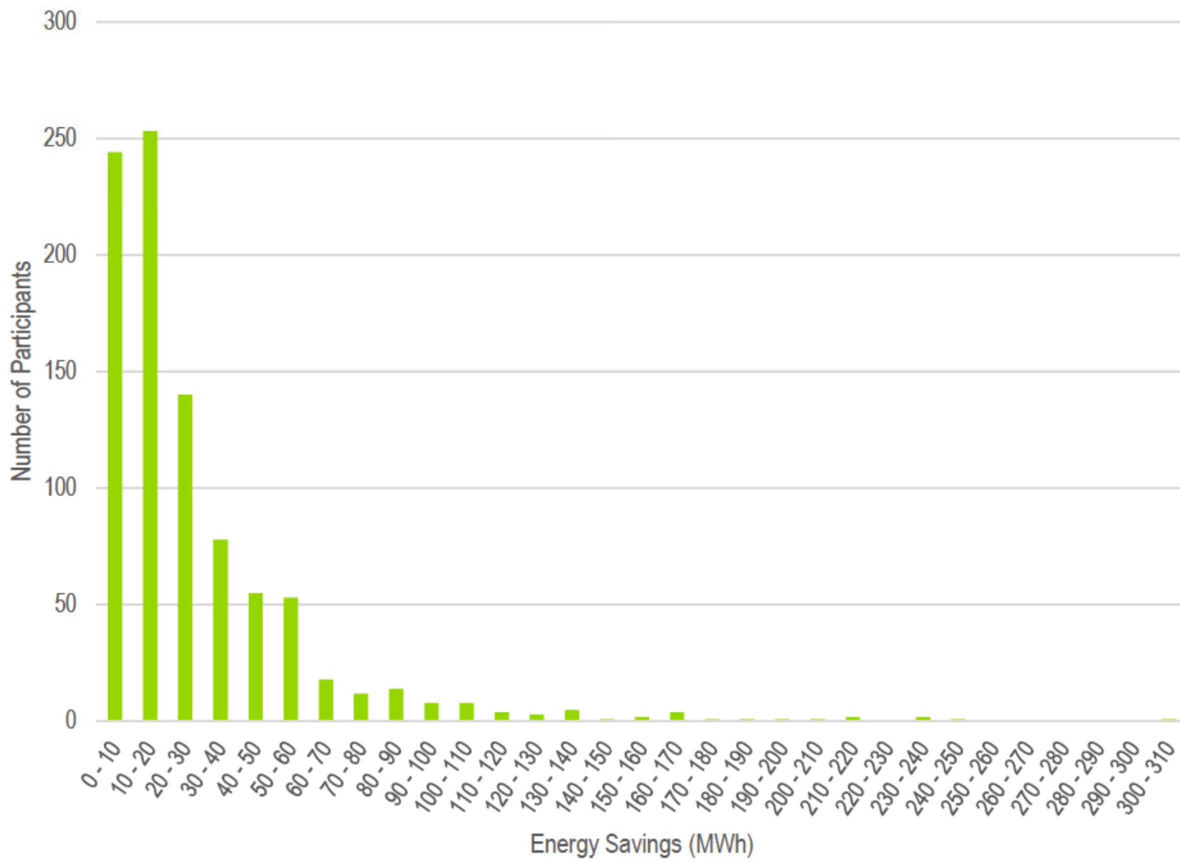


Source: SBES Tracking Database

2.2.2 Savings by Project

Because the SBES program is limited to small business customers only, the variations in project energy and peak demand savings and the quantity of measures installed exhibit a more narrow spread than typical large business program offerings. Nevertheless, there is still a mix of various project sizes, as shown in Figure 2-2, with very few project sites reporting savings over 200 MWh per year. The largest sites reported savings of 307 MWh per year, and were eligible to participate in the SBES program because they consisted of several smaller projects that qualified individually. The largest projects typically consisted of several independent customer accounts, meters, or buildings completed as a single energy efficiency project.

Figure 2-2. Histogram of Reported Energy Savings per Project

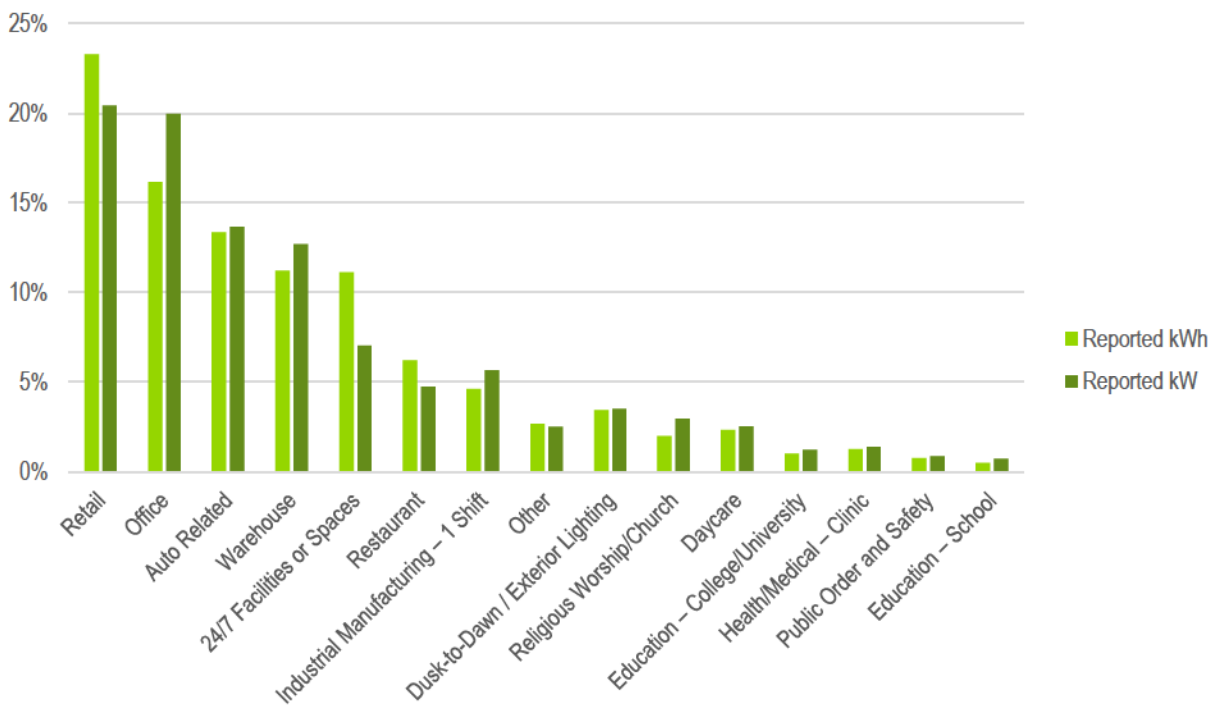


Source: SBES Tracking Database

2.2.3 Savings by Facility Type

Navigant reviewed the business type data in the tracking database to understand the participant demographics. The business type data tracks established SIC codes, which results in many unique detailed building types. In order to apply assumptions from the PA TRM, such as HVAC interactive effects and coincidence factors, Navigant mapped the SIC codes to the facility types detailed in the PA TRM. These facility types are shown below in Figure 2-3. The distribution of facility types is representative of a large variety of small business customers, indicating that the program is successfully recruiting participants across several sectors. The retail, office and auto related facilities represent the largest contributors or energy and demand savings.

Figure 2-3. Reported Energy Savings by Facility Type



Source: SBES Tracking Database

3. KEY RESEARCH OBJECTIVES

As outlined in the Statement of Work (SOW), the primary purpose of the EM&V activities is to estimate verified gross and net annual energy and peak demand impacts associated with program activity for PY2016. Additional research objectives include the following:

3.1 Impact Evaluation

The impact evaluation focuses on quantifying the magnitude of verified energy savings and peak demand reductions. Objectives include:

- Verify deemed savings estimates through review of measure assumptions and calculations.
- Perform on-site verification of measure installations, and collect data for use in an engineering analysis.
- Estimate the amount of observed energy and peak demand savings (both summer and winter) by measure via engineering analysis.

3.2 Net-to-Gross Analysis

The net-to-gross analysis focuses on estimating the share of energy savings and peak demand reductions that can be directly attributed to the SBES program itself. Objectives include:

- Assess the Net-to-Gross ratio by addressing spillover and free-ridership in participant surveys.

3.3 Process Evaluation

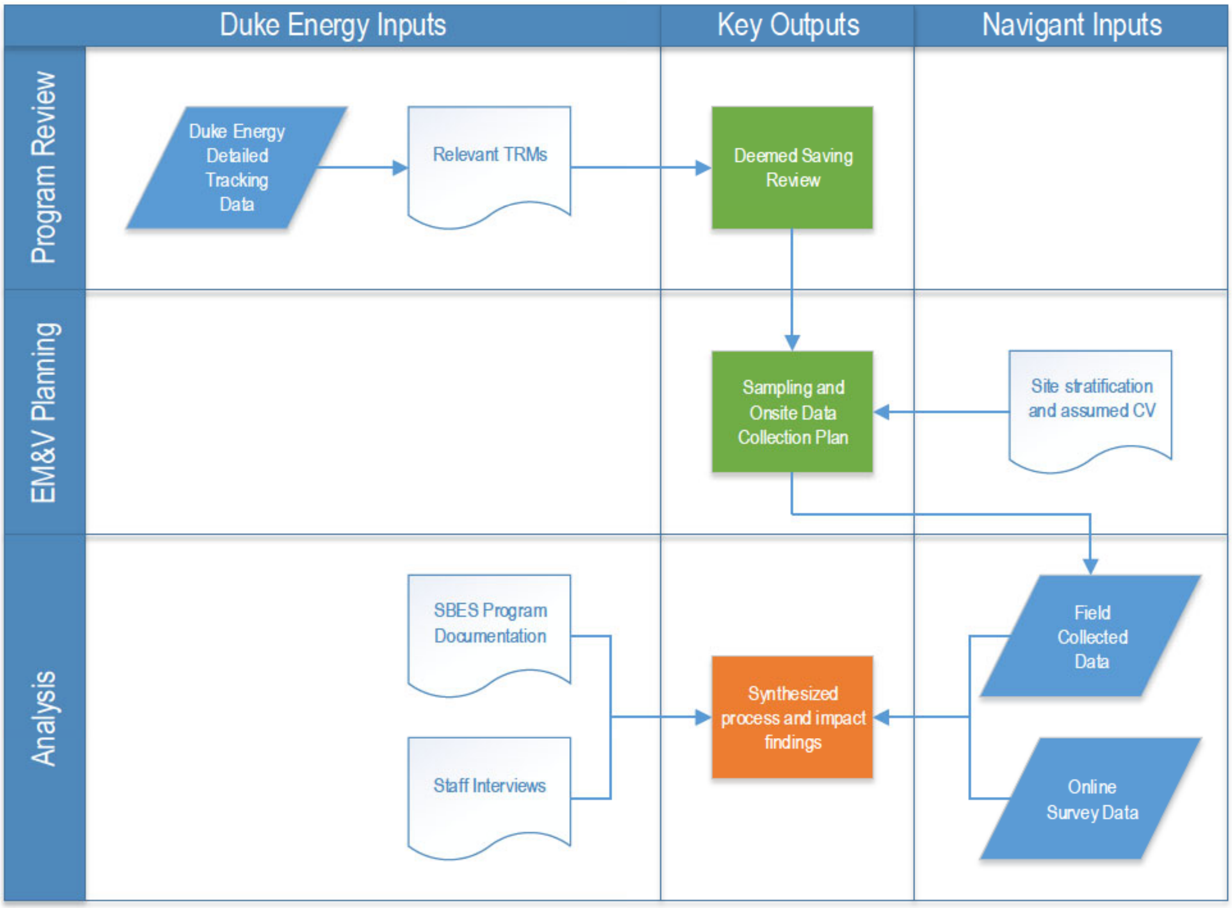
The process evaluation focuses on the program implementation and the customer experience. Objectives include:

- Perform interviews with program management and Implementation Contractor.
- Perform participant surveys with customers.
- Identify barriers to participation in the program, and how the program can address these barriers.
- Identify program strengths and the potential for introducing additional measures.

3.4 Evaluation Overview

Figure 3-1 outlines the high-level approach used for evaluating the SBES Program, which is designed to address the research objectives outlined above. The impact, net-to-gross, and process sections provide further detail for each of the individual EM&V activities.

Figure 3-1. Evaluation Process Flow Diagram



Source: Navigant analysis

4. IMPACT EVALUATION

The purpose of this impact evaluation is to quantify the verified gross and net energy and demand savings estimates for the SBES Program. Table 4-1 shows high-level program results of Navigant's impact analysis. Ultimately, Duke Energy can use these results as an input to system planning. As noted above, although the program-level gross realization rate is 104 percent, Navigant found variability in site-level results.

