Commonwealth of Kentucky
Michael G. Adams, Secretary of State

Michael G. Adams
Secretary of State
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Certificate of Existence

Authentication number: 295791
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I, Michael G. Adams, Secretary of State of the Commonwealth of Kentucky, do hereby certify that according to the records in the Office of the Secretary of State,

DUKE ENERGY KENTUCKY, INC.

is a corporation duly incorporated and existing under KRS Chapter 14A and KRS Chapter 271B, whose date of incorporation is March 20, 1901 and whose period of duration is perpetual.

I further certify that all fees and penalties owed to the Secretary of State have been paid; that Articles of Dissolution have not been filed; and that the most recent annual report required by KRS 14A.6-010 has been delivered to the Secretary of State.

IN WITNESS WHEREOF, I have hereunto set my hand and affixed my Official Seal at Frankfort, Kentucky, this 15th day of August, 2023, in the 232nd year of the Commonwealth.

Michael G. Adams
Secretary of State
Commonwealth of Kentucky
295791/0052929

Appendix A
Cost Effectiveness Test Results - 2023-24 Forecast
as amended 8/15/23

Program Name	UCT	TRC	RIM	PCT
Residential Programs				
Income Qualified Neighborhood	0.47	0.54	0.33	2.32
Income Qualified Services	0.26	0.42	0.21	2.68
My Home Energy Report	2.31	2.31	0.80	n /a
Residential Energy Assessments	1.62	1.60	0.53	26.42
Peak Time Rebate Pilot Program	0.22	0.25	0.22	n /a
Power Manager®	1.98	2.66	1.98	n /a

Kentucky DSM Rider

Comparison of Revenue Requirement to Rider Recovery

Residential Programs	(1) Projected Program Costs 7/2021 to 6/2022 (A)	(2) Projected Lost Revenues 7/2021 to 6/2022 (A)	(3) Projected Shared Savings 7/2021 to 6/2022 (A)	(4) Program Expenditures 7/2021 to 6/2022 (B)	(5) Program Expenditures (C) Gas	(6) Program Expenditures (C) Electric	(7) Lost Revenues 7/2021 to 6/2022 (B)	(8) Shared Savings 7/2021 to 6/2022 (B)	(9) 2021 Reconciliation Gas (D)	(10) 2021 Reconciliation Electric (E)	(11) Rider Collection (F) Gas	(12) Rider Collection (F) Electric	(13) (Over)/Under Collection Gas (G)	(14) (Over)/Under Collection Electric (H)
Low Income Neighborhood	$ 535,375	$ 16,582	$ (18,687)	$ 104,995	$ -	$ 104,995	$ -	$ (36)						
Low Income Services	$ 674,774	$ 13,372	$ (23,004)	$ 432,099	$ 187,632	$ 244,468	$ 727	$ (13,376)						
My Home Energy Report	$ 92,858	$ 59,707	$ 4,925	$ 50,491	$ -	$ 50,491	$ 11,087	$ 9,277						
Residential Energy Assessments	$ 259,935	$ 20,469	$ 6,026	$ 231,275	$ -	$ 231,275	$ 88,419	$ 22,158						
Residential Smart $aver®	$ 1,009,464	$ 138,531	$ 39,241	$ 934,741	$ -	$ 934,741	$ 35,996	$ 35,448						
Power Manager®	$ 702,947	$ -	$ 113,199	$ 549,189	$ -	$ 549,189	$ 134,593	$ 119,030						
Peak Time Rebate Pilot Program	$ 197,549	$ -	$ -	$ 243,802	$ -	$ 243,802	$ -							
Revenues collected											$1,384,977	$6,830,599		
Total	$ 3,472,902	$ 248,660	$ 121,701	$ 2,546,593	$ 187,632	$ 2,358,961	$ 270,821	$ 172,502	$ 749,237	$ 6,081,080	$ 1,384,977	$ 6,830,599	$ (448,108)	$ 2,052,765

(A) Amounts identified in report filed in Case No. 2021-00313
(B) Actual program expenditures, lost revenues (for this period and from prior period DSM measure installations), and shared savings for the period July 1, 2021 through June 30, 2022.
(C) Allocation of program expenditures to gas and electric in accordance with the Commission's Order in Case No. 2014-00388.
(D) Recovery allowed in accordance with the Commission's Order in Case No. 2012-00085.
(E) Recovery allowed in accordance with the Commission's Order in Case No. 2012-00085.
(F) Revenues collected through the DSM Rider between July 1, 2021 and June 30, 2022.
(G) Column (5) + Column (9) - Column(11).
(H) Column (6) + Column (7) + Column (8) + Column (10) - Column(12).

Commercial Programs	(1) Projected Program Costs 7/2021 to 6/2022 (A)	(2) Projected Lost Revenues 7/2021 to 6/2022 (A)	(3) Projected Shared Savings 7/2021 to 6/2022 (A)	(4) Program Expenditures 7/2021 to 6/2022 (B)	(5) Lost Revenues 7/2021 to 6/2022 (B)	(6) Shared Savings 7/2021 to 6/2022 (B)	(7) 2021 Reconciliation (C)	(8) Rider Collection (D)	(9) (Over)/Under Collection (E)
Small Business Energy Saver	$ 827,238	$ 40,699	$ 105,787	$ 854,019	$ 259,488	$ 109,862			
Smart $aver® Non-Residential	$ 1,443,155	$ 121,142	$ 378,913	$ 1,591,233	$ 233,141	$ 134,761			
Total	$ 2,270,393	$ 161,841	$ 484,700	$ 2,445,253	$ 492,629	$ 244,623	$ (4,889,472)	$ (1,934,669)	$ 227,701
PowerShare®	$ 857,738	$ -	$ 107,428	$ 848,940	$ -	$ 87,480	$ (738,460)	$ 334,692	$ (136,731)

(A) Amounts identified in report filed in Case No. 2021-00313
(B) Actual program expenditures, lost revenues (for this period and from prior period DSM measure installations), and shared savings for the period July 1, 2021 through June 30, 2022.
(C) Recovery allowed in accordance with the Commission's Order in Case No. 2012-00085.
(D) Revenues collected through the DSM Rider between July 1, 2021 and June 30, 2022.
(E) Column (4) + Column (5) + Column (6) + Column (7) - Column (8)

Kentucky DSM Rider

2023-2024 Projected Program Costs, Lost Revenues, and Shared Savings
as Amended 8.15.23

Residential Program Summary (A)

	Costs	Lost Revenues	Shared Savings	Total	Allocation of Costs (B) Electric	Gas	Electric Costs	Budget (Costs, Lost Revenues, & Shared Savings) Electric	Gas Costs
Low Income Neighborhood	$ 512,928	$ -	$ (27,182)	$ 485,746	100.0%	0.0%	$ 512,928	$ 485,746	$ -
Low Income Services	$ 940,323	$ -	$ (55,087)	$ 885,236	73.5%	26.5%	$ 690,937	$ 635,850	$ 249,386
My Home Energy Report	$ 275,858	$ -	$ 34,165	$ 310,023	100.0%	0.0%	$ 275,858	$ 310,023	$ -
Residential Energy Assessments	$ 286,985	$ -	$ 17,859	$ 304,844	100.0%	0.0%	$ 286,985	$ 304,844	$ -
Residential Smart $aver®	$ 520,248	$ -	$ 39,668	$ 559,916	100.0%	0.0%	$ 520,248	$ 559,916	$ -
Power Manager®	$ 1,104,092	$ -	$ 101,191	$ 1,205,282	100.0%	0.0%	$ 1,104,092	$ 1,205,282	$ -
Peak Time Rebate Pilot Program	$ 216,000	$ -	$ -	$ 216,000	100.0%	0.0%	$ 216,000	$ 216,000	$ -
Total Costs, Net Lost Revenues, Shared Savings	$ 3,856,433	$ -	$ 110,615	$ 3,967,048			$ 3,607,047	$ 3,717,662	$ 249,386

NonResidential Program Summary (A)

	Costs	Lost Revenues	Shared Savings	Total	Allocation of Costs (B) Electric	Gas	Electric Costs	Budget (Costs, Lost Revenues, & Shared Savings) Electric	Gas
Business Energy Saver (C)	$ 879,517	$ -	$ 126,001	$ 1,005,518	100.0%	0.0%	$ 879,517	$ 1,005,518	NA
Smart $aver® Non-Residential (D)	$ 2,090,665	$ -	$ 473,988	$ 2,564,653	100.0%	0.0%	$ 2,090,665	$ 2,564,653	NA
PowerShare®	$ 1,063,284	$ -	$ 93,220	$ 1,156,504	100.0%	0.0%	$ 1,063,284	$ 1,156,504	NA
Total Costs, Net Lost Revenues, Shared Savings	$ 4,033,467	$ -	$ 693,208	$ 4,726,675			$ 4,033,467	$ 4,726,675	NA
Total Program	$ 7,889,900	$ -	$ 803,823	$ 8,693,723					

(A) Costs, Lost Revenues (for this period and from prior period DSM measure installations), and Shared Savings for Year 10 of portfolio.
(B) Allocation of program expenditures to gas and electric in accordance with the Commission's Order in Case No. 2014-00388.
(C) Small Business energy Saver and SmartPath are indiviual sets of measure that are part of a single and larger program referred to as Business Energy Saver beginning July 1, 2023.
(D) Smart $aver® Non-Residential consists of the following technologies: Energy Efficient Food Service Projects, HVAC, Lighting, IT, Pumps and Motors, and Process Equipment.
(E) Yellow highlighted rows include modifications to programs as described in application.

Duke Energy Kentucky
Demand Side Management Cost Recovery Rider (DSMR)
Summary of Calculations for Programs

July 2023 to June 2024
as Amended 8.15.23

	Program Costs (A)
Electric Rider DSM	
Residential Rate RS	$ 3,717,662
Distribution Level Rates Part A DS, DP, DT, GS-FL, EH & SP	$ 3,570,171
Transmission Level Rates & Distribution Level Rates Part B	$ 1,156,504
Gas Rider DSM	
Residential Rate RS	$ 249,386

(A) See Appendix B, page 2 of 7

Duke Energy Kentucky
Demand Side Management Cost Recovery Rider (DSMR)
Summary of Billing Determinants

Year	July 2023 - June 2024
Projected Annual Electric Sales kWH	
Rate RS	1,473,213,420
Rates DS, DP, DT, GS-FL, EH, & SP	2,383,557,890
Rates DS, DP, DT, GS-FL, EH, SP, & TT	2,607,935,890
Projected Annual Gas Sales CCF	
Rate RS	62,655,685

Duke Energy Kentucky
Demand Side Management Cost Recovery Rider (DSMR)
Summary of Calculations

July 2021 to June 2022

Rate Schedule Riders	True-Up Amount (A)	Expected Program Costs (B)	Total DSM Revenue Requirements	Estimated Billing Determinants (C)		DSM Cost Recovery Rider (DSMR)	
Electric Rider DSM							
Residential Rate RS	$ 2,157,456	$ 3,717,662	$ 5,875,118	1,473,213,420	kWh	$ 0.003988	$/kWh
Distribution Level Rates Part A DS, DP, DT, GS-FL, EH & SP	$ 239,314	$ 3,570,171	$ 3,809,485	2,383,557,890	kWh	$ 0.001598	$/kWh
Transmission Level Rates & Distribution Level Rates Part B TT	$ (143,705)	$ 1,156,504	$ 1,012,799	2,607,935,890	kWh	$ 0.000388	$/kWh
Distribution Level Rates Total DS, DP, DT, GS-FL, EH & SP						$ 0.001987	$/kWh
Gas Rider DSM							
Residential Rate RS	$ (470,962)	$ 249,386	$ (221,576)	62,655,685	CCF	$ (0.003536)	$/CCF
Total Rider Recovery			$ 10,475,826				

(A) (Over)/Under of Appendix B page 1 multiplied by the average three-month commercial paper rate for 2019 to include interest on over or under-recovery in accordance with the Commission's order in Case No. 95-312. Value is: **1.051000**
(B) Appendix B, page 2.
(C) Appendix B, page 4.