Table 4-1. PY2016 SBES Summary of Program Impacts

	Energy Savings (MWh)	Summer Peak Demand Reductions (MW)	Winter Peak Demand Reductions (MW)
Reported Gross Savings	26,021	4.5	4.7
Realization Rate	1.04	0.74	0.83
Verified Gross Savings	27,145	3.3	3.9
NTGR	1.02	1.02	1.02
Verified Net Savings	27,688	3.4	4.0

Source: Navigant analysis, totals subject to rounding.

4.1 Impact Methodology

The methodology for assessing the gross energy savings and peak demand reductions follows IPMVP Option A (Retrofit Isolation: Key Parameter Measurement)[4]. This involved an engineering-based approach for estimating savings, supplemented by key parameter measurements. This also included using time-of-use lighting loggers to directly measure operating hours and coincidence factors for program-incented lighting measures. Note that for the refrigeration measures, verification activities were performed on-site to assess installation and operation.

The evaluation team employed the following steps to conduct the impact analysis:

1. **Review Field Data and Design Sample** – First, the team analyzed the tracking data to determine the most appropriate sampling methodology. The team created four strata based on reported energy savings (small, medium, and large lighting, and refrigeration) to ensure that a variety of different businesses and measures were captured in the site visits. A subset of each strata was selected for more detailed data logger deployment (20 of 60 total sites visits were logged). The sample was designed to utilize double-ratio techniques to meet a precision target of 90/10 at the program level while attempting to minimize sample sizes.
2. **Pull Sample** – Next, the team pulled a sample from the four strata and scheduled site visits, including several backup sites in the event that a visitation could not be arranged.
3. **Perform Participant Site Visits** – The evaluation team used an electronic data collection system in the field to ensure consistency and decrease data processing time. For all site visits, Navigant

[4] International Performance Measurement & Verification Protocol Concepts and Options for Determining Energy and Water Savings Volume I. http://www.nrel.gov/docs/fy02osti/31505.pdf

field technicians uploaded all collected site data to the online system as soon as they were completed. Navigant performed quality control verifications for all field data collection forms and online data entry. This included a thorough inspection of each site's building characteristic inputs, operating schedules, measure-level in-service rates, and descriptions. The following steps were taken at each participant site:

a. The team first determined the in-service rate (ISR) of the equipment for each measure found. The field technicians accomplished this by visually verifying and counting all equipment included in the project documentation.

b. The team then calculated the difference in watts between the base-case fixtures and the energy-efficient fixtures for each fixture type installed on-site. The team verified efficient fixture wattage through visual inspection, while deriving base-case fixture wattage from customer-provided data found in the documentation review, if available, or from information found by field technicians during the site visits. There is typically little to no information about the specifications of base-case equipment that has been removed from a site. If both customer data and field data were insufficient, the team utilized the tracking data and assessed the reasonableness of their assumptions.

c. Operating hours were determined from a detailed customer interview for each unique lighting schedule in the building, and adjusted for holiday building closures. For the subset of sites that received logging, the EM&V team left time-of-use loggers in place for roughly four weeks and then returned to retrieve the logging equipment.

d. Coincidence factors and HVAC interactive factors were taken from the PA TRM. For logged sites, the team calculated both summer and winter coincidence factors from the logger data.

4. **Calculate Project-Level Savings** – The team calculated project-level energy and demand savings for each site in the sample based on operational characteristics found on site and engineering-based parameter estimates. The project-level savings represent the total of all of the individual measure-level savings at each site.

Calculate Program-Level Savings – The team calculated verification rates for all sites and applied a ratio, representing the adjustment based on the logger data, resulting in final verified savings for each sampled site. Next, the team calculated stratum-level realization rates, consisting of the sum of the verified savings divided by the deemed reported savings. Last, the team applied the stratum-level realization rates to the deemed reported savings for each respective strata, and arrived at final program-level realization rates. Note that for demand savings, final program-level realization rates were calculated by comparing verified demand savings to reported demand savings using the demand ratios outlined in Section 1.Key evaluation parameters came primarily from on-site data; however, where this data was lacking or was deemed unusable, customer application data was used in its place. As there are many parameter inputs to the savings calculation for each site, this approach ensures that the best available data is used for each site's savings estimate. Table 4-2 below details the final site visit disposition.

Table 4-2. Onsite Sample Summary

Strata	Population Size	Onsite Verification Sample Size	Onsite Metering Sample Size (Subset of Verification Sample)
Lighting Large	60	13	5
Lighting Medium	174	11	4
Lighting Small	509	19	7

Refrigeration	169	17	4
Total	**912**	**60**	**20**

Source: Navigant analysis

4.2 Algorithms and Parameters

Navigant used data collected from the field and the engineering review to calculate site-level energy and demand savings, using the following algorithms. Table 4-3, Table 4-4, and Table 4-5 show the algorithms that the evaluation team used to calculate verified savings for lighting measures and refrigeration measures, respectively. The impact evaluation effort focused on verifying the inputs for these algorithms. Detailed descriptions of each parameter and any related assumptions are outlined in the following section, along with relevant findings.

Table 4-3. Verified Savings Algorithms for Lighting Measures

Measure	Energy Savings Algorithm	Coincident Peak Demand Savings Algorithm
Lighting Measures	kWh = Qty * HOU * Watts_Reduced * IF_Energy	kW = Qty * CF * Watts_Reduced * IF_Demand
Qty = quantity of equipment verified on-site		
HOU = annual operating hours		
Watts_Reduced = difference between efficient and baseline watts		
CF = coincidence factor		
IF_Energy = heating, ventilating, and air conditioning (HVAC) interaction factor for energy savings calculations		
IF_Demand = HVAC interaction factor for demand savings calculations		

Source: Navigant analysis and PA TRM

Table 4-4. Verified Savings Algorithms for Refrigeration Measures

Measure	Energy Savings Algorithm	Coincident Peak Demand Savings Algorithm
Refrigeration ECM Motors	kWh = kW * HOU	kW = Qty * Watts_Reduced * LF * DC * (1 / DG / COP)
Anti-Sweat Heater Controls	kWh = kW / DoorFt * 8760 * HA * (1 + Rh / COP)	kW = kW / DoorFt * HP * (1 + Rh / COP) * DF
Qty = quantity of equipment verified on-site		
Watts_Reduced = difference between efficient and baseline watts		
LF = Load factor (0.9)		
DC = Duty cycle (1.00 for coolers, 0.944 for freezers)		
DG = Degradation factor of compressor COP (0.98)		
COP = Coefficient of performance (2.5 for coolers, 1.3 for freezers)		
HOU = Hours of use (8760, or less with defined facility closures)		
HA = Percent of time case ASH with controls will be off annually (0.85 for coolers, 0.75 for freezers)		
HP = Percent of time case ASH with controls will be off during the peak period (0.2 for coolers, 0.1 for freezers)		
Rh = Residual heat fraction (0.65)		
DF = Demand diversity factor (1.0)		

Source: Navigant analysis and PA TRM

Table 4-5. Verified Savings Algorithms for HVAC Measures

Measure	Energy Savings Algorithm	Coincident Peak Demand Savings Algorithm
Programmable Wifi Thermostats	kWh_Verified = [Baseline Energy Use (kWh/Ton) – Proposed Energy Use (kWh/Ton)] * Cooling Capacity (Tons)	NA
Baseline Energy Use (kWh/Ton) = estimate of baseline energy use from Il TRM		
Proposed Energy Use (kWh/Ton) = estimate of proposed energy use from Il TRM		
Cooling Capacity (Tons) = Capacity of cooling system in tons		

Source: Navigant analysis and IL TRM

4.3 Key Impact Findings

The energy realization rates by strata are shown in Table 4-6. This shows the verification realization rate, the metering realization rate, and the final realization rate by strata. The total realization rate for each strata is calculated by multiplying the verification realization rate to the metering realization rate adjustment. This method in effect extrapolates the project-specific results to the stratum-level, which implicitly assumes that these findings in aggregate are representative of other sites within their stratum. In addition, the weighted final realization rate for the program is shown, which represents the total program savings as a weighted result of each stratum. Additional information specific to the metering realization rate adjustments is provided in Section 4.4.2 and 9.APPENDIX A

Table 4-6. Energy Impacts by Strata

Strata	Verification Realization Rate (kWh)	Metering Realization Rate Adjustment (kWh)	Total Realization Rate (kWh)
Lighting Large	1.00	0.93	0.93
Lighting Medium	1.00	1.07	1.07
Lighting Small	1.07	1.13	1.21
Refrigeration	1.02	0.97	0.99
Total	**1.01**	**0.97**	**1.04**

Source: Navigant analysis, totals subject to rounding.

The summer and winter peak demand reductions are shown in Table 4-7 and Table 4-8. There is a reduction in the realization rates for both summer and winter demand savings due to application of coincidence factors based on both deemed values from the PA TRM and logger data. Navigant notes that these realization rates are calculated by comparing verified savings with the Duke Energy reported savings calculated from demand ratios rather than reported in the detailed measure database.

Table 4-7. Summer Peak Demand Impacts by Strata

Strata	Verification Realization Rate (Summer kW)	Metering Realization Rate Adjustment (Summer kW)	Total Realization Rate (Summer kW)
Lighting Large	0.68	0.92	0.62
Lighting Medium	0.59	0.98	0.57
Lighting Small	1.02	1.01	1.03
Refrigeration	0.80	0.97	0.77
Total	**0.78**	**0.96**	**0.74**

Source: Navigant analysis, totals subject to rounding

Table 4-8. Winter Peak Demand Impacts by Strata

Strata	Verification Realization Rate (Winter kW)	Metering Realization Rate Adjustment (Winter kW)	Total Realization Rate (Winter kW)
Lighting Large	1.07	0.96	1.03
Lighting Medium	0.79	0.77	0.61
Lighting Small	0.85	1.00	0.84
Refrigeration	0.98	0.95	0.94
Total	**0.89**	**0.94**	**0.83**

Source: Navigant analysis, totals subject to rounding

Overall, the realization rates are 1.04 for energy savings, and 0.74 and 0.83 for summer and winter peak demand reductions, respectively. This indicates that the program is very closely reporting energy impacts at the aggregate program level, despite varying realization rates for each individual stratum. The demand reductions reported by the program are consistently higher than those found by the evaluation team as well.

4.4 Detailed Impact Findings

This section examines findings from the evaluation of lighting measures in order to identify the main drivers of the verified savings values. The evaluation team uses the Field Verification Rate (FVR) to describe the overall verified savings relative to the reported savings for each measure. FVRs reflect differences between the quantity of equipment installed on-site and the quantity reported in the tracking database, as well as differences between operating characteristics verified in the field and assumed operating characteristics in the program deemed savings estimates. The team calculates the field verification rate as the verified savings divided by the reported savings by measure, which is driven by a combination of the in-service rate, the hours of use adjustment rate, the lighting power adjustment rate, the HVAC interactive effect adjustment rate, and the coincidence factor, described as follows:

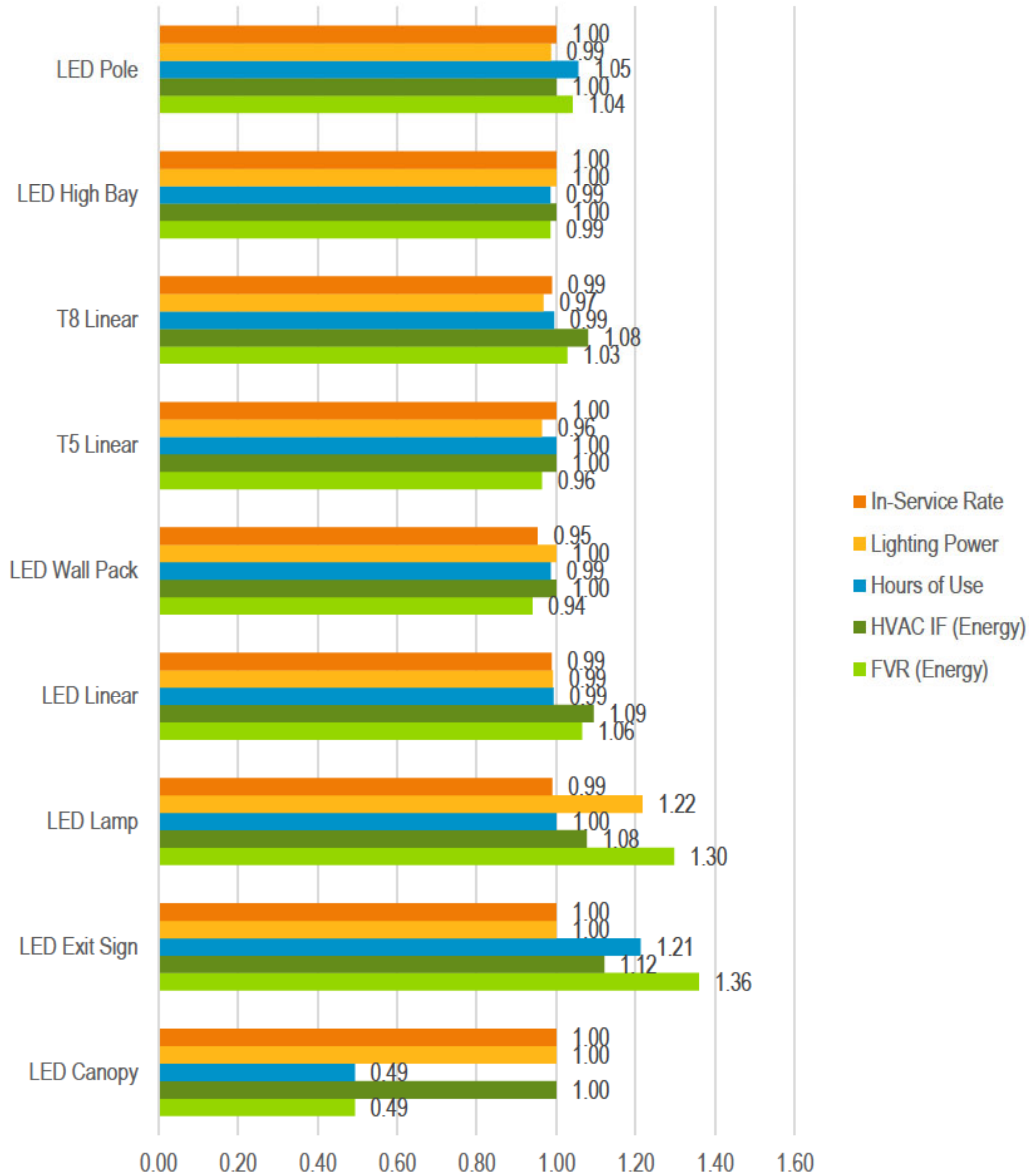
1. **In-Service Rate**[5] **(ISR)** is the ratio of the verified (i.e., installed) quantity to the reported quantity.
2. **Hours of Use (HOU) Adjustment Rate** reflects discrepancies between reported and verified operating hours.
3. **Lighting Power Adjustment Rate** is a ratio of the verified wattage difference between the efficient and baseline equipment to the reported wattage difference between the efficient and baseline equipment.
4. **HVAC Interactive Effect (IE) Adjustment Rate** is a multiplier that reflects HVAC interactive effects due to space heating and cooling loads caused by a reduction in heat output from efficient lighting. Note that the IC did not deem HVAC IE for any measures so this adjustment is equal to the average HVAC IE itself. There are separate adjustments for energy savings and peak demand reduction.
5. **Coincidence Factor** represents the portion of installed lighting that is on during the peak utility hours. This affects only summer and winter peak demand reductions, not energy savings.

Figure 4-1 below shows the relative effect of each of the aforementioned adjustment rates on the measure-level FVR for energy savings, which the following subsections describe in further detail. Note that FVR cannot be used to derive program level realization rates. This is because the contributions of each parameter update are described relative to their reported value (from the detailed measure tracking dataset), while the program analysis was structured to stratify savings by participant energy savings per site rather than by individual measures.

Overall, the FVR values indicate that, across the different lighting measure types, in-service rates, lighting power, and hours of use adjustments tend to result in minor decreases to the verified energy savings, while HVAC interactive effects result in an increase in savings. These effects roughly cancel each other out in aggregate.

[5] In-Service Rate is an industry-standard term that describes verified quantities of installed equipment relative to reported quantities.

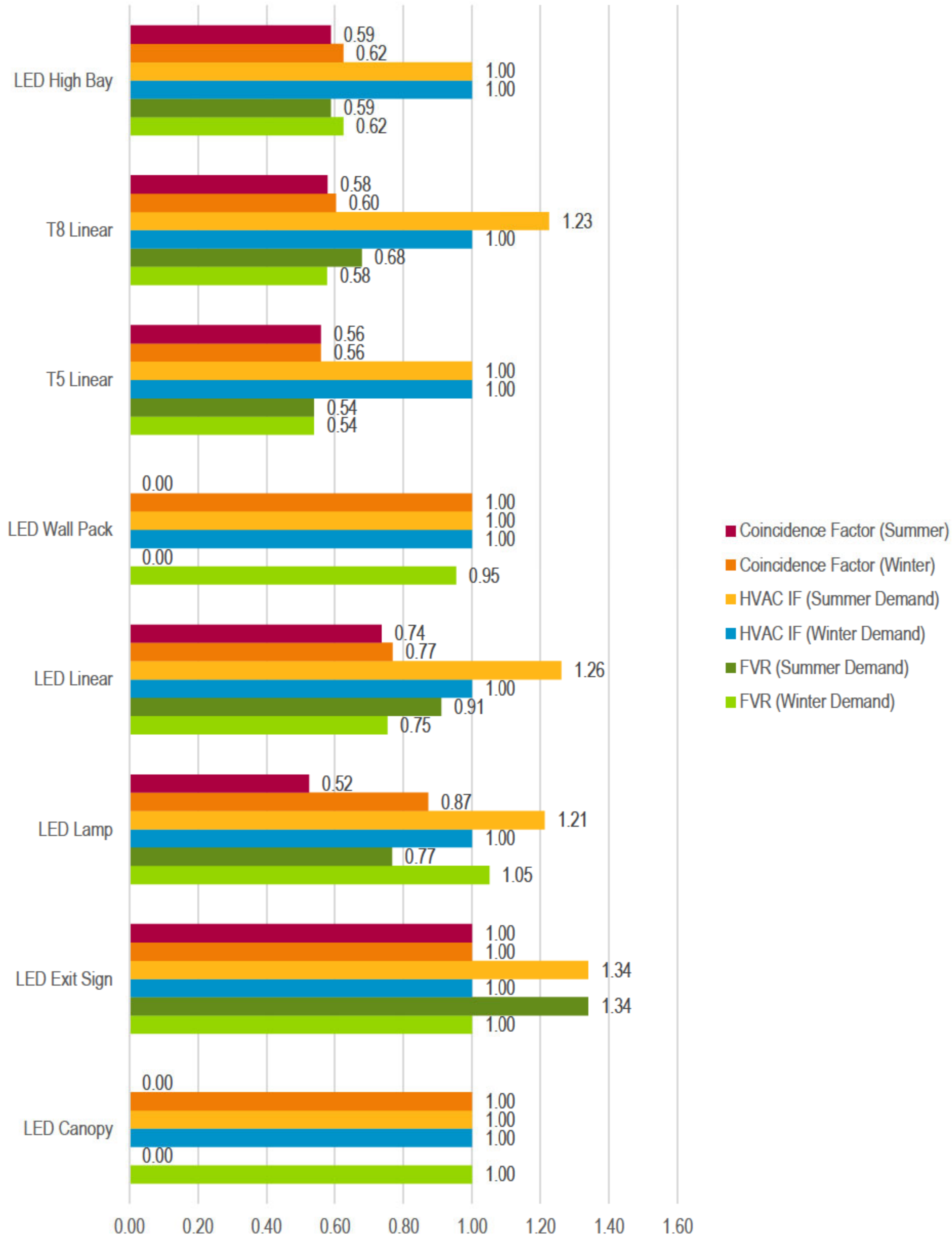
Figure 4-1. Gross Energy Savings Field Verification Rates



Source: Navigant analysis

Figure 4-2 below shows the relative effect of each of the aforementioned adjustment rates on the measure-level FVR for summer peak demand reductions, which the following subsections describe in further detail. Overall, application of the coincidence factor decreases both summer and winter peak demand reductions, while HVAC interactive effects increase summer peak demand reductions.

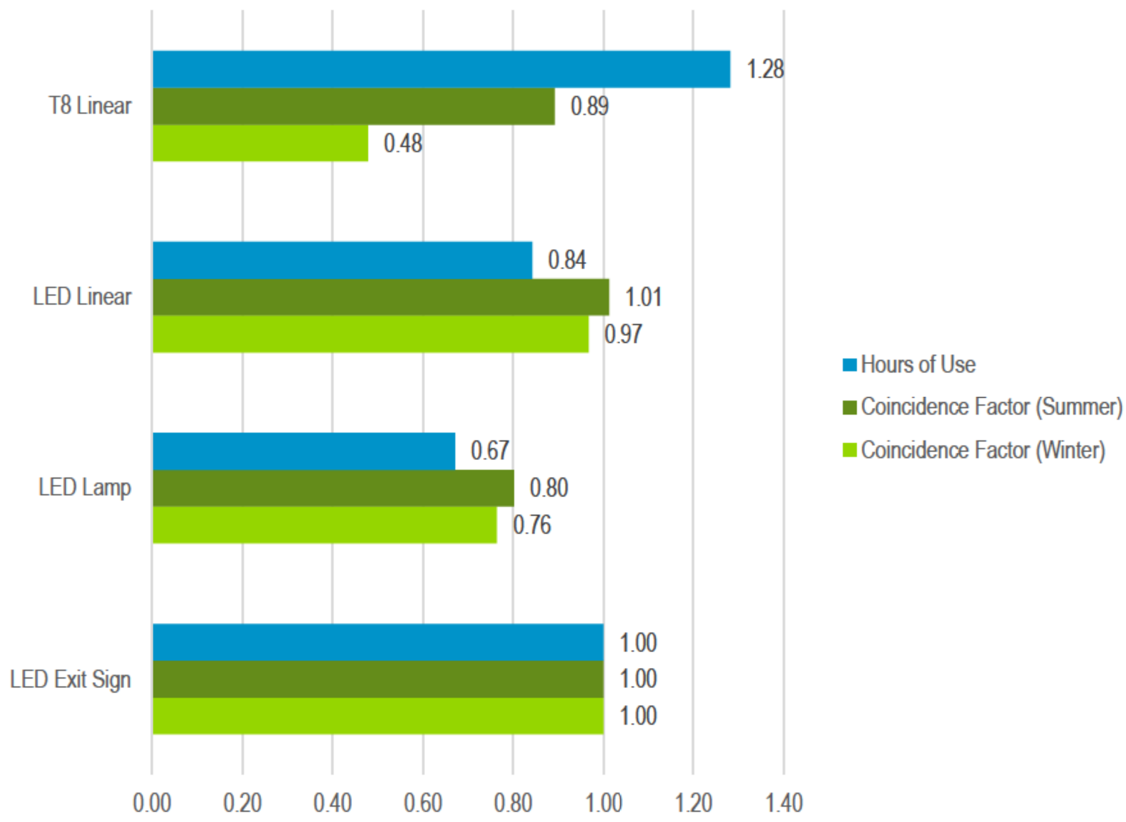
Figure 4-2. Gross Peak Demand Reductions Field Verification Rates



Source: Navigant analysis

The final adjustment to develop site-specific verified gross savings is the ratio of metered HOU and coincidence factors compared to estimated (or deemed) HOU and CF used for verification. The results of these adjustments, analogous to FVR, are shown in Figure 4-3 below. The metered data results in a downward adjustment of HOU for LED linear retrofits and LED lamps, but an upward adjustment of HOU for T8 linear retrofits. Overall, there is a decrease in both summer and winter coincidence factors for most lighting measures. Note that these adjustments are relative to the evaluation team's verified energy and demand savings estimates rather than the tracking data.

Figure 4-3. HOU and CF Adjustments from Metered Data



Source: Navigant analysis

The remainder of this section discusses in more detail the parameters that are part of the energy and peak demand savings algorithms: ISR, HOU, lighting power, HVAC interactive effects and coincidence factors.

4.4.1 In-Service Rates

The Navigant evaluation team visually counted fixtures on-site to quantify the quantity and type of lighting equipment installed. The team calculated the ISR as the ratio between the findings from the on-site verification compared to the quantity reported in the program-tracking databases. On-site verifications determined the total count of installed equipment.

As shown in Figure 4-1 above, the ISR for each measure varies from 0.95 for LED wall packs and 1.00 for the majority of the remaining lighting measures. Overall the ISR values are very high and indicate that the program is accurately tracking installed measures.

4.4.2 Hours-of-Use Adjustments

The EM&V team performed customer interviews and installed data loggers to make adjustments to hours of use to estimate final verified impacts. For all sample sites, the EM&V team performed interviews with customers using a similar approach as the IC. This relies on the customer to self-report hours on a daily or weekly basis, and rolls them up to an basis which is also corrected for holidays, seasonal variations in use, and any other change in operating characteristics. The purpose of validating the self-reported hours of use is to confirm whether the estimates provided by the customer during implementation is what actually makes it into the tracking database. The EM&V also installed data loggers at a nested sample of sites to measure the accuracy of the self-reported hours. For logged sites, the team extrapolated the time of use logger data to develop annual hours of operation.

During the on-site participant interviews, the EM&V team found that the hours of use that site technicians reported was close to the HOU reported in the tracking database, with adjustment values ranging from 0.49 for LED canopy fixtures and 1.21 for LED exit signs. Overall, these findings suggest that the tracking data is accurately reflecting what customers estimate their operating hours to be. However, it is well-known that estimating operation hours for lighting is difficult, and many evaluations have found that customers tend to overestimate operation hours for lighting. Therefore, the EM&V team used results from the data loggers to adjust impacts.