Allocation Factors based on July 2021-June 2022

Summary of Load Impacts July 2021 Through June 2022 (1)

Residential Programs	kWh	% of Total Res Sales	ccf	% of Total Res Sales	Elec % of Total % of Sales	Gas % of Total % of Sales
Low Income Neighborhood	101,731	0.0067%	-	0.0000%	100%	0%
Low Income Services	220,462	0.0146%	6,549	0.0112%	57%	43%
My Home Energy Report	1,733,860	0.1145%	-	0.0000%	100%	0%
Residential Energy Assessments	675,452	0.0446%	-	0.0000%	100%	0%
Residential Smart $aver®	2,061,006	0.1361%	-	0.0000%	100%	0%
Power Manager®	-	0.0000%	-	0.0000%	100%	0%
Peak Time Rebate Pilot Program	-	0.0000%	-	0.0000%	100%	0%
Total Residential	4,792,511	0.3164%	6,549	0.0112%		
Total Residential (Rate RS) Sales For July 2021 Through June 2022	1,514,696,464	100%	58,620,591	100%		

(1) Load Impacts Net of Free Riders at Meter

Allocation Factors Projected

Summary of Load Impacts July 2023 Through June 2024 (1)

Residential Programs	kWh	% of Total Res Sales	ccf	% of Total Res Sales	Elec % of Total % of Sales	Gas % of Total % of Sales
Low Income Neighborhood	344,934	0.0234%	-	0.0000%	100%	0%
Low Income Services	255,140	0.0173%	3,917	0.0063%	73.5%	26.5%
My Home Energy Report	1,646,312	0.1117%	-	0.0000%	100%	0%
Residential Energy Assessments	735,753	0.0499%	-	0.0000%	100%	0%
Residential Smart $aver®	1,526,852	0.1036%	-	0.0000%	100%	0%
Power Manager®	-	0.0000%	-	0.0000%	100%	0%
Total Residential	4,508,991	0.3061%	3,917	0.0063%		
Total Residential (Rate RS) Sales Projected	1,473,213,420	100%	62,655,685	100%		

(1)Load Impacts Net of Free Riders at Meter

RIDER DSMR

DEMAND SIDE MANAGEMENT RATE

The Demand Side Management Rate (DSMR) shall be determined in accordance with the provisions of Rider DSM, Demand Side Management Cost Recovery Rider, Sheet No. 61 of this Tariff.

The DSMR to be applied to residential customer bills is $(0.004784003536) per hundred cubic feet. (RI)

A Home Energy Assistance Program (HEA) charge of $0.30 will be applied monthly to residential customer bills.

The DSMR to be applied to non-residential service customer bills is $0.00 per hundred cubic feet.

RIDER DSMR

DEMAND SIDE MANAGEMENT RATE

The Demand Side Management Rate (DSMR) shall be determined in accordance with the provisions of Rider DSM, Demand Side Management Cost Recovery Rider, Sheet No. 61 of this Tariff.

The DSMR to be applied to residential customer bills is $(0.003536) per hundred cubic feet. (I)

A Home Energy Assistance Program (HEA) charge of $0.30 will be applied monthly to residential customer bills.

The DSMR to be applied to non-residential service customer bills is $0.00 per hundred cubic feet.

RIDER DSMR

DEMAND SIDE MANAGEMENT RATE

The Demand Side Management Rate (DSMR) shall be determined in accordance with the provisions of Rider DSM, Demand Side Management Cost Recovery Rider, Sheet No. 75 of this Tariff.

The DSMR to be applied to residential customer bills is $0.~~003497~~ 003988 per kilowatt-hour. (I)

A Home Energy Assistance Program (HEA) charge of $0.30 will be applied monthly to residential customer bills.

The DSMR to be applied to non-residential distribution service customer bills is $0.001987 per kilowatt-hour.

The DSMR to be applied for transmission service customer bills is $0.000388 per kilowatt-hour.

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Thirty-Fourth Revised Sheet No. 78
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Duke Energy Kentucky
1262 Cox Road
Erlanger, KY 41018

RIDER DSMR

DEMAND SIDE MANAGEMENT RATE

The Demand Side Management Rate (DSMR) shall be determined in accordance with the provisions of Rider DSM, Demand Side Management Cost Recovery Rider, Sheet No. 75 of this Tariff.

The DSMR to be applied to residential customer bills is $0.003988 per kilowatt-hour. (I)

A Home Energy Assistance Program (HEA) charge of $0.30 will be applied monthly to residential customer bills.

The DSMR to be applied to non-residential distribution service customer bills is $0.001987 per kilowatt-hour.

The DSMR to be applied for transmission service customer bills is $0.000388 per kilowatt-hour.

Issued by authority of an Order by the Kentucky Public Service Commission dated ____ in Case No. 2023-00269.

Issued: August 15, 2023
Effective: September 15, 2023
Issued by Amy B. Spiller, President /s/ Amy B. Spiller

Duke Energy Kentucky, Inc.
1262 Cox Road
Erlanger, Kentucky 41018

RESIDENTIAL ENERGY ASSESSMENT PROGRAM

APPLICABILITY

Available to residential customers in the Company's electric service area with individually-metered, single-family residences receiving concurrent service from the Company and choose to participate by enrolling through the marketing channels utilized by the program.

PROGRAM DESCRIPTION

The Residential Energy Assessment Program (REA) is part of Duke Energy Kentucky's portfolio of programs offered through Rider Demand Side Management Program (Rider DSM) and recovered through the Company's Rider DSMR (Demand Side Management Rate).The purpose of this program is to assist residential customers in assessing their energy usage and to provide recommendations for more efficient use of energy in their homes. The program will also help identify those customers who could benefit most by investing in new energy efficiency measures, undertaking more energy efficient practices and participating in Duke Energy Kentucky programs.

The Company may require a minimum number of months of historical usage data before performing an analysis to customers as follows:

On-site Audit and Analysis

Duke Energy Kentucky will perform on-site assessments of owner-occupied residences. Duke Energy Kentucky reserves the right to determine eligibility throughout the life of the program. Duke Energy Kentucky will provide a detailed Residential Energy Assessment including energy efficiency recommendations.

Participating customers will be offered an energy efficiency starter kit which includes energy efficient measures to include but not limited to high efficiency water and lighting measures.

Virtual, Phone Assisted and Web-Based Audit and Analysis (T)

Duke Energy Kentucky will offer virtual, phone or web-based assessments to renters in single family (T)
residences, as well as, owners and renters who reside in condominiums, townhomes or (T)
manufactured homes. (T)

SERVICE REGULATIONS

The provisions contained in this tariff sheet do not supersede or replace any of the charges and terms contained in the standard base rate and rider tariff sheets. The standard base rate and rider charges apply to all customers.

The supplying of, and billing for, service and all conditions applying thereto, are subject to the jurisdiction of the Kentucky Public Service Commission, and to Company's Service Regulations currently in effect, as filed with the Kentucky Public Service Commission, as approved by law.

KY.P.S.C. Electric No. 2
~~Fourth~~Fifth Revised Sheet No. 107
Cancels and Supersedes
~~Third~~Fourth Sheet No. 107
Page 1 of 1

Duke Energy Kentucky, Inc.
1262 Cox Road
Erlanger, Kentucky 41018

~~MY~~ HOME ENERGY REPORT PROGRAM (T)

APPLICABILITY

Applicable to residential customers in the Company's electric service area with individually-metered, single-family residences and multifamily dwellings receiving concurrent service from the Company.

PROGRAM DESCRIPTION

The My Home Energy Report is part of Duke Energy Kentucky's portfolio of programs offered through Rider Demand Side Management Program (Rider DSM) and recovered through the Company's Rider DSMR (Demand Side Management Rate). The purpose of this ~~voluntary opt-in~~ opt-out program is to use comparative household electric usage data for similar residences in the same geographic area to help customers to better manage and reduce energy usage. These normative comparisons are intended to induce an energy consumption behavior change. The program will assist residential customers in assessing their energy usage and provide recommendations for more efficient use of energy in their homes. The program will help identify those customers who could benefit most from investing in new energy efficiency measures, undertaking more energy efficient practices and participating in Duke Energy Kentucky programs. (T)

- Customers will receive periodic comparative usage data reports via direct mail and/or online channels. ~~Delivery may be interrupted during the off-peak energy usage months in the fall and spring.~~ (T)
- The Company may require a minimum number of months of historical usage data before allowing participation. (T)

Customers can opt out of receiving the report at any time by contacting Duke Energy Kentucky.

SERVICE REGULATIONS

The provisions contained in this tariff sheet do not supersede or replace any of the charges and terms contained in the standard base rate and rider tariff sheets. The standard base rate and rider charges apply to all customers.

The supplying of, and billing for, service and all conditions applying thereto, are subject to the jurisdiction of the Kentucky Public Service Commission, and to Company's Service Regulations currently in effect, as filed with the Kentucky Public Service Commission, as approved by law.

Issued by authority of an Order by the Kentucky Public Service Commission dated ~~April 29, 2020~~___ in Case No. ~~2019-00406~~2023-00269.

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Issued by Amy B. Spiller, President /s/ Amy B. Spiller

Duke Energy Kentucky, Inc.
1262 Cox Road
Erlanger, Kentucky 41018

LOW INCOMEINCOME QUALIFIED NEIGHBORHOOD ENERGY SAVER PROGRAM (T)

APPLICABILITY

This program is available only to individually-metered residential customers in neighborhoods selected by the Company, at its sole discretion, which are considered low incomeincome qualifed based on third party data, which includes income level and household size. Areas targeted for participation in this program will approximately have 50% of the households have income equal to or less than 200% of the federal poverty level established by the U. S. Government. (T)

PROGRAM DESCRIPTION

The Low IncomeIncome Qualified Neighborhood Energy Saver Program is part of Duke Energy Kentucky's portfolio of programs offered through Rider Demand Side Management Program (Rider DSM) and recovered through the Company's Rider DSMR (Demand Side Management Rate). The purpose of this program is to assist low incomeincome qualified customers in reducing energy costs through energy education and by installing or providing energy conservation measures for each customer's residence. (T) (T)

Under this program, participating customers will receive the following:

- An energy assessment to identify energy efficiency opportunities in the customer's home;
- One-on-one education on energy efficiency techniques and measures; and
- A comprehensive package of energy conservations measures installed or provided to the extent the measure is identified as an energy efficiency opportunity based on the results of the energy assessment. Energy conservation measures, up to $210, may include energy-efficient lightbulbs, water-saving showerheads and faucet aerators, air conditioning/heating system filters, water heater wrapslow-cost energy efficiency starter items, such as air infiltration reduction measures, energy efficient lighting, water conservation measures, HVAC filters, or other energy saving devices. Based on the opportunities identified during the energy assessment the customers could also be eligible to receive additional energy efficiency measures including attic insulation, duct sealing, air sealing w/blower door, floor/belly insulation in mobile homes, and a smart thermostat. (T) (T) (T) (T) (T) (T) (T) (T)

SERVICE REGULATIONS

The provisions contained in this tariff sheet do not supersede or replace any of the charges and terms contained in the standard base rate and rider tariff sheets. The standard base rate and rider charges apply to all customers.