Additional adjustments based on logger data range from 0.67 for LED lamps and 1.28 for T8 linear retrofits, as shown in Figure 4-3. This demonstrates that although the IC is reasonably characterizing hours of use based on customer interviews, but the data loggers show that customers tended to overestimate hours of use for LED linear lighting measures and underestimate HOU for T8 linear lighting measures. Additional care should be used to ensure that lights that are on 24/7, such as LED exit signs, are credited with the correct HOU.

4.4.3 Lighting Power

The evaluation team based the lighting power parameter on the best estimates available for actual power draw of the baseline and efficient equipment. The baseline equipment is assumed to be as-found lighting installed and in use at the time of the audit; however, because the baseline equipment was no longer present at the participant sites, the team could not verify the baseline power draw and defaulted to the values provided by the IC.

The evaluation team verified the efficient equipment wattage from manufacturer specification sheets to provide a more accurate lighting power figure than the deemed values that the IC used. Overall lighting power level differences were minor across the measure categories, between 0.96 for T5 linear retrofits and 1.22 for LED lamps.

The evaluation team would like to note that it was often difficult or impossible to record efficient wattages due to the prevalence of exterior, canopy, and high bay LED fixtures installed in PY2016. In addition, the newer linear LED systems can be configured in a variety of ways, including with or without an electronic ballast. The manufacturer specifications for these systems typically do not account for every installation scenario with different ballast brands, models, and configurations possible. The team did not perform power measurements as part of this evaluation, but encourages the IC team to ensure that the power consumption of these systems is accurately characterized as their contribution to total program savings grows.

4.4.4 HVAC Interactive Effects

The evaluation team applied HVAC interactive effects for both energy, summer and winter peak demand. The deemed values are based on the facility heating and cooling system types as verified in the field for the sample sites. Note that the IC did not apply HVAC interactive effects for any of the lighting measures claimed in PY2016. This adjustment is between 1.00 and 1.12 for energy and 1.00 and 1.34 for summer peak demand. Deemed values are described in Section 9 for energy and summer peak demand, and are based on the PA TRM; winter peak demand interactive effects were assumed to be 1.0 for all measures.

4.4.5 Coincidence Factors

Similar to the HVAC interactive effects, the team applied coincidence factors based on the deemed values found in the PA TRM. This factor takes into account that not all lights are on for the duration of the peak demand period. Coincidence factors range from 0.0 and 1.0, based on building type, and are detailed in Section 9. The IC did not apply coincidence factors for lighting measures, and did not separately report winter demand savings. The metered data further validates the deemed coincidence factors. Note that although the detailed IC database does not include a coincidence factor, the demand ratios provided by Duke Energy and used as the final reported deemed savings implicitly include these assumptions.

LED exit signs that are on all day receive a CF on 1.0, while exterior lights receive a CF of 0.0 (summer) and 1.0 (winter). For logged sites, the team extrapolated the time of use logger data to develop coincidence factors. As shown in Figure 4-3, the CF adjustments based on metered data range from 0.89 to 1.01 for summer, and 0.48 to 1.00 for winter. The overall effect on demand savings from metering was an decrease in both summer and winter savings compared to the coincidence factors applied in the verification phase based on the PA TRM. The overall effect of applying coincidence factors is also a decrease from reported savings, and is the primary driver of the demand realization rates.

4.4.6 Refrigeration Measure Parameters

For refrigeration measures, the engineering analysis follows a deemed savings methodology based on the PA TRM. The PA TRM assumptions and parameters used to estimate reported energy savings and peak demand reductions were deemed appropriate by the evaluation team. The team verified that the measures were installed and operational during on-site visits to projects that installed efficient refrigeration equipment.

The evaluation team focused their deemed savings review on LED case lighting, EC motor upgrades, and anti-sweat heater controls. Onsite, the team verified LED case lighting and EC motor upgrades, but no anti-sweat heater controls because they did not fall into the onsite sample. For LED case lighting, the team applied HVAC interactive effects and coincidence factors from the PA TRM, which differ from the general lighting parameters. The values used are summarized below in Table 4-9, and result in an increase in LED case lighting savings.

Table 4-9. LED Case Lighting Savings Parameters

LED Case Lighting Parameter	Value
HVAC Interactive Effects (Both Energy and Summer/Winter)	1.41 (Cooler) / 1.52 (Freezer)
Coincidence Factor	0.92

Source: PA TRM

4.4.7 Thermostat Measure Parameters

There were eight total programmable Wifi thermostat measures claimed during the PY2016 evaluation period. For these thermostat measures, the engineering analysis follows a deemed savings methodology based on the IL TRM. The reported energy savings accurately followed the methodology outlined in the IL TRM, although Navigant believes that the programmable thermostat measures likely overestimate energy savings based on the following assumptions:

1. The claimed energy savings range from 3% to 53% (23% average) of the total customer energy bill for a 12-month cycle. Space cooling, ventilation and heating typically make up roughly 20-30% of total electricity use[6], while Wifi thermostats are claimed to save up to 10% of the HVAC energy usage[7]. Therefore, Navigant would expect the total energy bill savings of approximately 2-3% as a reasonable estimate for energy savings. Navigant acknowledges that in total energy usage reported in the tracking database may not accurately reflect total customer usage, however, due to additional meters on site and changes in operation.
2. The energy savings algorithm derives the majority of savings due to running the HVAC system in automatic fan mode rather than continuous fan mode during the unoccupied portions of the day. It is unclear from the tracking data and audit whether this represents the true operational characteristics. A 2012 ACEEE paper[8] focused on small business Wifi thermostats found that

[6] EIA estimates 25.9% commercial and 26.6% residential use for space heating, cooling and ventilation (US average) https://www.eia.gov/energyexplained/index.cfm?page=electricity_use

[7] Ten percent savings is a rough estimate from the DOE. Navigant recognizes there is significant potential for variation site to site, however. https://energy.gov/energysaver/thermostats

[8] http://aceee.org/files/proceedings/2012/data/papers/0193-000237.pdf

only roughly one-quarter of energy savings from these thermostats were realized, and indicated that operational characteristics are both a key input to energy savings and difficult to accurately assess due to customer behavior.

3. The Belleville, IL (Zone 4) climate is most closely aligned to Cincinnati, OH based on cooling degree days, and is an appropriate approximation.

The system size (tons cooling) is not detailed in the tracking data, but appears reasonable from back-calculations and was used in a separate thermostat workbook provided to the evaluation team.

5. NET-TO-GROSS ANALYSIS

The impact analysis described in the preceding sections addresses *gross program savings*, based on program records, modified by an engineering review, field verification, and metering of measure installations. *Net savings* incorporate the influence of free ridership (savings that would have occurred even in the absence of the program) and spillover (additional savings influenced by the program but not captured in program records) and are commonly expressed as a NTG ratio applied to the verified gross savings values.

Table 5-1 shows the results of Navigant's NTG analysis. Navigant anticipated low free ridership and spillover based on previous findings from evaluations of SBES in other Duke Energy territories.

Table 5-1. PY2016 Net-to-Gross Results

	Lighting	Refrigeration	Lighting & Refrigeration
Estimated Free Ridership	0.04	0.06	0.04
Estimated Spillover	0.04	0.14	0.06
Estimated NTG	**1.00**	**1.08**	**1.02**

Source: Navigant analysis, totals subject to rounding.

This report provides definitions, methods, and further detail on the analysis and findings of the net savings assessment. The discussion is divided into the following three sections:

- Defining free ridership, spillover, and net-to-gross (NTG) ratio
- Methods for estimating free ridership and spillover
- Results for free ridership, spillover, and NTG ratio

5.1 Defining Free Ridership, Spillover, and Net-to-Gross Ratio

The methodology for assessing the energy savings attributable to a program is based on a NTG ratio. The NTG ratio has two main components: free ridership and spillover.

Free ridership is the share of the gross savings that is due to actions participants would have taken even in the absence of the program (i.e., actions that the program did not induce). This is meant to account for naturally occurring adoption of energy efficient technology. The SBES Program covers a range of energy efficient lighting and refrigeration measures and is designed to move the overall market for energy efficiency forward. However, it is likely that some participants would have wanted to install, for various reasons, some high efficiency equipment (possibly a subset of those installed under the SBES Program), even if they had not participated in the program or been influenced by the program in any way.

Spillover captures program savings that go beyond the measures installed through the program. Spillover adds to a program's measured savings by incorporating indirect (i.e., non-incentivized) savings and effects that the program has had on the market above and beyond the directly incentivized or directly induced program measures.

Total spillover is a combination of non-reported actions to be taken at the project site itself (*within-facility spillover*) and at other sites (*outside-facility spillover*). Each type of spillover is meant to capture a different aspect of the energy savings caused by the program, but not included in program records.

The **overall NTG ratio** accounts for both the net savings at participating projects and spillover savings that result from the program but are not included in the program's accounting of energy savings. When the NTG ratio is multiplied by the estimated gross program savings, the result is an estimate of energy savings that are attributable to the program (i.e., savings that would not have occurred without the program).

The basic equation is shown in Equation 1.

Equation 1. Net-to-Gross Ratio

$$NTG = 1 - \text{Free Ridership} + \text{Spillover}$$

The underlying concept inherent in the application of the NTG formula is that *only* savings caused by the program should be included in the final net program savings estimate but that this estimate should include *all* savings caused by the program.

5.2 Methods for Estimating Free Ridership and Spillover

5.2.1 Estimating Free Ridership

Data to assess free ridership were gathered through the self-report method—a series of survey questions asked of SBES participants. Free ridership was asked in both direct questions, which aimed at obtaining respondent estimates of the appropriate free ridership rate that should be applied to them, and in supporting or influencing questions, which could be used to verify whether the direct responses are consistent with participants' views of the program's influence.

Respondents were asked three categories of program-influence questions:

- **Likelihood:** to estimate the likelihood that they would have incorporated lighting measures "of the same high level of efficiency," if not for the assistance of the SBES Program. In cases where respondents indicated that they might have incorporated some, but not all, of the measures, they were asked to estimate the share of measures that would have been incorporated anyway at high efficiency. This flexibility in how respondents could conceptualize and convey their views on free ridership allowed respondents to give their most informed response, thus improving the accuracy of the free-ridership estimates.
- **Prior planning:** to further estimate the probability that a participant would have implemented the measures without the program. Participants were asked the extent to which they had considered installing the same level of energy-efficient lighting prior to participating in the program. The general approach holds that if customers were not definitively planning to install all of the efficiency lighting prior to participation, then the program can reasonably be credited with at least a portion of the energy savings resulting from the high-efficiency lighting. Strong free ridership is reflected by those participants who indicated they had already allocated funds for the purchase and selected the lighting and an installer.
- **Program importance:** to clarify the role that program components (e.g., information, incentives) played in decision-making, and to provide supporting information on free ridership. Responses to

these questions were analyzed for each respondent, not just in aggregate, and were used to identify whether the direct responses on free ridership were consistent with how each respondent rated the "influence" of the program.

Free-ridership scores were calculated for each of these categories[9] and then averaged and divided by 100 to convert the scores into a free-ridership percentage. Next, a timing multiplier was applied to the average of the three scores to reflect the fact that respondents indicating that their energy efficiency actions would not have occurred until far into the future may be overestimating their level of free ridership. Participants were asked, without the program, when they would have installed the equipment. Respondents who indicated that they would not have installed the lighting for at least two years were not considered free riders and had a timing multiplier of 0. If they would have installed at the same time as they did, they had a timing multiplier of 1; within one year, 0.67; and between one and two years, 0.33. Participants were also asked when they learned about the financial incentive; if they learned about it after the equipment was installed, then they had a free ridership ratio of 1.

5.2.2 Estimating Spillover

The basic method for assessing participant spillover (both within-facility and outside-facility) was an approach that asked a set of questions to determine the following:

- **Whether spillover exists at all.** These were yes/no questions that asked, for example, whether the respondent incorporated energy efficiency measures or designs that were not recorded in program records. Questions related to extra measures installed at the project site (within-facility spillover) and to measures installed in non-program projects (outside-facility spillover) within the service territory.
- **The share of those savings that could be attributed to the influence of the program.** Participants were asked if they could estimate the energy savings from these additional extra measures to be less than, similar to, or more than the energy savings from the SBES program equipment.
- **Program importance.** Estimates were derived from a question asking the program importance, on a 0 to 10 scale. Participants were also asked how the program influenced their decisions to incorporate additional energy efficiency measures.

---

[9] Scores were calculated by the following formulas:

» Likelihood: The likelihood score is 0 for those that "definitely would NOT have installed the same energy efficient measure" and 1 for those that "definitely WOULD have installed the same energy efficient measure." For those that "MAY HAVE installed the same energy efficient measure," the likelihood score is their answer to the following question: "On a scale of 0 to 10 where 0 is DEFINITELY WOULD NOT have installed and 10 is DEFINITELY WOULD have installed the same energy efficient measure, can you tell me the likelihood that you would have installed the same energy efficient measure?" If more than one measure was installed in the project, then this score was also multiplied by the respondent's answer to what share they would have done.