The supplying of, and billing for, service and all conditions applying thereto, are subject to the jurisdiction of the Kentucky Public Service Commission, and to Company's Service Regulations currently in effect, as filed with the Kentucky Public Service Commission, as approved by law.

Issued by authority of an Order of the Kentucky Public Service Commission dated April 29, 2020___ in Case No. 2019-004062023-00269.

Issued: February 19, 2021August 15, 2023
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Issued by Amy B. Spiller, President /s/ Amy B. Spiller

Duke Energy Kentucky, Inc.
1262 Cox Road
Erlanger, Kentucky 41018

KY.P.S.C. Electric No. 2
~~Third~~Fourth Revised Sheet No. 106
Cancels and Supersedes
~~Second~~Third Revised Sheet No. 106
Page 1 of 2

~~LOW~~ INCOME QUALIFIED SERVICES PROGRAM (T)

APPLICABILITY

Available to ~~low~~ income qualified residential customers in the Company's electric service area. (T)

PROGRAM DESCRIPTION

The ~~Low~~ Income Qualified Services Program is part of Duke Energy Kentucky's portfolio of programs offered through Rider Demand Side Management Program (Rider DSM) and recovered through the Company's Rider DSMR (Demand Side Management Rate). The purpose of this program is to assist ~~low~~ income qualified customers with installation of energy efficiency measures in their home to reduce energy usage. Eligible customers must have income to or less than 200% of the federal poverty level established by the U.S. Government. (T) (T)

Weatherization and equipment replacement assistance is available to income qualified customers on Duke Energy Kentucky's system in existing, individually metered, residences, condominiums, and mobile homes.

- Funds are available for (i.) weatherization measures, and/or (ii.) refrigerator replacement with an Energy Star appliance, and/or (iii.) furnace repair/replacement. The measures eligible for funding will be determined by an energy audit of the residence.
- A home energy audit will be provided at no charge to the customer.
- Availability of this program will be coordinated through vendors or local agencies that administer weatherization programs. The vendor or agency must certify the household income level according to Duke Energy standards.

Payment Plus provides energy efficiency and budget counseling to help customers understand how to control their energy usage and how to manage their household bills. Participants are also encouraged to participate in weatherization and equipment replacement assistance to increase the energy efficiency in customers' homes. Bill assistance credits are provided to customers upon completion of each component of Payment Plus.

Participants are not eligible for payments under any other Duke Energy Kentucky Energy Efficiency Programs for the same energy efficiency measure provided under this program.

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Duke Energy Kentucky, Inc.
1262 Cox Road
Erlanger, Kentucky 41018

PAYMENT

Participants in the weatherization and equipment replacement assistance provision of this program may receive assistance with energy efficiency measures as shown below. Payments will be made to the administering agency on behalf of the customer.

1. Weatherization Tier 1. Homes with energy usage up to 7 kWh or 1 therm per square foot of conditioned space can receive up to $600800 for weatherization measures. (T)
2. Weatherization Tier 2. Homes with energy usage more than 7 kWh or 1 therm per square foot of conditioned space can receive assistance of up to $4,000500 for weatherization measures. (T)
3. Equipment Replacement
   a) Refrigerator replacement cost
   b) Furnace replacement cost

To provide an incentive for customers to enroll in Payment Plus, bill assistance is available to help customers gain control of their bills. The credits[1] are as follows:

1. $200 for participating in the EE counseling.
2. $150 for participating in the budgeting counseling.
3. $150 for participating in the Residential Conservation and Energy Education program if enrolled in Payment Plus.

SERVICE REGULATIONS

The provisions contained in this tariff sheet do not supersede or replace any of the charges and terms contained in the standard base rate and rider tariff sheets. The standard base rate and rider charges apply to all customers.

The supplying of, and billing for, service and all conditions applying thereto, are subject to the jurisdiction of the Kentucky Public Service Commission, and to Company's Service Regulations currently in effect, as filed with the Kentucky Public Service Commission, as approved by law.

[1] This is a one-time credit.

Duke Energy Kentucky, Inc.
1262 Cox Road
Erlanger, Kentucky 41018

RESIDENTIAL DIRECT LOAD CONTROL - POWER MANAGER PROGRAM

APPLICABILITY

Applicable to residential customers in the Company's electric service area with individually-metered, single-family residences receiving concurrent service from the Company.

This program is available on a voluntary basis, at the Company's option, in areas where the Company operates applicable load control devices or to customers who have a Duke Energy approved thermostat as described below. (T) (T)

This program is available for the cycling control of electric central air conditioning (cooling) systems where the following requirements are met:

Load Control Device (Installed by Company) (T)

1. The Customer must agree to enroll all operable central air conditioning units installed in the residence.
2. The Company shall have the right to require satisfactory permission for the installation and operation of load control devices on customer equipment upon entering a program enrollment agreement with the Customer.
3. Neither the Customer nor his agent shall disconnect or otherwise interfere with the Company's equipment required to cycle the Customer's appliance except for the replacement of or service to the appliance.
4. The Customer shall immediately notify the Company of the removal of, disconnection of or damage to the load control device.

Company-Approved Two-Way Communication Thermostat (Installed by Customer) (T)

An eligible Customer could participate in the program by installing and utilizing the Customer's own two-way communication thermostat. The Customer's thermostat must be an Duke Energy approved thermostat model. Additionally, the Customer must agree to enroll all operable central air conditioning units installed in the residence. (T) (T) (T) (T)

Participants may enroll in only one of the above two Power Manager program options, and cannot be enrolled in more than one program offering simultaneously. (T) (T)

PROGRAM OPTIONS

Customers may elect to enroll in Power Manager by choosing among program options offered by the Company.

The Company will establish bill credit incentives based on the program chosen by the Customer in the program enrollment agreement. Bill credit incentives will be presented to the customer in the program enrollment agreement.

INTERRUPTION PERIODS

The Company shall have the right to intermittently interrupt (cycle) service to the Customer's central

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1262 Cox Road
Erlanger, Kentucky 41018

electric air conditioning (cooling) systems during non-holiday weekday peak load and/or high price periods for economic purposes as determined by the Company. The Company will limit the number of these cycling events to no more than 10 during the cooling season from May through October. The duration of each event will not exceed 12 hours and will be restricted to occur between the hours of 6 AM to 11 PM Eastern Daylight Time (EDT).

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INTERRUPTION PERIODS (Contd.)

In addition, the Company shall have the right to intermittently interrupt (cycle) service to the Customer's central air conditioning (cooling) systems at any time during the cooling season from May through October in which the Company experiences emergency conditions such as capacity problems related to the generation, transmission and delivery of electricity, or as directed by the regional transmission operator. The number of cycling events for emergency conditions is independent of the implementation of the program for economic conditions as described above.

The Company, at its sole discretion, may limit requests for curtailment to geographic regions.

The Company reserves the right to test the function of the load control provisions at any time.

SERVICE REGULATIONS

The provisions contained in this tariff sheet do not supersede or replace any of the charges and terms contained in the standard base rate and rider tariff sheets. The standard base rate and rider charges apply to all customers.

The supplying of, and billing for, service and all conditions applying thereto, are subject to the jurisdiction of the Kentucky Public Service Commission, and to Company's Service Regulations currently in effect, as filed with the Kentucky Public Service Commission, as approved by law.

Measure	Technology	Program	Category	Type
LED Downlight LLLC greater than 18W	Lighting	Smart $aver® Non-Residential	Add	Non-Residential
LED Downlight LLLC up to 18W	Lighting	Smart $aver® Non-Residential	Add	Non-Residential
LED Highbay LLLC replacing 2-lamp 8ft T12	Lighting	Smart $aver® Non-Residential	Add	Non-Residential
LED Highbay LLLC replacing 251W-400W HID	Lighting	Smart $aver® Non-Residential	Add	Non-Residential
LED Highbay LLLC replacing 4-lamp 4ft T5HO	Lighting	Smart $aver® Non-Residential	Add	Non-Residential
LED Highbay LLLC replacing 6-lamp 4ft T8	Lighting	Smart $aver® Non-Residential	Add	Non-Residential
LED Highbay LLLC replacing greater than 400W HID	Lighting	Smart $aver® Non-Residential	Add	Non-Residential
LED Lowbay LLLC replacing 176W-250W HID	Lighting	Smart $aver® Non-Residential	Add	Non-Residential
LED Lowbay LLLC replacing up to 175W HID	Lighting	Smart $aver® Non-Residential	Add	Non-Residential
LED Panel 1x4 LLLC replacing or in lieu of T8 FL	Lighting	Smart $aver® Non-Residential	Add	Non-Residential
LED Panel 2x2 LLLC replacing or in lieu of T8 FL	Lighting	Smart $aver® Non-Residential	Add	Non-Residential
LED Panel 2x4 LLLC replacing or in lieu of T8 FL	Lighting	Smart $aver® Non-Residential	Add	Non-Residential
LED 3ft Tube 1-LED, rplcg or in lieu of T8 fluor	Lighting	Smart $aver® Non-Residential	Add	Non-Residential
LED 8ft Tube 1-LED, rplcg or in lieu of T8 fluor	Lighting	Smart $aver® Non-Residential	Add	Non-Residential
LED Downlight greater than 18W	Lighting	Smart $aver® Non-Residential	Add	Non-Residential
LED Exterior replacing above 400W HID retrofit Lamp	Lighting	Smart $aver® Non-Residential	Add	Non-Residential
Occupancy Sensors per watt	Lighting	Smart $aver® Non-Residential	Add	Non-Residential
Time Clocks External Lighting	Lighting	Smart $aver® Non-Residential	Add	Non-Residential
Building Operator Certificate	Process	Smart $aver® Non-Residential	Add	Non-Residential

Status Update for Duke Energy Kentucky Energy Efficiency and Demand Response Programs; 2023-2025

Planned[1] Evaluation, Measurement and Verification Activities and Evaluation Reports