» Prior planning: If participants stated they had considered installing the measure prior to program participation, then the prior planning score is the average of their answers to the following two questions: "On a scale of 0 to 10, where 0 means you 'Had not yet planned for equipment and installation' and 10 means you 'Had identified and selected specific equipment and the contractor to install it', please tell me how far along your plans were" and "On a scale of 0 to 10, where 0 means 'Had not yet budgeted or considered payment' and 10 means 'Already had sufficient funds budgeted and approved for purchase', please tell me how far along your budget had been planned and approved."

» Program importance: This score was calculated by taking the maximum importance on a 0 to 10 scale of the four program importance questions and subtracting from 10 (i.e., the higher the program importance, the lower the influence on free ridership).

If respondents said no, they did not install additional measures, they received a zero score for spillover. If they said yes, then the individual's spillover was estimated as the self-reported savings as a share of project savings, multiplied by the program-influence score. Then, a 50 percent discount was applied to reflect uncertainty in the self-reported savings and divided by 10 to convert the score to a spillover percentage.

5.2.3 Combining Results across Respondents

The evaluation team determined free ridership and spillover estimates for each of the following:

- Individual respondents, by evaluating the responses to the relevant questions and applying the rules-based approach discussed above
- Measure categories:
    - For free ridership: by taking the average of each respondent's score within each category, weighted by the respondent's share of savings within the measure category
    - For spillover: by taking the sum of the individual spillover results (in kWh) for each measure category and dividing by the category's total program savings in the sample
- The program as a whole, by combining measure-level results:
    - For free ridership: measure category results were subsequently weighted by each category's share of total program savings
    - For spillover: similarly, measure category results were subsequently weighted by each category's share of total program savings

5.3 Results for Free Ridership, Spillover, and Net-to-Gross

This section presents the results of the attribution analysis for the SBES Program. Specifically, results are presented for free ridership and spillover (within-facility and outside-facility), which are used collectively to calculate an NTG ratio.

5.3.1 Review of Data Collection Efforts for Attribution Analysis

The EM&V team conducted 110 surveys with SBES participants to estimate free ridership, spillover, and NTG ratios. Table 5-2 shows the number of completions, by measure group.

Table 5-2. Attribution Survey Completes by Project Type

Measure Category	Surveys
Lighting	102
Refrigeration	8
Total	**110**

Source: Navigant analysis

5.3.2 Free-Ridership Results

The evaluation team asked participants a series of questions regarding the likelihood, scope, and timing of the investments in energy-efficient lighting if the respondent had not participated in the program. The purpose of the surveys was to elicit explicit estimates of free ridership and perspectives on the influence of the program. The evaluation team estimates free-ridership for the SBES Program at 4 percent of program-reported savings.

5.3.3 Spillover Results

The SBES Program influenced approximately 16 percent of participants to install additional energy efficiency measures on-site and influenced 10 percent of participants to install additional measures at other locations. Based on the survey findings, the evaluation team estimates the overall program spillover to be 6 percent of program-reported savings. Participants reported a variety of spillover measures installed, including lighting (most common) and water heaters.

5.3.4 Net-to-Gross Ratio

As stated above, the NTG ratio is defined as follows in Equation 2 below.

Equation 2. Net-to-Gross Ratio

$$NTG = 1 - \text{free ridership} + \text{spillover}$$

Using the overall free ridership value of 4 percent and the overall spillover value of 6 percent, the NTG ratio is 1 – 0.04 + 0.06 = 1.02. The estimated NTG ratio of 1.02 implies that for every 100 megawatt-hours (MWh) of realized savings recorded in SBES records, 102 MWh is attributable to the program.

Table 5-3. SBES Free Ridership, Spillover, and NTG Ratio

	Free Ridership	Spillover	NTG Ratio
SBES Program Total	0.04	0.06	1.02

Source: Navigant analysis, totals subject to rounding.

6. PROCESS EVALUATION

The purpose of the process evaluation is to understand, document and provide feedback on the program implementation components and customer experience for the Small Business Energy Saver (SBES) Program in the DEO jurisdiction.

6.1 Process Methodology

The evaluation team conducted in-depth interviews with SBES Program staff and IC staff and customer participant surveys, as noted previously. The process findings summarized in this document are based on the results of:

- Customer journey mapping with program participants;
- Participant surveys with 110 program participants;
- Interviews with the Duke Energy Program Manager and the Implementation Contractor (IC) staff; and
- A review of the program documentation.

6.2 Customer Journey Mapping

The Customer Journey Mapping analysis aimed to gather qualitative data about customer experiences with the SBES Program to understand customer sentiments and perspectives on program performance and establish a deeper understanding of customer satisfaction throughout the program process. Key aspects of journey mapping involved the development of a process map and the identification of the journey mapping lenses. In conversations with program staff, Navigant explored staff perceptions concerning the use of a variety of potential journey mapping lenses. Journey mapping lenses included a set of overarching questions and potential customer satisfaction concerns as the core focus of this research effort and were included in participant interviews. To conduct the customer journey analysis, Navigant completed seven steps, working closely with Duke Energy staff:

1. Program document review and conversations with program staff
2. Development of a process map and identification of journey mapping lenses
3. Development of a sampling plan, recruitment strategy and interview guide
4. Fielding of interviews
5. Analysis of interview notes
6. Development of Journey Map and other findings

In total, Navigant interviewed 8 Duke Energy Ohio SBES Program customers across various building types and measures. The final participant sample included a diverse mix of office, retail, warehouse and restaurant owners or managers who participated in upgrading their lighting or lighting and refrigeration equipment through the SBES Program. All interviewees installed lighting measures and one installed refrigeration measures in addition to the lighting measure. Table 6-1 shows specific customer characteristic information.

Table 6-1. SBES Interviewee Characteristics

Building Type	Business Type	Lighting	Refrigeration	Lighting KWh*	Refrigeration KWh*
Restaurant	Pizza Parlor	X	X	Medium	Low
Restaurant	Restaurant	X	--	Medium	--
Retail	Outdoor Equipment Store	X	--	Medium	--
Retail	Auto Repair Shop	X		High	--
Retail	Picture Framing Store	X		Medium	--
Retail	Apothecary Shop	X		Low	--
Warehouse	Warehouse	X		Medium	--
Office	Information Technology (IT) Service Company	X	--	Low	--

**Low = <10,000 KWh; Medium = 10,000-30,000 KWh; High = >30,000 KWh*
Source: Navigant analysis

6.3 Participant Survey Sampling Plan and Achievements

The participant survey targeted a random sample of all PY2016 program participants broken out by measure family. The two measure families are lighting and refrigeration. Navigant weighed customer responses by their stratum savings for net-to-gross findings as described in the preceding section. The process evaluation findings presented in this section are not weighted.

The survey effort successfully completed surveys with 110 customers, of which 102 were participants that only installed lighting measures and 8 were participants that installed some refrigeration measures. The survey targets were loosely designed to achieve 90/10 confidence and precision, with significant oversampling due to the relatively inexpensive per-survey cost.

6.4 Program Review

The evaluation team designed the program review task to understand changes and updates to the program design, implementation and energy and demand savings assumptions. The key program characteristics include the following:

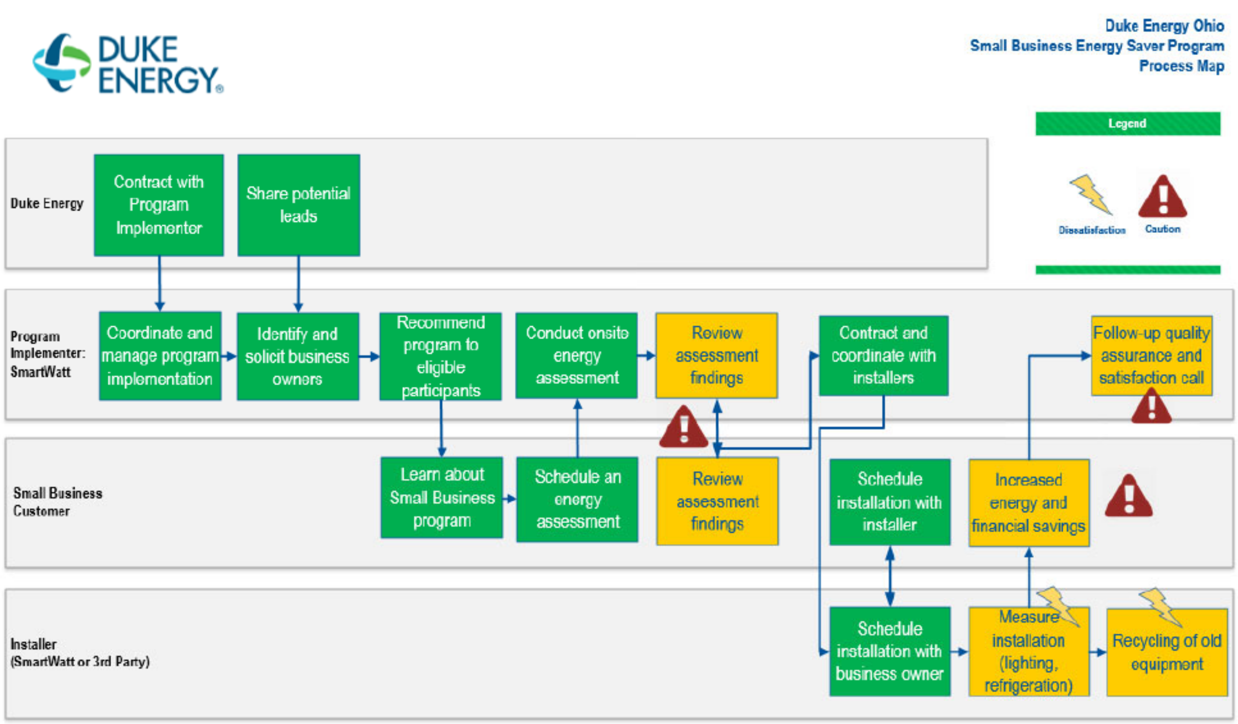
- **Program Design** – The SBES program is designed to offer high incentives (up to 80 percent of the total cost of the project) on efficient equipment to reduce energy use and peak demand. It specifically targets small business customers that are typically difficult for utilities to reach and often do not pursue energy efficiency on their own. The SBES program formally launched in DEO in 2014 (although savings were all claimed starting in 2015), and Duke Energy utilized expertise gained from managing similar programs in other jurisdictions.

- **Program Implementation** – A third-party contractor, Smart Watt Energy, administers the SBES program on Duke Energy's behalf. The Implementation Contractor, (IC) handles all aspects of the program, including customer recruitment, facility assessments, equipment installation (through independent installers contracted by the IC), and payment and incentive processing. The IC reports energy and peak demand reduction estimates to Duke Energy. The program had a successful launch in DEO and was able to exceed their energy savings goal while scoring high on customer satisfaction. Several quality control checks were carried over from similar programs in other jurisdictions.
- **Incentive Model** – The IC offers potential participants a recommended package of energy efficiency measures along with equipment pricing and installation costs. The incentive is proportional to estimated energy savings and can be as high as 80 percent of the total cost of the project.
- **Savings Estimates** – Energy and peak demand savings are estimated on a per-measure basis, taking into account existing equipment, proposed equipment, and operational characteristics unique to each customer. The savings estimates are derived from assumptions in the PA TRM.

6.5 Customer Journey Map Findings

Navigant developed a process map detailing the journey of the customer's experience through the SBES program (see Figure). Findings depicted in the process map below indicate isolated instances of dissatisfaction with the measure installation and recycling of old equipment processes. Potential customer dissatisfaction and areas of concerns are seen in the presentment onsite energy assessment findings and post-installation bill savings understanding phases.

Figure 6-1. Duke Energy Ohio SBES Process Map



Source: Navigant analysis

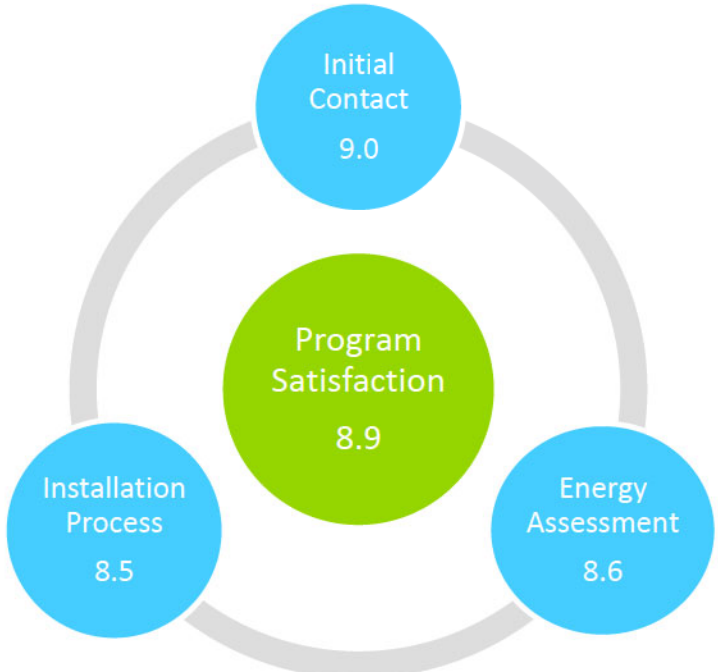
More specifically, participant interviews offered insight into the overall customer satisfaction with the SBES program and certain steps in the program participation process. Navigant examined the six process customer journey phases within the SBES program: 1) the Initial Contact; 2) the Energy Assessment; 3) the Installation Process; 4) Recycling of Old Equipment; 5) Equipment Performance; and 6) Savings. The list below outlines the key findings for each of these customer journey phases.