Residential Customer Programs	Program/Measure	Last Evaluation completion	Next Evaluation ==>	Q1 2023	Q2 2023	Q3 2023	Q4 2023	Q1 2024	Q2 2024	Q3 2024	Q4 2024	Q1 2025	Q2 2025	Q3 2025	Q4 2025
Low Income Neighborhood	Neighborhood	12/20/2022													
Low Income Services	Refrigerator Replace	7/31/2013	TBD												
	Weatherization/Payment Plus	7/31/2013													
	Pay For Performance	N/A													
My Home Energy Report	MyHER	2/12/2014		M&V	M&V	Report									
Residential Energy Assessments	HEHC	8/7/2020		M&V	M&V	M&V	M&V	M&V	M&V	M&V	Report				
Residential Smart Saver®	HVAC	9/21/2015		M&V	M&V	Report									
	Specialty Bulbs/Online Savings Store	10/6/2022													
	Water Measures	9/25/2020								M&V	M&V	M&V	Report		
	Multi-Family	12/26/2019		M&V	M&V	M&V	Report*								
Power Manager		8/31/2020		M&V	M&V	M&V	M&V	M&V	Report						
Peak Time Rebate Pilot	Peak Time Rebate	5/18/2023		M&V	Report										

Non-Residential Customer Programs	Program/Measure	Last Evaluation completion	Next Evaluation ==>	Q1 2023	Q2 2023	Q3 2023	Q4 2023	Q1 2024	Q2 2024	Q3 2024	Q4 2024	Q1 2025	Q2 2025	Q3 2025	Q4 2025
Small Business Energy Saver		11/10/2022													
Smart $aver® Non-Res, Custom		1/18/2022													
Smart $aver® Non-Res, Prescriptive		7/24/2019			M&V	M&V	M&V	M&V	M&V	M&V	Report				
PowerShare		2/14/2017				M&V	M&V	Report							

[1] Future Evaluation Report dates are projections only. Actual report dates will vary depending on program participation, time to achieve a significant sample and the time needed to collect adequate data.
* Postponed timing due to pandemic program suspension

LEGEND	
M&V	Data collection (surveys, interviews, onsite visits, billing data) and analysis
Report	Evaluation Report

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Duke Energy Kentucky Neighborhood Energy Saver Program

2018-2019 Evaluation Report – FINAL

December 20, 2022

Opinion Dynamics

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1. Evaluation Summary

1.1 Program Summary

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

The program employs a neighborhood canvas approach to drive participation while working with existing organizations in each community to maximize the number of customers benefitting from the program. Each year the program team has a goal of serving 600 households and achieving an overall neighborhood penetration rate of 65%.[1]

The program period under evaluation is June 1, 2018, through June 30, 2019.[2]

1.2 Evaluation Objectives

The scope of this evaluation included estimation of gross impacts and a process evaluation. The evaluation objectives were to:

- Review and update, as necessary, deemed savings estimates through a review of measure assumptions and calculations.
- Verify measure installation and persistence.
- Estimate program energy (kWh) and summer and winter demand (kW) savings, and realization rates.
- Identify ways the Duke Energy program team may be able to improve the NES Program in the future based on the evaluation of program impacts.
- Assess participant satisfaction with the program, identify any barriers to participation in the program, and recommend strategies for addressing those barriers.

To achieve these objectives, Opinion Dynamics completed several data collection and analytic activities, including an interview with the program manager, a participant telephone survey, an analysis of survey results, an analysis of program tracking data, a consumption analysis, a deemed savings review, an engineering analysis, and a process analysis.

1.3 High Level Findings

Overall, NES Program teams implemented the program effectively and exceeded the program's annual goal to serve 600 households. Participation was strong with a total of 612 DEK customers from six different neighborhoods participating in the NES Program between June 1, 2018 and June 30, 2019. Of the 612

[1] Based on communications by NES Program staff (April 13, 2021) and Duke Energy EM&V staff (September 26, 2022).
[2] The evaluation period was selected to ensure that sufficient post-installation usage data was available for participants before the COVID-19 pandemic.

participants, 551 were single-family households and 61 were multifamily.[3] The program penetration rate was 53%, slightly below the goal of 65%.[4]

1.3.1 Impact Findings

Based on results of the consumption analysis, the average annual net energy savings per household are 892 kWh. At the program level, estimated net energy savings are 546 MWh for the evaluation period. The estimates include savings from equipment installed by program representatives, as well as savings from any additional behavioral changes and participant spillover attributable to the program. Table 1 presents net impact results, including demand savings, which are calculated by applying the ratios of engineering analysis kW to kWh savings (see Table 5 below) to the consumption analysis-derived energy savings.

Table 1. Net Impact Results

Per Household			Program Level		
Energy Savings (kWh)	Summer Coincident Demand (kW)	Winter Coincident Demand (kW)	Energy Savings (kWh)	Summer Coincident Demand (kW)	Winter Coincident Demand (kW)
892	0.07266	0.10785	545,607	44.47	66.01

As part of the impact evaluation, we also conducted an engineering analysis to (1) provide insight into how each measure contributes to overall program savings and (2) develop kW to kWh savings ratios to determine ex post demand savings for the program. The engineering analysis included development of in-service rates (ISRs) and a review of deemed savings values.

Overall ISRs are high for all measures (see Table 2). Verification rates equaled 100% for all measures, which means customers confirmed that they received the quantities tracked in the program data. Installation rates for LEDs and domestic hot water measures ranged from 90% to 96%, which means virtually all received measures were installed. The persistence rates for LEDs and faucet aerators were just under 100% due to removal of some of these measures.

Table 2. Measure In-Service Rates

Measure	Verification Rate	Installation Rate	Persistence Rate	ISR
LEDs	100%	95%	95%	91%
Faucet Aerators	100%	96%	96%	93%
Low Flow Showerheads	100%	90%	100%	90%
HVAC Filters [A]	100%	100%	N/A	100%
Infiltration Measures [B]	100%	*Not asked*	*Not asked*	100%
Pipe Insulation Wrap [B]	*Not asked*	*Not asked*	*Not asked*	100%
Tank Insulation Wrap [B]	*Not asked*	*Not asked*	*Not asked*	100%

[A] Since HVAC filters are designed to be removed and replaced regularly, the persistence rate is not applicable for this measure.
[B] Customers often do not have visibility into the installation of infiltration and insulation measures, and these measures are unlikely to be removed. We therefore only verified the receipt of infiltration measures and assumed 100% for all other rates.

[3] A majority of the single-family homes (457) are manufactured homes. We classify these as single-family for the purposes of this report.
[4] Calculated as participating households based on unique account numbers (612) divided by the total number of eligible households in the targeted neighborhoods (1,161).

Table 3 presents the per unit ex post deemed savings values for all program measures, developed as part of our engineering analysis.

Table 3. Ex Post Per Unit Deemed Energy Savings and Demand Reduction Values

Measure	Energy Savings (kWh)	Summer Peak Demand (kW)	Winter Peak Demand (kW)
Lighting			
LEDs (75W equivalent)	39.11	0.0031	0.0053
LEDs (60W equivalent)	32.43	0.0025	0.0044
LEDs (40W equivalent)	22.42	0.0018	0.0031
LEDs 5W or similar - Globes	19.56	0.0015	0.0027
LEDs 5W or similar - Candelabra Bulbs	20.03	0.0016	0.0027
Domestic Hot Water			
Low Flow Showerhead	415.87	0.0144	0.0288
Water Heater Insulation Wrap	121.54	0.0139	0.0139
Pipe Insulation (5-ft. sections)	192.79	0.0220	0.0220
Kitchen Faucet Aerator	98.01	0.0049	0.0099
Bathroom Faucet Aerator	15.02	0.0016	0.0031
Air Sealing			
Infiltration Reduction	81.22	0.0202	0.0273
HVAC			
HVAC Filters	17.08	0.0085	0.0035

Note: The values above are the ex post deemed savings values weighted by (1) fuel type and (2) the share of the measure installed in single-family and multifamily homes, respectively. The values do not reflect ISRs. The ex post deemed savings values are presented in the *DEK NES Program Deemed Savings Review Revised Final Memorandum* from Opinion Dynamics to Duke Energy's EM&V Team. August 29, 2022, which can be found in Appendix B.

We calculated engineering-based gross impacts for the various measures installed through the program by applying ISRs and deemed savings values to quantities in the program tracking database (see Table 4). Low flow showerheads are responsible for the largest proportion of savings (41%) followed by lighting (29%).

Table 4. Total Measure-Level Gross Energy Savings

Measure Type	Energy (kWh)	Percent of Total kWh [A]
Low Flow Showerheads	193,876	43%
Lighting	137,955	31%
Faucet Aerators	47,492	11%
Infiltration Reduction	33,059	7%
Pipe Insulation	20,436	5%
HVAC Filters	9,479	2%
Water Heater Insulation Wrap	7,778	2%
Total	**450,075**	**100%**

[A] Column may not sum to 100% exactly due to rounding.

Table 5 shows the program-level energy and demand savings, based on the engineering analysis, and the resulting kW to kWh savings ratios. As noted above, we multiply these ratios by the consumption analysis-derived energy savings to arrive at summer and winter coincident demand reduction.

Table 5. Gross Annual Program Impact Results from Engineering Analysis

Energy Savings (kWh)	Summer Coincident Demand (kW)	Winter Coincident Demand (kW)	Summer Demand Ratio (kW/kWh)	Winter Demand Ratio (kW/kWh)
450,075	36.7	54.5	0.000081503	0.00012098

1.3.2 Process Evaluation Findings

The research team focused the process evaluation on several questions related to energy education, NES participant satisfaction, potential barriers to participation, and the overall effectiveness of the program. Key process findings include:

- **The program exceeded its participation goals in terms of the number of enrolled households, but fell slightly short of its neighborhood penetration goal.** During the evaluation period, the program served 612 households, exceeding its goal of 600 households. The penetration rate was 53%, slightly short of the goal of 65%.
- **The program is successful in providing most participating households with a comprehensive package of energy savings measures.** Ninety percent or more of participating households received LEDs, HVAC filters, and educational and other measures, while two-thirds or more received infiltration reduction measures, kitchen aerators, and bathroom aerators.
- **Cross-participation among program participants is high.** More than two of every five program participants (41%) also participated in another Duke Energy program after participating in the NES Program, most of them in the Smart $aver Residential Program. This suggests successful promotion of additional energy savings opportunities and Duke's other programs by NES program representatives.
- **The program's outreach methods are successful.** Almost half of all participants (48%) first heard about the program through Duke Energy's direct outreach (mail, post card, or door hanger) and another 26% learned about the program when a representative came to their door, suggesting that the initial contact made by the program team is an effective form of outreach.
- **The educational component of the program is successful.** Eighty-three percent of respondents recalled receiving in-person education and almost all of those (96%) thought that the information was either very useful or useful. Additionally, 90% of respondents reported that they were more knowledgeable about ways to save energy in their homes after their NES Program participation than they were beforehand.
- **Participants are highly satisfied with their program experience.** Ninety-three percent of DEK respondents reported they were mostly or completely satisfied with the program and with the energy-saving products they received. In addition, all surveyed participants were mostly or completely satisfied with the NES Program representatives who visited their homes and their communication with Duke Energy.
- **Participants encounter no barriers to participation.** When all 29 survey respondents were asked whether they encountered any barriers to participation, none said that they did.

1.3.3 Recommendations

Based on our evaluation, the DEK NES Program is operating successfully. We therefore recommend Duke Energy continue offering the program as it has been.

2. Program Description

2.1 Program Design

Duke Energy's NES Program provides one-on-one energy education, on-site energy assessments, and appropriate packages of no-cost energy conservation measures to customers in income-qualified neighborhoods. The program is available to active DEK account holders who are individually metered homeowners or tenants living in pre-determined neighborhoods. Neighborhoods targeted for this program are eligible to participate if at least 50% of the households within the community have incomes less than or equal to 200% of the federal poverty guidelines. Participants are limited to a one-time receipt of energy efficiency measures through the NES Program. The overall goal of the NES Program is to offer persistent energy and demand savings to Duke Energy customers through the direct installation of energy savings measures and by providing education on other ways to reduce household energy use.

In targeted neighborhoods, the NES implementation team recruits customers via door-to-door canvassing and community events. Program staff work with community leaders and organizations to maximize the number of customers benefiting from the program. Each engaged neighborhood consists of approximately 500 to 1,500 households, and program staff aim to serve at least 600 households in the DEK jurisdiction per year.

2.2 Program Implementation

Honeywell Building Solutions implements the DEK NES Program in partnership with Duke Energy program staff. The implementer performs all assessments and installations. DEK program staff are heavily involved in selecting specific neighborhoods based on program eligibility criteria.

Prior to participating in the program, residents in the selected neighborhoods receive targeted mailings that provide introductory information about how to participate, the benefits of participation, and a notice that additional information from program staff will be circulated throughout their community, (including additional mailings and a community launch event). The implementation team organizes at least one community launch event in each targeted neighborhood, to both make residents aware of the program and provide demonstrations of the measures the NES Program offers. The Duke Energy NES program manager noted that reaching out to neighborhoods allows the program to reach a large number of customers in a cost-effective manner.

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

2.3 Program Performance

The program period under evaluation is June 1, 2018, through June 30, 2019. Over this period, the program teams served 612 DEK households in six different neighborhoods, which surpassed the DEK goal to serve at least 600 households annually. The neighborhood penetration rate of 53%, calculated as a ratio of households served (612) to the number of eligible households (1,161), fell just short of the goal of 65%.

Table 6 shows a comprehensive breakdown of DEK participants' home types by location based on information present in the program tracking data. A majority of the participants (90%) were from single-family households. Most single-family and multifamily households were located in Florence, KY. We did note that a single household from Crittenden and another two from Union participated, which is unexpected since the NES Program typically targets homes in selected neighborhoods.

Table 6. Breakdown of Participant Home Types by Location

Location	Single-Family	Multi-Family	Total Treated
Florence, KY 41042	351	59	410
Covington, KY 41015	6	0	6
Walton, KY 41094	173	2	175
Crittenden, KY 41030	1	0	1
Union, KY 41091	2	0	2
Elsmere, KY 41018	18	0	18
Total	**551**	**61**	**612**

Note: The counts above for single-family are inclusive of manufactured homes. There were a total of 457 manufactured homes.

Based on the results from the consumption analysis, participants save an average of 892 kWh per household per year. Energy and demand savings are displayed in Table 7.

Table 7. Annual Energy Savings and Summer and Winter Peak Demand Reduction per Household

Energy Savings (kWh)	Summer Peak Demand (kW)	Winter Peak Demand (kW)
892	0.07266	0.10785

Note: Demand savings are calculated by applying the kW-to-kWh savings ratio from the engineering analysis to net energy savings from the consumption analysis.

3. Overview of Evaluation Activities

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

- An interview with the DEK program manager
- A review of program materials and program tracking data
- A participant telephone survey
- A consumption analysis
- An engineering analysis of deemed savings
- A process evaluation

The subsections below provide a summary of these activities. Section 4 presents additional results of the consumption and engineering analyses. Section 5 provides results from the process evaluation.

3.1 Program Staff Interviews

Opinion Dynamics conducted an in-depth interview with NES program staff responsible for program administration during the evaluation period. The in-depth interview allowed the evaluation team to discuss implementation of the DEK NES Program, including implementation differences between the DEK program and NES programs in other Duke Energy jurisdictions. We also used this interview to identify program successes, to discuss any difficulties in administering the program, and to determine any barriers for the program achieving its goals.

3.2 Program Material and Data Review

DEK Program administration staff provided Opinion Dynamics with information on the program, including marketing materials and program tracking databases. Review of these materials informed development of the participant survey instrument and the engineering analysis.

- **Marketing Materials.** Opinion Dynamics reviewed the leave-behind brochure, the customer survey booklet, the pre-participation program informational brochure, the leave-behind door hanger, the energy efficiency brochure about other Duke Energy programs, the introduction letter to the NES Program, and postcards sent to participants with information about how to participate.
- **Program Database.** The program staff provided Opinion Dynamics with tracking data covering the evaluation period of June 1, 2018, to June 30, 2019. The database provided us with information on the quantities, location, and types of measures installed in each treated household.

3.3 Participant Survey

The purpose of the participant survey was to collect information to support the development of ISRs and the process evaluation. Opinion Dynamics implemented the survey as a computer-assisted telephone interviewing (CATI) survey between October and November 2021. We fielded the participant survey with customers who participated in the program between July 1, 2019, and March 31, 2020 (i.e., “future participants”) as their recollection of their participation details was likely to be stronger than those who participated in the program during the evaluation period. Though we fielded the survey with customers who participated more recently, we expect their responses about the verification, installation, and persistence of program measures would be similar to the customers who participated during the evaluation period.

3.3.1 Sample Design

We attempted a census for the participant survey and tried to reach all 332 DEK participants from the "future participant" group. The evaluation team completed 29 interviews and achieved a response rate of 28.7%; the average interview length was nine minutes.

3.4 Consumption Analysis

Opinion Dynamics conducted a consumption analysis to determine the energy savings attributable to the NES Program during the evaluation period. We specified linear fixed effects regression (LFER) models to estimate the overall net ex post program savings for the DEK jurisdiction. The fixed effect in our models is the customer, allowing us to control for all household factors that do not vary over time. Treatment customers included those who participated in the program during the evaluation period. We attempted to construct a comparison group consisting of future participants, but due to some differences in treatment and comparison group composition (e.g., differences in seasonal energy consumption and the shares of customers relying on electric vs. gas heating fuel), savings results are based on a pre-post LFER model including treatment customers only. Section 0 provides a summary of the consumption analysis approach; Appendix A contains the detailed methodology description.

3.5 Engineering Analysis

The engineering analysis was used (1) to provide a ratio of kW demand to kWh energy savings, which we applied to the consumption analysis energy savings to estimate demand savings, and (2) to better understand the relative contribution of each measure to overall energy savings.

The engineering analysis consisted of two components:

- **Measure verification and development of measure-specific ISRs:** We verified measures and developed measure-specific ISRs based on responses to the participant survey.[5]
- **A deemed savings review of all program measures:** We reviewed measure-level savings algorithms and parameters and revised input assumptions, as needed. To develop ex post deemed energy and demand savings for each measure, we leveraged, in order of preference, program tracking data, survey results,[6] and Technical Reference Manuals (TRMs). The deemed savings review memorandum developed for Duke Energy provides more detail on the sources and inputs used in the deemed savings review.[7] This document is available as part of Appendix B.

We calculated program-level savings by applying ISRs and ex post deemed savings values to the measure quantities tracked in the program tracking database.

[5] While equivalency checks for the consumption analysis found differences between participants during the evaluation period and future participants (who were included in the survey), we do not expect this to impact the validity of survey-based ISRs. ISRs reflect whether customers received the quantity of measures recorded in the program tracking data, had the measures installed by program staff, and left them in place, which we do not expect to be affected by the observed differences between the two groups.

[6] Detailed survey questions about participant demographics were not included on the survey fielded for this evaluation to keep the survey length short. We relied on participant demographic data from the survey implemented to evaluate the Duke Energy Indiana NES Program in an earlier program period (April 1, 2017, to March 31, 2018).

[7] *DEK NES Program Deemed Savings Review Revised Final Memorandum* from Opinion Dynamics to Duke Energy's EM&V Team. August 29, 2022.

4. Impact Evaluation

4.1 Methodology

The impact analysis included a consumption analysis as well as an engineering analysis. The consumption analysis determined the net evaluated energy (kWh) impacts for the program. The engineering analysis supplemented the consumption analysis by providing (1) a kW-to-kWh savings ratio, which we applied to the consumption analysis energy savings to estimate demand savings, and (2) insights into the relative contribution of each measure to overall savings.

4.1.1 Consumption Analysis

Opinion Dynamics conducted a consumption analysis to determine evaluated energy savings for the DEK jurisdiction. Consumption analysis is a statistical analysis of energy consumption recorded in utility billing records. Because billing records reflect whole-building energy use, the method is well suited for studying the combined impact of the NES Program's mix of energy efficiency measures (and any behavioral changes) per home. Per-household energy savings are estimated by examining variation among participants' monthly electricity consumption in the pre- and post-program periods, ideally relative to the variation in a comparison group's electricity consumption during those times. For this consumption analysis, we were not able to leverage a comparison group due to nonequivalence between the treatment group and the available comparison group customers.

Data Cleaning and Preparation

Prior to specifying the models, we performed a thorough cleaning of the consumption and participation data. We checked data for gaps and inconsistencies as well as for sufficiency. Among other checks, we ensured the participants retained in the analysis had sufficient pre- and post-participation consumption data, participation dates were accurate, and the consumption data was free of outliers, such as bill periods with unreasonably small or unreasonably large consumption.

Comparison Group Selection

Incorporation of a comparison group into the consumption analysis allows evaluators to control for changes in economic conditions and other non-program factors that might affect energy use during the study period. Like many other energy efficiency programs, the NES Program was not designed as an experiment. As such, our preferred approach is to leverage a quasi-experimental approach to the evaluation by developing a comparison group of participants.

There are multiple approaches to selecting a comparison group, including the use of future participants, past participants, or similar non-participants. When possible, it is preferable to use future program participants as a comparison group. The use of future participants—who are similar to the evaluated participants—as the comparison group allows us to effectively control for self-selection biases. The use of a comparison group, however, is predicated on reasonable equivalency in pre-period energy consumption between the treatment group and future participants.

For this evaluation, we were unable to construct a viable comparison group from future participants due to pronounced differences in energy consumption and observable housing characteristics. Due to these differences, we chose to proceed with a treatment participant only modeling approach that evaluates the impacts without a comparison group. This is an acceptable option when a suitable comparison group cannot be constructed and when the nonequivalence of the available comparison group may impact the accuracy or rigor of savings estimates.[8]

Controlling for Participation in Other Programs

Some customers participated in other Duke Energy programs after participating in the NES Program. Including those customers in the consumption analysis would result in double counting of savings from other programs and artificially inflating the estimate of savings from the NES Program. In order to obtain the most accurate estimate of the effects of the NES Program, we removed customers who cross-participated in the following programs from the analysis: Residential Energy Efficient Products & Services, Smart $aver Residential, Residential Energy Assessments, and Low Income Services.