1. **Initial Contact** – Respondents felt highly satisfied with their initial contact and introduction into the program. Interviewees cited knowledgeable and personable sales representatives and Duke Energy's financial incentives as a major reason for their participation in the program and high satisfaction in this phase.
2. **Energy Assessment** – Similar to the Initial Contact phase, respondents reported high satisfaction with the Energy Assessment process overall. Many thought the assessments were thorough and quick. Despite the high satisfaction ratings overall, some interviewees felt that the representatives did not present the assessment clearly and tried to sell the program too aggressively.
3. **Installation Process** – Similar to the previous two phases, participants expressed high satisfaction ratings for the Installation Process overall. In general, respondents were pleased that installers worked around employees and customers, minimizing disruption to the business. However, a couple respondents noted isolated issues with the installation process, including unprofessional behavior, untimely installations, and scheduling snafus.
4. **Recycling of Old Equipment** – Although a couple participants noted that installers did not clean up after the installation and the recycling contractors collected equipment in an untimely manner, most respondents felt satisfied with the post-installation and cleanup process.
5. **Equipment Performance** – A small portion of interviewees had issues with equipment failures and product mis-specifications, causing discontent. Respondents also mentioned that they did not know who to call when issues arose.
6. **Energy Savings** – The energy savings experienced by customers received mixed reviews. While some felt they were saving money on their electric bills, others felt the initial energy assessment oversold savings.

Although respondents provided positive feedback overall, the findings indicate isolated problems throughout the process. This fact indicates inconsistencies in the program participation process, mostly as a result of poor performances from program subcontractors.

In general, interviewees reported high satisfaction ratings with the SBES program in Ohio despite program inconsistencies. Out of a 1-10 rating scale, customer program satisfaction averaged 8.9. Overall customer satisfaction with their initial contact with SmartWatt was a 9.0 and the energy assessment rated 8.6. Interviewee satisfaction of equipment installation was 8.5 as a result of the isolated problems, such as equipment failure and unprofessional installers. In general, most customers felt that the program process went smoothly and produced tangible savings. Figure 6-2 below shows the average satisfaction ratings from interviewees by program component through the installation process.

Figure 6-2. Overall Program Satisfaction



6.6 Participant Survey Findings

The following sections detail the process findings from all relevant sources of program information, including interviews with Duke Energy and IC staff and the results of the customer surveys, organized by topic. This discussion addresses 1) overall customer experience; 2) implementation contractor; 3) installation contractor; 4) program benefits; 6) upgraded equipment; and 7) participant suggested improvements.

The feedback received indicates that the SBES Program serves Duke Energy's customers well and represents an important component of Duke Energy's portfolio of business energy efficiency programs. Key findings are as follows:

- A majority of SBES participants were satisfied with the program. On a scale of 0 to 10, where 0 indicates "not satisfied at all" and 10 indicates "extremely satisfied":
    - 79 percent of participants indicated 8-10 for satisfaction with overall program experience.
    - 79 percent of participants indicated 8-10 for satisfaction with the contractor's quality of work.
    - 83 percent of participants indicated 8-10 for satisfaction with the energy efficiency assessment conducted by SmartWatt Energy.
- The post-installation inspection appears to be a significant driver of overall program satisfaction.
- Eighty-three percent of participants stated that equipment offered through the program allowed them to upgrade all of the equipment they wanted at the time.

The following sections detail the process findings and addresses the following topics:

1. Overall customer experience;
2. Implementation contractor;
3. Installation contractor;
4. Program benefits;
5. Upgraded equipment; and
6. Suggested improvements.

6.6.1 Customer Experience

Customers reported very high satisfaction with their overall program experience. Just 7% rated their overall satisfaction as less than 5, and 79% rated their satisfaction as an 8, 9, or 10.

Navigant identified some correlations with overall program satisfaction that provide insight into drivers of high satisfaction:

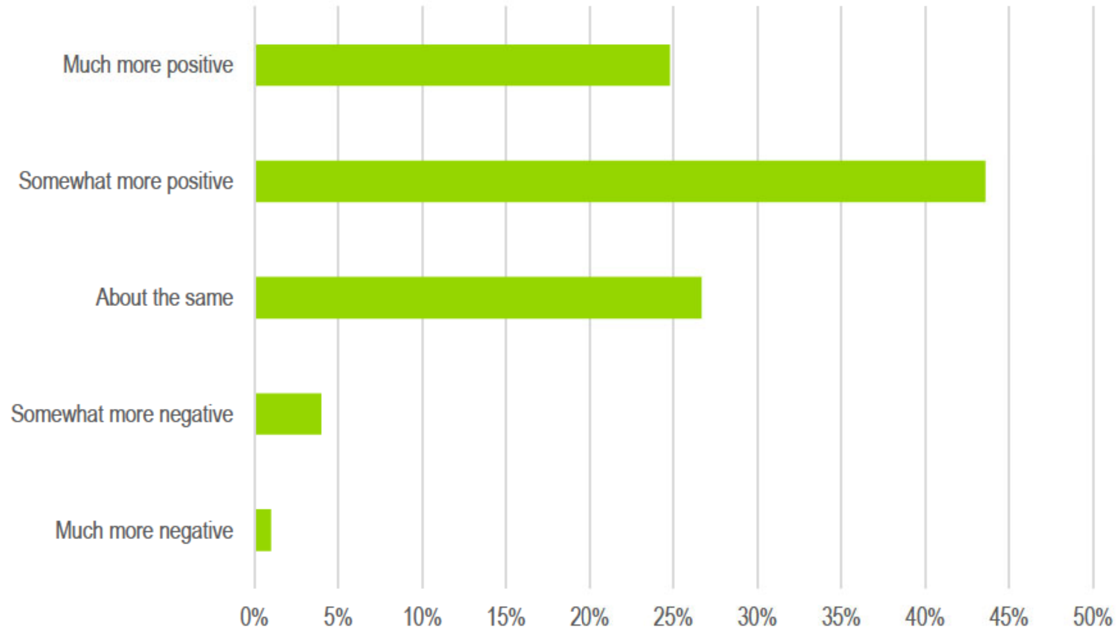
- Customers with overall high program satisfaction were more satisfied on average with every program element, but the difference was particularly noticeable on two program elements:
    - **The energy savings resulting from the new equipment**: highly satisfied customers gave an average rating of 9.1 vs. 5.4 among less satisfied customers.
    - **Program communications**: highly satisfied customers gave an average rating of 9.2 vs. 4.6 among less satisfied customers.
- Satisfaction with the **post-installation inspection** was very high with an average rating of 8.8, and customers who received a post-installation inspection[10] had statistically significant higher average satisfaction with the program overall and many of the individual program components. It appears that the post-installation inspection is a significant driver of overall program satisfaction.
    - Customers who received a post-installation inspection had an average overall satisfaction with the overall program of 9.3 vs. 7.8 for customers who did not receive an inspection.
    - Customers who received a post-installation inspection also had statistically significant higher average satisfaction with their installation contractor, the post-installation clean-up, the energy efficiency equipment installed, the quality of the light from new light fixtures, the energy savings resulting from new equipment, program communications, the amount of the rebate, and Duke Energy overall.

More than four out of five customers (84%) said they were very likely to participate in this program or a similar program in the future, rating their likelihood as an 8, 9, or 10 on a 10-point scale. These findings indicate both high program satisfaction and an opportunity to continue to market energy efficiency programs to previous participants to achieve deeper savings.

Participation in the SBES program generally served to improve customers' satisfaction with Duke Energy overall (Figure 6-3).

[10] SmartWatt is required to perform inspection visits on at least 20% of projects and all customer receive a follow up call after the project is complete.

Figure 6-3. Impact of SBES Participation on Attitude Toward Duke Energy (n=110)



Source: Navigant analysis

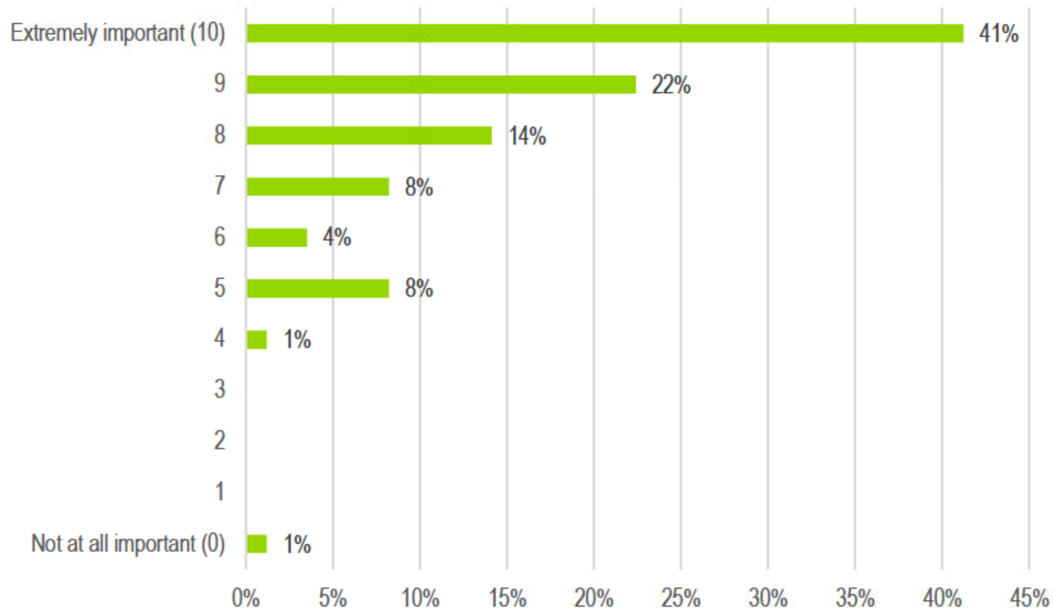
6.6.2 Implementation Contractor

As mentioned in the previous section, customers are highly satisfied with the services provided by the implementation contractor, SmartWatt Energy and that high satisfaction translates to high overall program satisfaction.

A large majority (89%) of customers said they knew who to contact if they had any questions or concerns about their project or any aspect of the program; of those, 75% identified a SmartWatt Energy employee as their helpful point of contact.

Overall, 86% of customers said that SmartWatt Energy helped them with their choice of energy-efficient measures. Of those customers, 78% said that the SmartWatt Energy's recommendation was very important in their decision to install energy-efficient equipment (8, 9, or 10), as shown in Figure 6-4.

Figure 6-4. Importance of SmartWatt Energy Recommendation (n=85)



Source: Navigant analysis

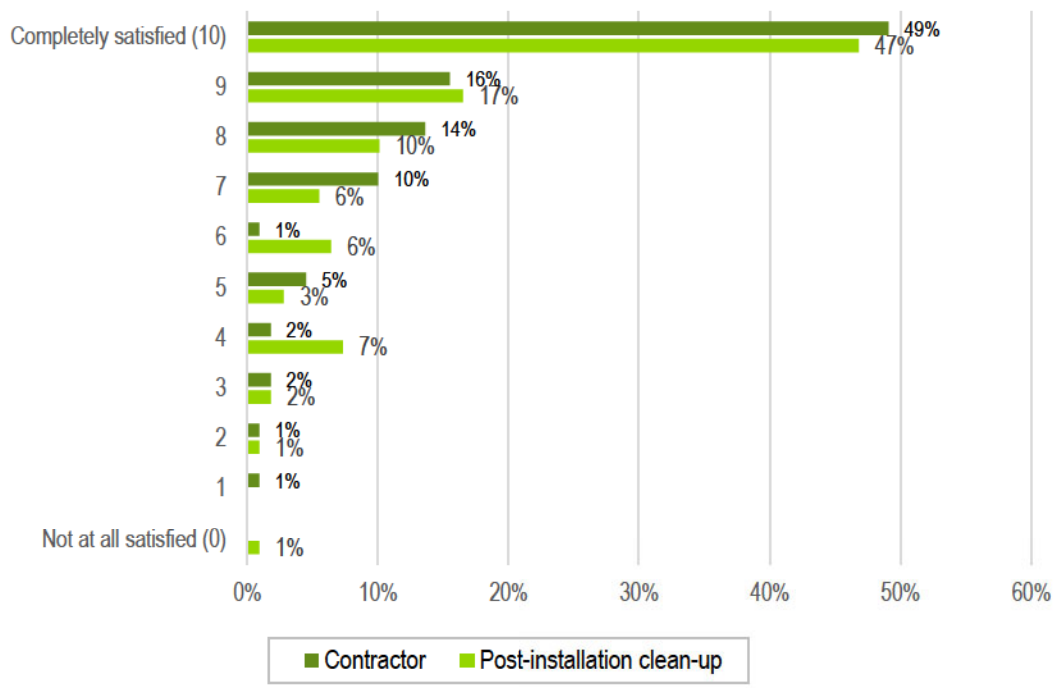
Customers are highly satisfied with the energy efficiency assessment conducted by SmartWatt Energy as well as the proposal prepared by SmartWatt Energy, with 83% rating their satisfaction as an 8 or higher for the assessment and 82% for the proposal. Nearly all (95%) said that the proposal was clear about the scope of work to be performed, and 98% said that the proposal was clear about their share of project costs.