After performing data cleaning and removing cross-participating customers, 357 of the 612 treatment group participants (or 58%) were available for developing the consumption analysis models.[9]

Modeling

We used a Linear Fixed Effects Regression (LFER) model for this analysis. Fixed effects models capture the effect of time invariant household-specific characteristics and are the best practice approach to modeling program savings in the industry. We specified a variety of models ranging from simple pre-post models to more complex models incorporating a variety of terms to control for known sources of variation. We specified distinct models with consideration of unique characteristics of participant populations and integration of additional terms in the models to control for variation. Consumption analyses typically include a series of additional variables to explain non-program variation in monthly energy use pre- and post-participation. Our final model specifications included weather (heating degree days and cooling degree days) in the model as well as monthly dummy variables to further control for seasonal differences in energy consumption. The final models also contained a control for electricity usage, which was interacted with the weather term so as not to be absorbed by the fixed effect. The final models produced savings associated with installed measures and any behavioral changes from energy efficiency knowledge gained during their participation process.

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

4.1.2 Engineering Analysis

The engineering analysis consisted of two distinct steps: (1) verification of measure installation and continued operation and (2) review of per-unit deemed savings values for program measures.

Measure Verification Methodology

The participant survey included questions designed to verify that participants received and installed program measures and that those measures remained in place and operational. The ISR for each measure represents

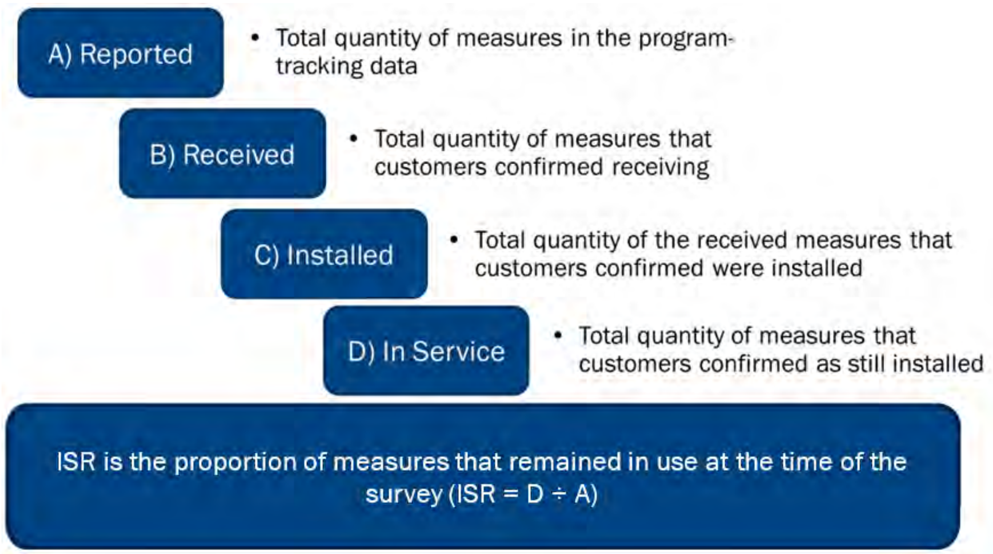
[8] While the comparison group of future participants differed from the treatment group in seasonal energy usage patterns and mix of fuel type for space heating, the evaluation team does not expect that the differences would result in largely different ISRs. Note that ISRs are only used in the engineering analysis, which focuses on the relative contribution of different measure types to program savings. ISRs do not affect the consumption analysis derived ex post net savings for the program.

[9] Note that participants who were excluded from the consumption analysis models are still included in the overall program savings estimate; they receive the average per household savings of modeled participants.

the share of measures in the program tracking data that were in service at the time of the survey, based on responses from surveyed participants who completed the ISR survey battery.

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

Figure 1. In-Service Rate Components



Based on the survey responses, we calculated the verification, installation, and persistence rates, as well as the resulting ISR—using the equations shown in Equation 1—for each participant and each measure they received. We then developed an average of all four rates for each measure group.

Equation 1. In-Service Rate Equations

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

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

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

$$In - Service\ Rate = \frac{(D)In\ Service\ Quantity}{(A)Reported\ Quantity}$$

In previous evaluations of the NES Program, Opinion Dynamics found that participants were unable to verify certain measures (e.g., water heater tank wraps and pipe wraps). For these measures, we assumed 100% for all four rates. Additionally, for some air infiltration measures, such as caulking or glass patch tape, participants were unable to verify installation and persistence of individual measures. As such, we asked participants to verify installation of the entire package of air infiltration measures and assumed that 100% of those treatments remain installed. As tank and pipe wraps and air infiltration measures are installed directly by program staff and in the case of infiltration measures, are difficult to remove, we consider these assumptions reasonable for this type of program.

Deemed Savings Review

To develop ex post per-unit savings for each program measure, we reviewed measure-level savings algorithms and parameters and revised input assumptions, as needed. We leveraged the following sources in our review:

- **Program tracking data:** Where available, we used program tracking data to update household characteristics such as the percentage of homes with electric heat, central cooling, and electric water heating. Since program tracking data is available for the population, it is the most reliable and evaluation-specific source of information.
- **Participant survey data:** Where not available from program tracking data, we used survey data to update household characteristics such as the number of people per household.[10] Since survey data is specific to the program's participants, it is preferable over deemed assumptions from TRMs.
- **Technical Reference Manual (TRM) assumptions:** We used algorithms and parameters from various TRMs. The preferred TRMs were the Indiana TRM v2.2 and the Illinois TRM V10.0. We also leveraged other TRMs, including the Mid-Atlantic TRM V10.0, if a parameter was not available from the Indiana or Illinois TRMs or if other TRMs were deemed to have more recent or more rigorous parameters.

For more information on the algorithms and inputs used to develop deemed savings estimates for each measure, see Appendix B.

Total Program Gross Savings

We developed total program gross savings by applying the measure-specific ISRs and the ex post deemed values to the measure quantities provided in the program tracking database, using the formula shown in Equation 2:

Equation 2

$$Sav = \sum_{i=1}^{n} Q_{dbi} \times ISR_i \times EST_i$$

Where:

i	=	Program measures 1…n, where n = maximum number of DEK NES Program measures
Sav	=	Total program savings
Q_{dbi}	=	Database quantity of measure i
ISR_i	=	In-service rate for measure i
EST_i	=	Per unit deemed savings estimate for measure i (KW or kWh)

Where measure savings vary based on the presence of electric heating equipment, electric water heating equipment, or central cooling equipment, our engineering team developed fuel-specific deemed values and applied them based on the space and water heating equipment specified within the program tracking database. For example, domestic hot water measures are available to all NES participants, regardless of the

[10] See Footnote 6.

fuel they use to heat water in their homes. Participants with electric water heaters are assigned ex post deemed savings values reflective of electric water heating while those with other water heating fuels are assigned zero savings. We then calculated per-household savings by dividing total program savings by the number of participating households.

4.2 Results

4.2.1 Consumption Analysis

This section provides average per-participant consumption analysis results. 27Appendix A contains the complete results of the final model used to estimate the per-household energy savings. Table 8 summarizes modeling results and presents key model fit metrics. The model showed positive statistically significant participation coefficients, indicating that it established a statistically significant relationship between participation in the program and energy consumption.

Table 8. Summary of Modeling Results

Model Output Component	
Modeled Customers (treatment only)	357
Modeled Baseline (kWh/day)	43.28
Modeled Savings (kWh/day)	2.44
Standard Error	0.24
Statistically Significant Participation Coefficient	Yes
Akaike Information Criterion	125,440
Bayesian Information Criterion	128,295
Adjusted R Squared	0.66

Table 9 contains annual savings with associated confidence bounds. The average annual per-household energy savings for DEK participants was 892 kWh, or 5.6% of the baseline consumption.

Table 9. Results of Consumption Analysis Models

Modeled Treatment Participants	Average Annual Baseline Energy Consumption per Participant (kWh)	Average Per Participant Ex Post Net Annual Savings (kWh)	Average Per Participant Savings Percentage	90% Confidence Interval	
				Lower	Upper
357	15,797	892	5.6%	749	1,034

Based on these results and the kW to kWh ratio from the engineering analysis, we developed average per participant demand savings. We then multiplied the per-participant savings by the total number of participants to develop program-level energy and demand savings (Table 10).

Table 10. Net Impact Results from Consumption Analysis

Per Household			Program Level		
Energy Savings (kWh)	Summer Coincident Demand (kW)	Winter Coincident Demand (kW)	Energy Savings (kWh)	Summer Coincident Demand (kW)	Winter Coincident Demand (kW)
892	0.07266	0.10785	545,607	44.5	66.0

4.2.2 Engineering Analysis

Measure Verification Results

The results of the measure verification analysis showed high ISRs for all measures, as shown in Table 11. Verification rates equaled 100% for all measures, which means customers confirmed that they received the quantities tracked in the program data. Installation rates for LEDs and domestic hot water measures ranged from 90% to 96%, which means virtually all received measures were installed. A few participants (n=3) mentioned the LEDs they received were spares that were not needed at the time of their home audit, resulting in an installation rate of 95% for LEDs. The persistence rates for LEDs and faucet aerators are just under 100% due to removal of these measures. Two participants mentioned they uninstalled the faucet aerators because they did not work with their sinks.

Table 11. Measure In-Service Rates

Measure	Verification Rate	Installation Rate	Persistence Rate	ISR
LEDs	100%	95%	95%	91%
Faucet Aerators	100%	96%	96%	93%
Low Flow Showerheads	100%	90%	100%	90%
HVAC Filters [A]	100%	100%	N/A	100%
Infiltration Measures [B]	100%	*Not asked*	*Not asked*	100%
Pipe Insulation Wrap [B]	*Not asked*	*Not asked*	*Not asked*	100%
Tank Insulation Wrap [B]	*Not asked*	*Not asked*	*Not asked*	100%

[A] Since HVAC filters are designed to be removed and replaced regularly, the persistence rate is not applicable for this measure.
[B] Customers often do not have visibility into the installation of infiltration and insulation measures, and these measures are unlikely to be removed. We therefore only verified the receipt of infiltration measures and assumed 100% for all other rates.

Ex Post Deemed Savings Estimates

Table 12 provides the estimated gross per-unit energy and demand savings for all measures installed through the program during the evaluation period. The values below are the average of single-family and multifamily fuel-weighted deemed values. As described in Section 3.5, we based the measure-level savings on program tracking data, survey results, and TRMs, in that order of source preference.

Table 12. Ex Post Per Unit Deemed Energy Savings and Demand Reduction Values

Measure	Energy Savings (kWh)	Summer Peak Demand (kW)	Winter Peak Demand (kW)
Lighting			
LEDs (75W equivalent)	39.11	0.0031	0.0053
LEDs (60W equivalent)	32.43	0.0025	0.0044
LEDs (40W equivalent)	22.42	0.0018	0.0031
LEDs 5W or similar – Globes	19.56	0.0015	0.0027
LEDs 5W or similar – Candelabra Bulbs	20.03	0.0016	0.0027
Domestic Hot Water			
Low Flow Showerhead	415.87	0.0144	0.0288
Water Heater Insulation Wrap	121.54	0.0139	0.0139
Pipe Insulation (5-ft. sections)	192.79	0.0220	0.0220
Kitchen Faucet Aerator	98.01	0.0049	0.0099

Measure	Energy Savings (kWh)	Summer Peak Demand (kW)	Winter Peak Demand (kW)
Bathroom Faucet Aerator	15.02	0.0016	0.0031
Air Sealing			
Infiltration Reduction	81.22	0.0202	0.0273
HVAC			
HVAC Filters	17.08	0.0085	0.0035

Note: The values above are the ex post deemed savings values weighted by (1) fuel type and (2) the share of the measure installed in single-family and multifamily homes, respectively. The values do not reflect ISRs. The ex post deemed savings values are presented in the *DEK NES Program Deemed Savings Review Revised Final Memorandum* from Opinion Dynamics to Duke Energy's EM&V Team. August 29, 2022, which can be found in Appendix B.

Total Program Savings

The evaluation team calculated total program savings by applying the deemed savings values and ISRs summarized above to measure quantities tracked in the program database.[11] Table 13 presents total gross program energy and demand savings by measure for the evaluation period. As this table shows, the individual measures that contributed the most to program savings are low flow showerheads (43%) followed by 60-watt equivalent LEDs (26%). On average, household annual savings were equal to 735 kWh, or slightly lower than the consumption analysis–based annual per household savings of 892 kWh.

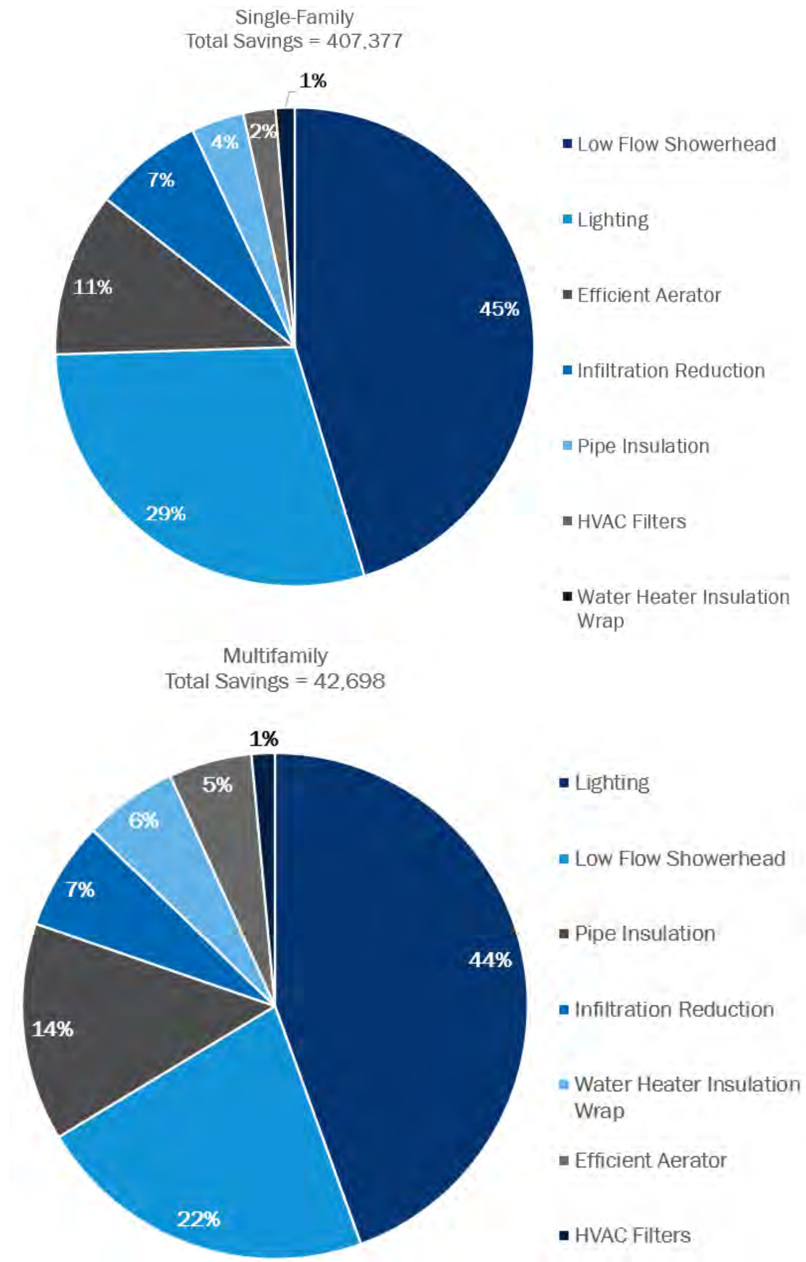
Table 13. Total Gross Program Energy and Demand Savings

Measure	Quantity in Database	Quantity Units	kWh	% of kWh	Summer kW	Winter kW
Lighting						
LEDs (75W equivalent)	23	Per bulb	815	<1%	0.06	0.11
LEDs (60W equivalent)	4,028	Per bulb	118,375	26%	9.29	16.13
LEDs (40W equivalent)	127	Per bulb	2,580	1%	0.20	0.35
LEDs 5W or similar–Globes	309	Per bulb	5,475	1%	0.43	0.75
LEDs 5W or similar–Candelabra Bulbs	590	Per bulb	10,709	2%	0.84	1.46
Domestic Hot Water						
Low Flow Showerhead	518	Per showerhead	193,876	43%	6.72	13.43
Water Heater Insulation Wrap	64	Per water heater	7,778	2%	0.89	0.89
Pipe Insulation (5-ft. sections)	106	Per 5-ft. of pipe	20,436	5%	2.33	2.33
Kitchen Faucet Aerator	404	Per aerator	36,661	8%	1.85	3.70
Bathroom Faucet Aerator	779	Per aerator	10,831	2%	1.12	2.24
Air Sealing						
Infiltration Reduction	407	Per home	33,059	7%	8.24	11.12
HVAC						
HVAC Filters	555	Per home	9,479	2%	4.72	1.94
Total	**7,910**		**450,075**	**100%**	**36.68**	**54.45**

[11] The ex post analysis applies fuel-type and housing-type specific deemed savings values, rather than the single-family weighted average values presented in Table 12.

We further examined the energy savings by disaggregating them by single-family and multifamily housing types. As Figure 2 shows, low flow showerheads contributed the most to single-family program savings (45%), followed by lighting (29%). The opposite is true for multifamily households where lighting measures were responsible for the largest share (44%), followed by low flow showerheads (22%). These different contributions are driven by (1) single-family households, on average, receiving more low flow showerheads (0.8 per household) than multifamily households (0.4 per household) and having a higher incidence of electric hot water heating (92% versus 72%); and (2) multifamily households, on average, receiving more LEDs (11.3 per household) than single-family households (8.0 per household).

Figure 2. Measure Contribution to Total Energy (kWh) Savings for Single-Family and Multifamily Households



5. Process Evaluation

5.1 Researchable Questions

Based on experience evaluating similar programs in previous years and discussions with DEK Program staff, Opinion Dynamics developed the following process-related research questions:

- How satisfied are participants with the program and the measures they received?
- How effective are the one-on-one education and program leave behind materials?
- What are barriers, if any, to implementing or participating in the program?

5.2 Methodology

The process evaluation relied on the following tasks:

- An in-depth interview with the DEK NES Program manager
- A review of secondary materials (i.e., NES marketing materials, data associated with neighborhood populations)
- A telephone survey of program participants
- An analysis of program tracking data

5.3 Key Findings

5.3.1 Program Participation

The NES Program began operation in the DEK territory in 2018. Between June 1, 2018, and June 30, 2019, the program team reached six neighborhoods and served 612 DEK customers. The program surpassed its goal to reach 600 customers but fell slightly short of its goal to reach at least 65% of the customers in the neighborhoods served. Overall, staff reached 53% of customers across all neighborhoods served during the evaluation period.

Measures Provided to NES Participants

To evaluate the success of the program in providing energy-saving measures to participants, and to determine if there were missed savings opportunities, Opinion Dynamics examined the number of measures provided to each home. Table 14 shows the share of homes that received at least one of each measure and the average quantity provided per home (not including homes that did not receive the measure). The table shows that 90% of participating households received at least one LED, with the average number exceeding eight bulbs. Aerators and infiltration reduction measures were provided to at least two-thirds of treated households, while 60% received low-flow showerheads. Almost all households also received education and other measures, as well as HVAC filters. The breadth and depth of the measures provided to participating households shows the success of the program's reach.

Table 14. Measure Installation Rates from Program Tracking Data

Measure Category	Measure	Number of Households with Measure	Percent of Households with Measure	Average Qty Per HH
Lighting	Any LEDs	549	90%	8.3
	LEDs (75W equivalent)	*9*	*1%*	*2.6*
	LEDs (60W equivalent)	*510*	*83%*	*7.9*
	LEDs (40W equivalent)	*22*	*4%*	*5.8*
	LEDs 5W or Similar-- Globes	*59*	*10%*	*5.2*
	LEDs 5W or Similar-- Candelabra Bulbs	*128*	*21%*	*4.6*
Hot Water	Kitchen Faucet Aerator	404	66%	1.0
	Bathroom Faucet Aerator	454	74%	1.7
	Low Flow Showerhead	368	60%	1.4
	Pipe Insulation (5-ft. sections)	60	10%	1.8
	Water Heater Insulation Wrap	64	10%	1.0
Infiltration Reduction	Any Infiltration Reduction	407	67%	n/a
	Door Sweep	*165*	*27%*	*1.3*
	Caulking	*162*	*26%*	*1.0*
	Weatherstripping per Door	*168*	*27%*	*1.2*
	Foam Insulation	*314*	*51%*	*1.0*
	Cover for A/C Installed	*95*	*16%*	*1.7*
	Poly Tape	*1*	*<1%*	*1.0*
HVAC	HVAC Filters	555	91%	12.0
Education/Other	Refrigerator Thermometer	556	91%	2.1
	Water Heater Temperature Check	571	93%	1.0
	Switch Plate Wall Thermometer	527	86%	1.0

Cross Participation

There were high levels of cross participation in other Duke Energy programs among DEK NES participants who participated between June 1, 2018, and June 30, 2019. As shown in Table 15 below, 251 DEK participants (41%) also participated in another Duke Energy program after participating in the NES Program, most of them in the Smart $aver Residential Program. In general, the share of cross-participation is relatively high in comparison to the NES Programs offered in Duke Energy's other jurisdictions. While it is unclear if these participants were directly influenced by the NES Program to participate in another Duke Energy program, the program's focus on energy education (see also Section 5.3.4 below) suggests that their experience with the NES Program and the information they received encouraged them to seek out another Duke Energy program for additional equipment and services.