Over half (53%) of customers received a post-installation inspection performed by SmartWatt Energy. Of those customers, 81% rated their satisfaction with the inspection as an 8 or higher.

6.6.3 Installation Contractors

Customer satisfaction with contractors is high. Figure 6-5 shows that 78 percent of survey respondents ranked their satisfaction with their contractor as an 8, 9, or 10, and 73 percent rated the contractor's post-installation clean-up as an 8, 9, or 10.

Figure 6-5: Customer Satisfaction with Contractor and Post-Installation Clean-up (n=110)



Source: Navigant analysis

6.6.4 Program Benefits

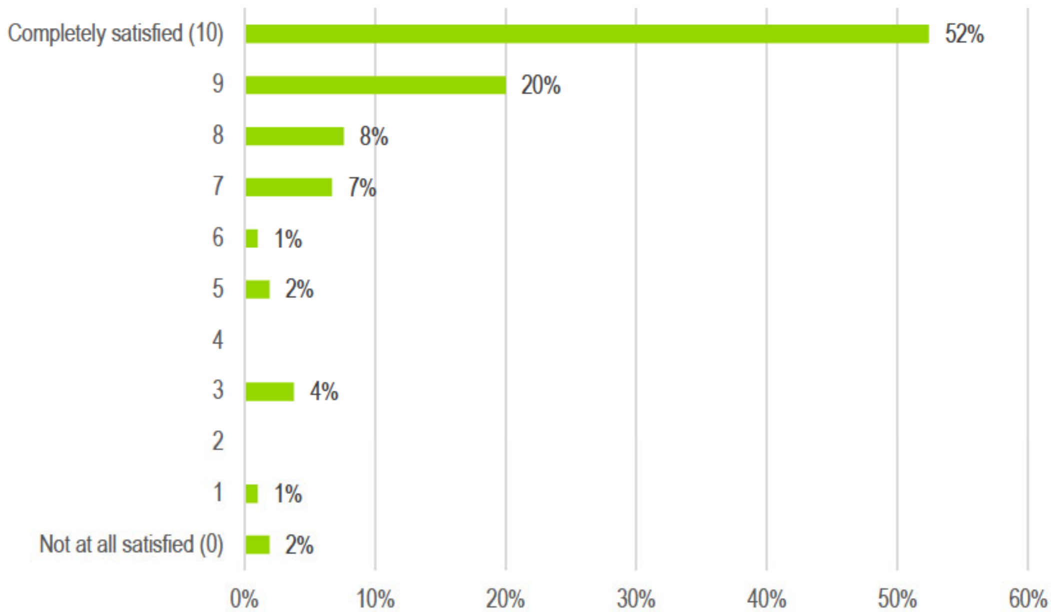
The majority of customers identified the energy savings and associated utility bill savings as the top benefits of participating in the SBES program. Better quality lighting and lower maintenance hassle were also significant benefits to many customers.

Another important survey finding was that 83 percent of customers stated that equipment offered through the program allowed them to upgrade all of the equipment they wanted at the time of the project, rather than piecing together the upgrades in multiple phases.

6.6.5 Upgraded Equipment

Customers are very satisfied with their new energy efficiency measures. Over three-quarters (83%) rated their satisfaction as an 8, 9, or 10 out of 10 (see Figure 6-6).

Figure 6-6: Participant Satisfaction with New Equipment (n=110)

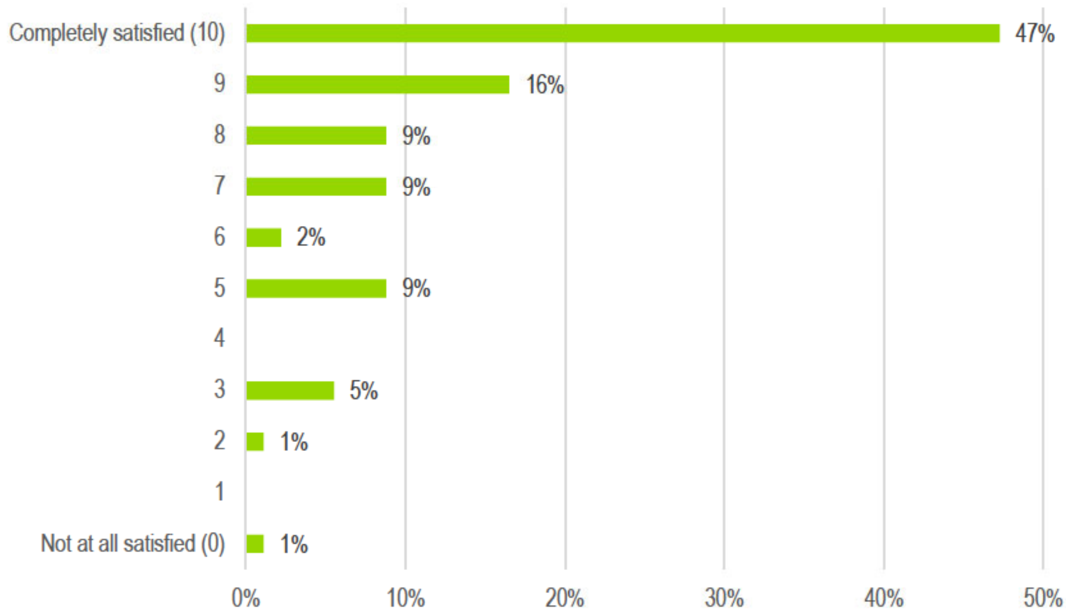


Source: Navigant analysis, totals subject to rounding

Lighting customers are very satisfied with the quality of the light produced by their new bulbs/fixtures, with 86% rating their satisfaction as an 8, 9, or 10.

Customer satisfaction with the energy savings resulting from their new equipment is slightly lower than satisfaction with the equipment itself. Nearly three-quarters (73%) rated their satisfaction as an 8, 9, or 10 out of 10, and the average rating was 8.3. This was the lowest-rated satisfaction metric in the customer survey, although still a relatively high level of satisfaction overall.

Figure 6-7: Participant Satisfaction with Energy Savings (n=110)

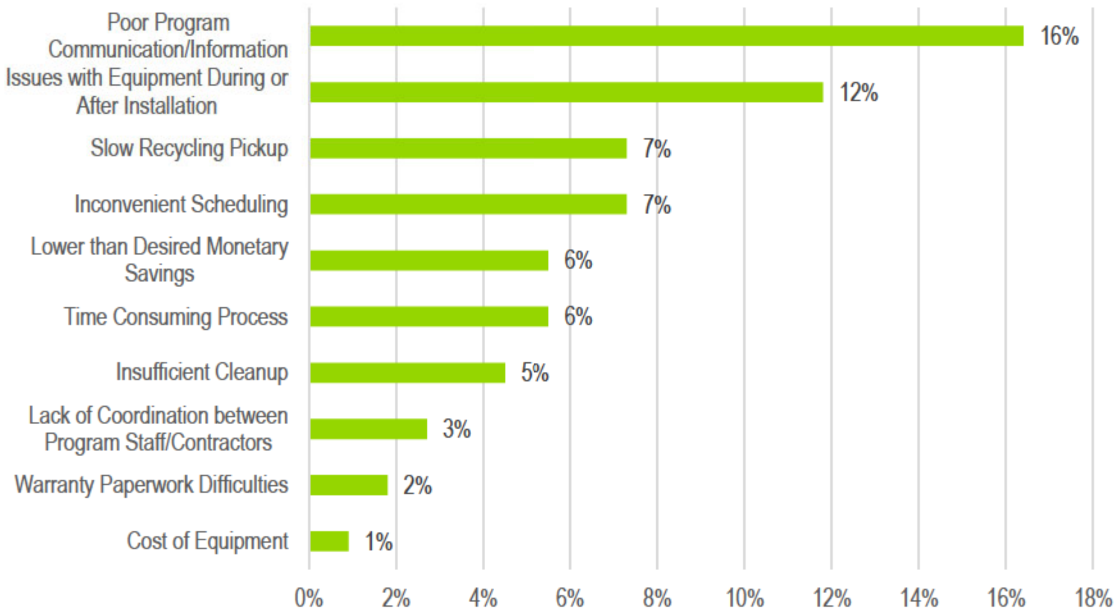


Source: Navigant analysis

6.6.6 Suggested Improvements

Overall program satisfaction is very high, but some customers had minor complaints or identified drawbacks of the program. The most common challenges (all mentioned by 16% of customers or less) are identified in Figure 6-8. Some customers felt that the program did not communicate clearly with them or had issues with the equipment during or after installation; other customers felt that the recycling pickup took too long or their energy savings expectations were not met. Note that many of the customer with complaints identified multiple issues (e.g., both a lack of communication *and* an equipment issue), and 67% of all customers did not mention *any* of the complaints shown in the figure below.

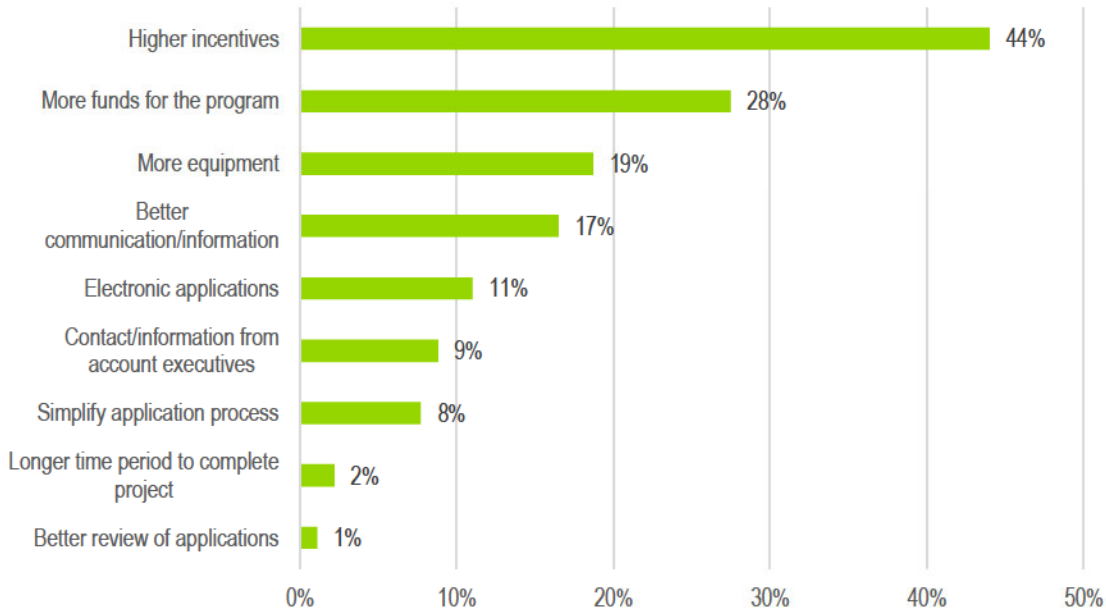
Figure 6-8. Program Challenges or Drawbacks (n=110)



Source: Navigant analysis

When asked how to improve the program, the most common responses were higher incentives and more funds for the program, followed by more equipment offered and better communication and program information, as shown in the following figure. Very few customers felt that the application process needed improvement or that longer time periods are necessary to complete projects.

Figure 6-9. Possible Program Improvements (n=110)



Source: Navigant analysis

7. SUMMARY FORM

Program Name

Completed EMV Fact Sheet

Description of program

Duke Energy's Small Business Energy Saver Program provides energy efficient equipment to eligible small business customer at up to an 80 percent discount. The program is delivered through an implementation contractor that coordinates all aspects of the program, from the initial audit, ordering equipment, coordinating installation, and invoicing.

The program consists of lighting and refrigeration measures.

- **Lighting measures:** LED lamps and fixtures, T8 fluorescent fixtures, occupancy sensors.
- **Refrigeration measures:** LED case lighting, EC motor upgrades, anti-sweat heater controls.
- **HVAC measures:** Programmable Wifi thermostats.

Date	August 29, 2018
Region(s)	Duke Energy Ohio
Evaluation Period	3/1/16 – 6/30/17
Annual net MWh Savings	27,688 MWh
Per Participant MWh Savings	30.36 MWh (across 912 total participants)
Coincident MW Impact	3.4 MW
Net-to-Gross Ratio	1.02
Process Evaluation	Annual
Previous Evaluation(s)	None

Evaluation Methodology

The evaluation team used engineering analysis, onsite field inspections, and time-of-use metering as the primary basis for estimating program impacts. Additionally, email surveys were conducted with participants to assess customer satisfaction and determine a net-to-gross ratio. Interviews were conducted with program and implementation team staff to understand program operational changes and enhancements.

Impact Evaluation Details

- **Onsite visits were conducted at 60 participant sites, while 20 of those sites were logged.** The evaluation team inspected program equipment to assess measure quantities and characteristics to compare with the program tracking database, and installed lighting loggers to verify hours of use and coincidence factors.
- **In-Service rates (ISRs) varied by equipment type.** The evaluation team found ISRs ranging from 0.95 for LED wall packs to 1.00for the majority of all other measures.
- **Participants achieved an average of 30.36 MWh of energy savings per year.** The program is accurately characterizing energy and demand impacts.

8. CONCLUSIONS AND RECOMMENDATIONS

The evaluation team performed extensive on-site work, email surveys, and analysis to determine gross and net verified savings. Overall conclusions and recommendations appear in the following sections.

8.1 Conclusions

Overall, the SBES Program performed very well in the DEO jurisdiction. The key to continued success is maintaining the strong foundation that the SBES program has built and continuing to monitor and improve customer issues as they arise.

- **Participants are overwhelmingly satisfied with the SBES Program, the implementation contractor, and Duke Energy.** A majority of customers plan to participate in Duke Energy programs in the future, and all participants surveyed reported a more positive or similar attitude towards Duke Energy. Customers are largely happy with all aspects of the SBES program, including the customer experience, the audit and installation process, and the upgraded equipment.
- The **energy savings realization rate is 1.04,** and is driven by several EM&V adjustments that roughly balanced out. The key adjustments the EM&V team made were the in-service rates and HVAC interactive effects. The **peak demand realization rate is lower at 0.74 (summer) and 0.83 (winter)** and is driven by HVAC interactive effects and coincidence factors.
- The evaluation effort estimated **free ridership for the SBES Program at 4 percent and spillover at 6 percent**, which drives an **NTG ratio of 1.02**. This indicates that the SBES Program is successfully reaching customers that would have not completed energy efficiency upgrades in the absence of the program. Spillover indicates that the program is showcasing the benefits of energy efficiency and driving customers to perform additional energy savings activities.

8.2 Recommendations

The evaluation team recommends a number of actions for improving the SBES Program, based on insights gained through the comprehensive evaluation effort for PY2016. These recommendations provide Duke Energy with a roadmap to fine-tune the SBES Program for continued success and include the following broad objectives:

Increasing Program Participation and Satisfaction

1. **Increase and improve program communications.** This is the most common challenge or drawback received from participants, with several customers noting specific communication issues regarding the responsibility for and timeline of recycling pickup. Additional education from both SmartWatt and Duke Energy account managers should help customers better understand the program participation process.
2. **Prioritize customer satisfaction training for installation contractors and customer follow-up services.** A minority of customers reported issues with installation and lighting equipment quality. Notably, overall satisfaction was higher for customers that received follow-up inspections from the implementation contractor than those that did not. There appears to be an opportunity to increase satisfaction by performing additional follow-up visits, although this must be balanced against increased cost. Additionally, this helps customers resolve equipment issues in a timely manner.

3. **Phase out T8 fluorescent lighting systems in favor of linear LED kits.** Linear LED lighting offers substantial savings above high-performance/reduced wattage T8 lamps and ballasts, which are increasingly perceived as outdated.

Improving Tracking Data and Reported Savings

4. **Track project facility types by using the same list of facility types specified in the Pennsylvania TRM.** This will reduce uncertainty in assigning facility types by the EM&V team based on SIC codes, and facilitate more direct application of HVAC interactive effects and coincidence factors.
5. **Track burnout lamps and fixtures during the initial audit.** It is likely that some burnouts were present and tolerated by customers, and may contribute to customers not realizing expected savings on their energy bills.
6. **Add connected load to occupancy sensor savings estimates.** Occupancy sensor savings were missing details on connected fixture load. This is a key input to the savings estimation, and should be recorded.

9. MEASURE-LEVEL INPUTS FOR DUKE ENERGY ANALYTICS

The SBES program estimates deemed savings on a per-fixture basis that takes into account specific operational characteristics. This approach differs from a more traditional prescriptive approach that applies deemed parameters by measure type and building type only.

For the lighting measures, the EM&V team applied HVAC interactive effects and coincident factors in the analysis that differed from those used by the IC; the values used are shown in Table 9-1 and Table 9-2. Note that for the PY2016 SBES evaluation the EM&V team applied the summer coincidence factors for both summer and winter peak demand reductions, with additional adjustments based on logger data for each of the corresponding peak periods.

Table 9-1. HVAC Interactive Effects[11]

Space Type	Energy HVAC Interactive Effect	Demand HVAC Interactive Effect
Air Conditioned/Cooled space	1.12	1.34
Freezer space	1.5	1.5
Medium-temperature refrigerated space	1.29	1.29
High-temperature refrigerated space	1.18	1.18
Uncooled space	1	1

Table 9-2. Coincidence Factors[12]

Facility Type	Annual Hours of Use	Summer Coincidence Factor
Auto Related	4,056	0.62
Daycare	2,590	0.62
Dusk-to-Dawn / Exterior Lighting	3,833	0
Education – School	1,632	0.31
Education – College/University	2,348	0.76
Grocery	4,660	0.87
Health/Medical – Clinic	3,213	0.73
Hospitals	5,182	0.8
Industrial Manufacturing – 1 Shift	2,857	0.57
Industrial Manufacturing – 2 Shift	4,730	0.57
Industrial Manufacturing – 3 Shift	6,631	0.57
Libraries	2,566	0.62
Lodging – Guest Rooms	914	0.09
Lodging – Common Spaces	7,884	0.9

[11] Pennsylvania Technical Reference Manual (TRM), 2015

[12] Pennsylvania Technical Reference Manual (TRM), 2015

Multi-Family (Common Areas) - High-rise & Low-rise	5,950	0.62
Nursing Home	4,160	0.62
Office	2,567	0.61
Parking Garages	6,552	0.62
Public Order and Safety	5,366	0.62
Public Assembly (one shift)	2,610	0.62
Public Services (nonfood)	3,425	0.62
Restaurant	3,613	0.65
Retail	2,829	0.73
Religious Worship/Church	1,810	0.62
Storage Conditioned/Unconditioned	3,420	0.62
Warehouse	2,316	0.54
24/7 Facilities or Spaces	8,760	1

Additionally, the Duke Energy DSMore table is embedded below for reference.

DSMore table
template -DEO SBES -

APPENDIX A. STATISTICS DETAIL

This appendix is intended to provide additional context around Navigant's sampling approach and impact findings for the PY2016 SBES evaluation for the DEO jurisdiction. Overall, Navigant believes that the evaluation results represents the program impacts in accordance with the evaluation approach and sample design. This is evidenced by the calculated statistical confidence and precision values, which were in line with expectations.

A.1 Sampling Approach

Navigant's methodology includes a double-ratio (nested) sampling approach. This approach is designed to efficiently utilize resources for primary data collection while minimizing sampling error. For the SBES program, Navigant chose a relatively large sample of sites to perform onsite verification activities, and a relatively smaller subsample of these sites for more detailed data collection with data loggers. The underlying assumption is that the larger verification sample represents the larger *population*, while the smaller metering sample represents the larger verification *sample*. This allows Navigant to perform high-rigor evaluation at lower cost for a given assumed sampling error.

For this evaluation, Navigant targeted 90/10 sampling and relative precision for the entire program. Sample sizes are ultimately driven by assumptions related to the variability of Navigant's verified savings compared to the Duke Energy deemed savings values. This is represented by the coefficient of variation, or CV. Less variation results in a lower CV value, which in turn results in lower sample sizes.

Based on previous evaluation work with the SBES program, Navigant designed a sample with 60 sites selected for verification, with a subsample of 20 of these sites for additional metering. Figure 9-1 illustrates the sample design and analysis plan.

Navigant will also note that the population split into four separate strata – large, medium, and small lighting, and one strata for refrigeration. The underlying assumption is that similar projects will tend to exhibit similar variations, so by grouping like projects (e.g. all refrigeration projects) we can further reduce sampling error and draw more meaningful conclusions from our onsite data collections efforts.

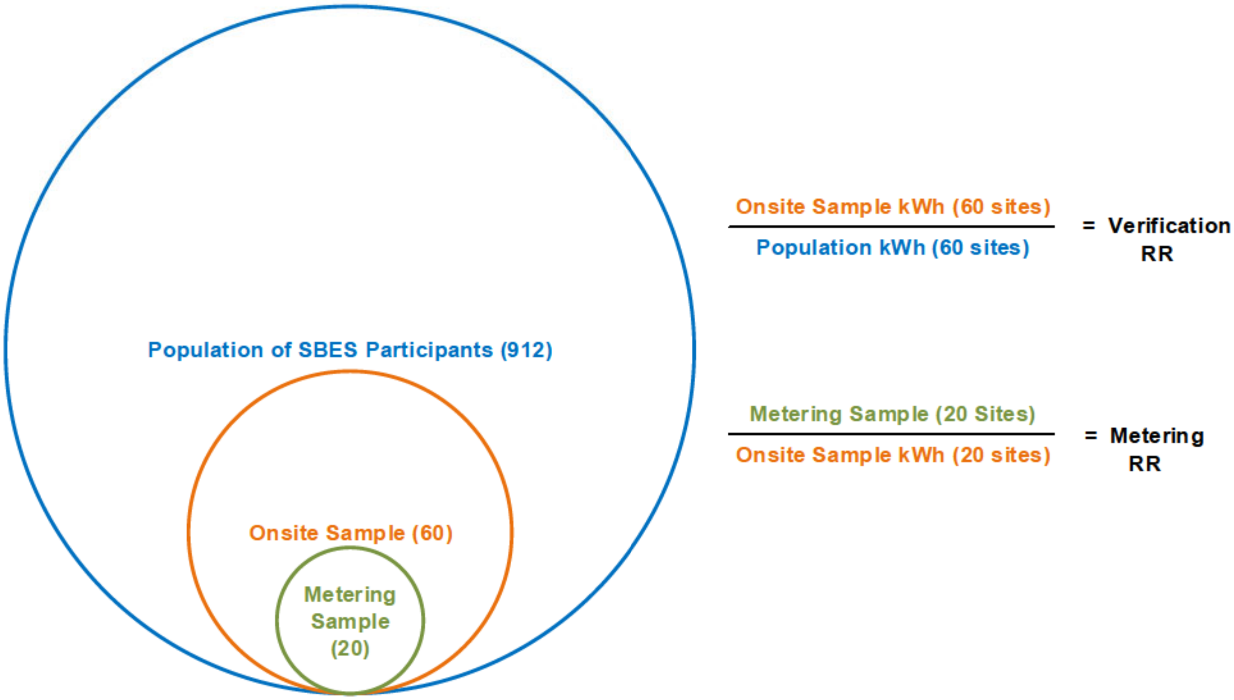


Figure 9-1. Illustration of Nested Sampling Concept

A.2 Analysis Approach

After performing the site visits, the next step is to analyze the measure-level data to develop project-level verification and metering estimates for each site. Because there are three sets of savings estimates, two ratios (hence double-ratio) are required to compare results.

1. The first ratio compares the onsite verification findings to the population for 60 sites. The onsite verification findings include all of Navigant's adjustments performed onsite, such as any adjustments due to in-service rate, HVAC interactive effects, wattage, or customer-reported hours of operation.
2. The second ratio compares the metering findings to the onsite findings for 20 sites. The only adjustment made here is due to hours of use adjustments (or for demand savings, the coincidence factor).

With these ratios, final program-level savings and realization rates are calculated. First, for each stratum, a total realization rate is calculated by multiplying the verification and metering realization rates together (ratios 1 and 2 outlined above). The total realization rate is then multiplied by the stratum deemed savings resulting in the verified savings. The verified savings for each of the four strata are then added together resulting in total program verified savings.

The last step of the analysis includes a statistical analysis to assess whether or not the precision targets were met. In some cases, if there is larger than expected variation between the claimed savings and the verified savings, it is possible that the precision target of 10% is not met. It is also possible that the "true" savings value will be outside of the confidence interval calculated from the statistics. This occurs on average 10% of the time at the 90% confidence level.