Table 15. Count of NES Cross Participants by Program

Program	DEK
Smart $aver Residential	221
Residential Energy Efficiency Products & Services	27
Low Income Services	2
Residential Energy Assessment	1
Total Unique Cross Participants	**251**

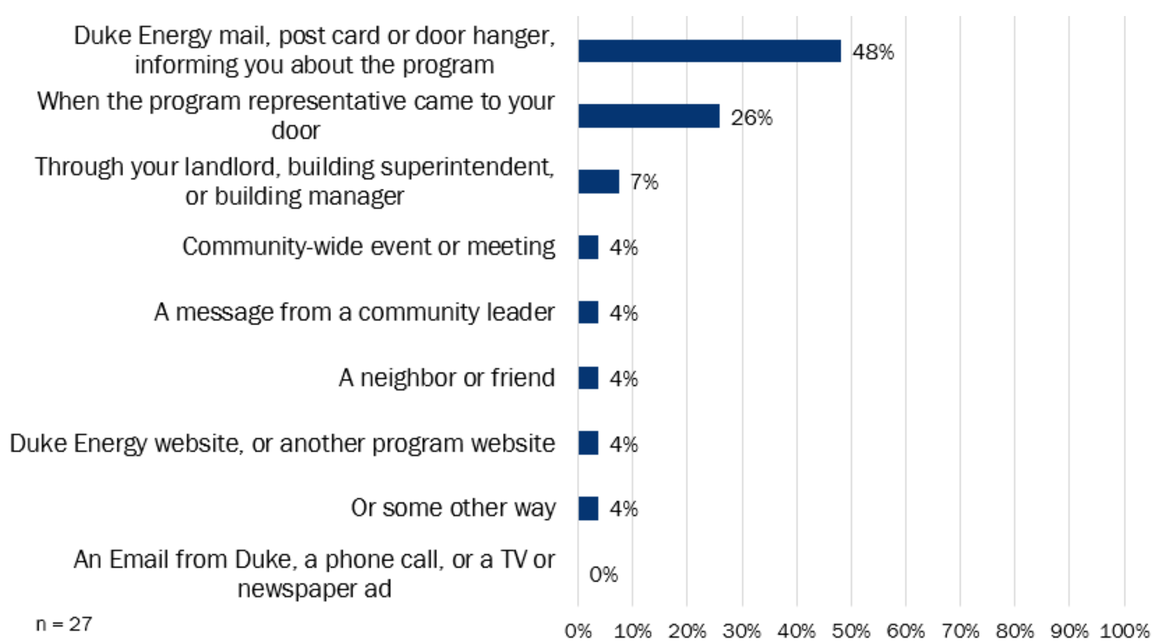
5.3.2 Marketing and Outreach

For each neighborhood, Duke Energy program staff and implementation teams conducted both broad and targeted outreach aimed at encouraging program participation and educating communities about energy efficiency. Program teams first sent customized introductory letters to neighborhood residents that provided information on the measures the program offers, the monetary savings participants can achieve by enrolling, and information about how to participate. The introductory letter also noted any local community organizations that program teams have partnered with and provided information about the neighborhood's community launch event.

In coordination with the implementation teams, program staff conducted a community launch event for each neighborhood, introducing the NES Program and the implementation teams, and showing residents the types of energy efficiency measures offered through the NES Program. Program teams also sent follow-up postcards reminding residents about the NES Program and, for those not home when an implementation team knocked on their door, crews left behind door hangers that provided an option to schedule an appointment to have measures installed.

Figure 3 shows participant responses about how they first heard about the NES Program. The most common way participants heard about the program was through a direct mailer, postcard, or door hanger (48%). The second most common method respondents cited was a home visit from a program representative (26% of participants). These responses indicate the initial contact made by the program team is an effective form of outreach that introduces a majority of NES participants to the program.

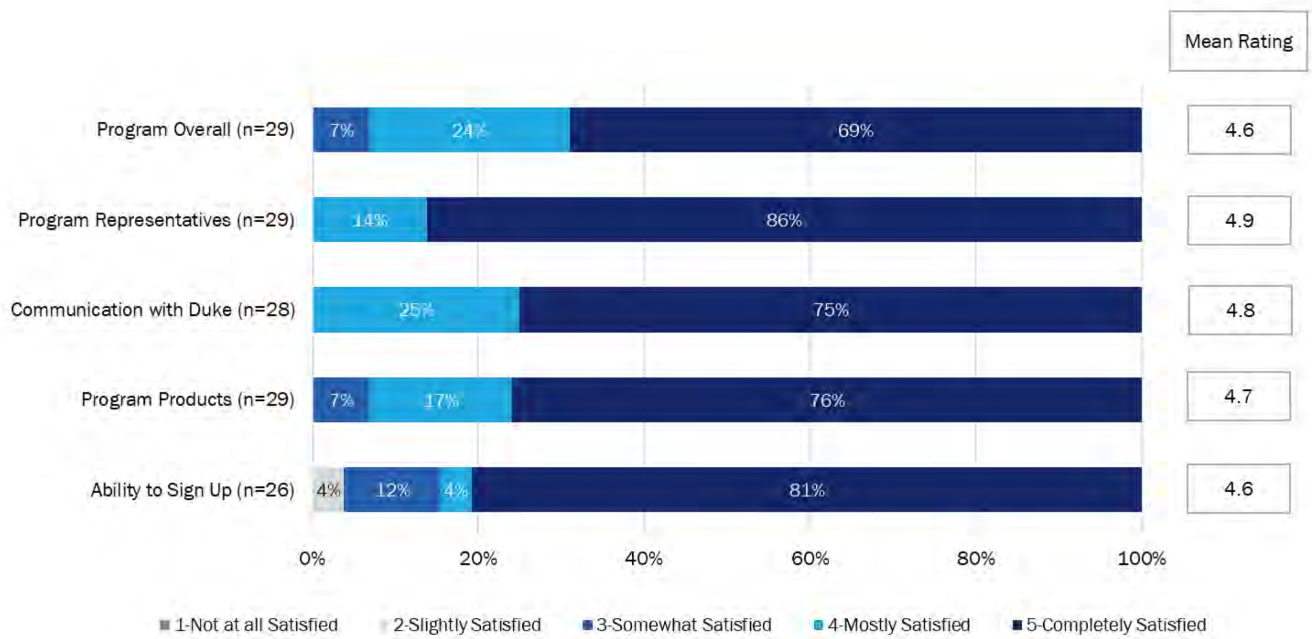
Figure 3. How Participants First Heard About the NES Program



5.3.3 Program Satisfaction

Participants were generally satisfied with all components of the program. As shown in Figure 4, on a five-point scale where 5 is "completely satisfied" and 1 is "not at all satisfied," 93% of DEK NES respondents reported that they were either "completely satisfied (5)" or "mostly satisfied (4)" with the program overall, as well as with program products they received. In fact, no participants expressed any dissatisfaction with any of the program components, (i.e., a rating of 1). All participants were also completely or mostly satisfied with program representatives who installed energy-efficient equipment and their communication with Duke Energy staff. Additionally, 85% of respondents were completely or mostly satisfied with their ability to sign up with the program. Based on the responses provided to the satisfaction questions, an overwhelming majority of customers were completely or mostly satisfied with the program overall as well as all aspects of the program about which they were asked.

Figure 4. Satisfaction with NES Program Overall and Program Components



5.3.4 Energy Education

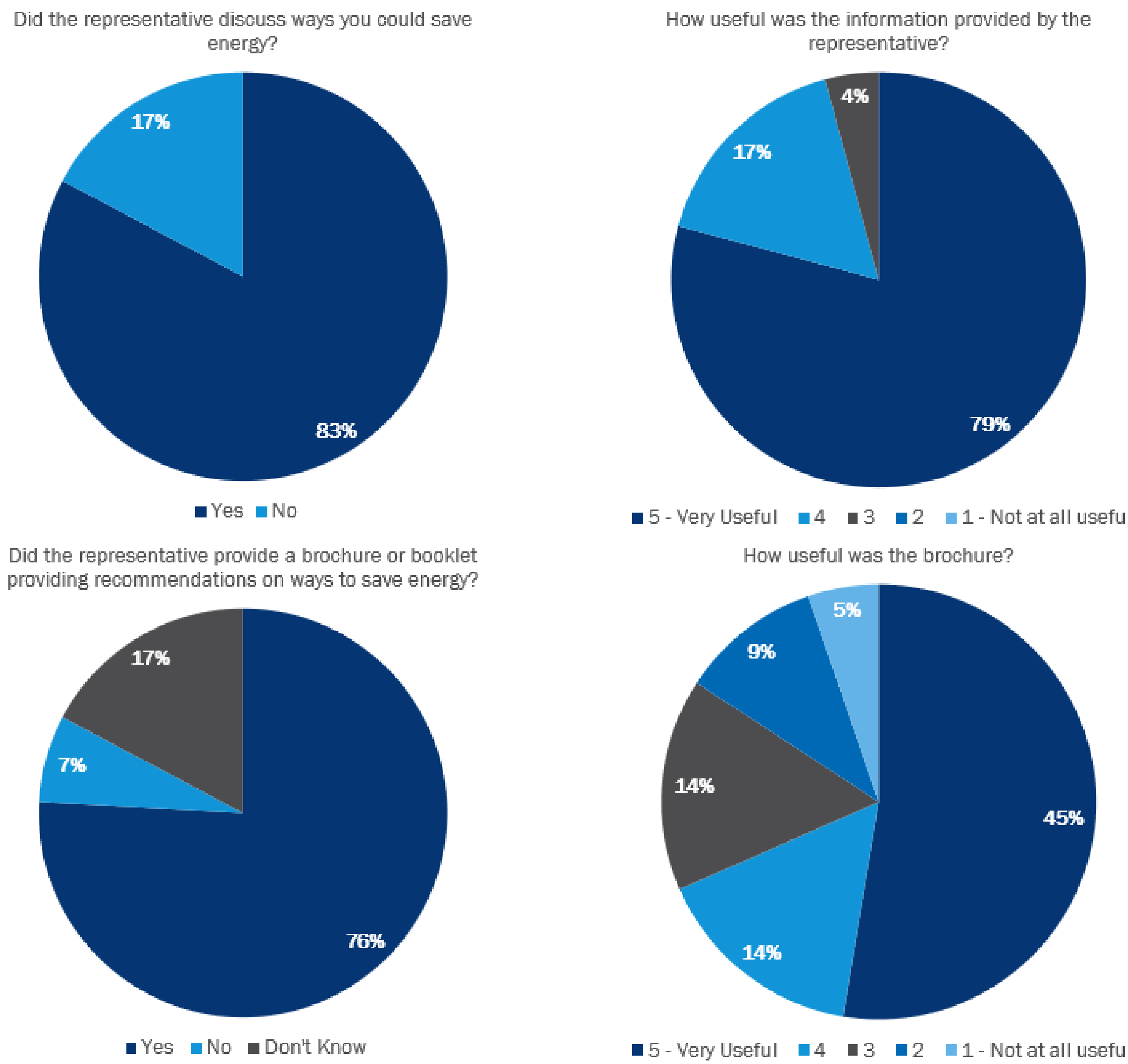
An important customer benefit of the NES Program is the energy education customers receive, which occurs at several points during the participation process:

- Prior to the in-home visits by program representatives, customers receive information about ways to save energy through mailings and flyers either left at their homes or provided at community launch events.
- During the launch events, program staff discuss the energy-saving measures offered through the NES Program and how each measure saves energy in participants' homes.
- During the in-home visits, the implementation team provides more detail on energy-saving measures, discusses other ways participants might change their behavior to save more energy, and answers participant questions. The implementation team then leaves behind information to reinforce the energy education, provides other tips for saving energy in their homes, and shares information about other Duke Energy programs for which participants may have been eligible.

Overall, our evaluation found the energy education provided through the program to be very effective, especially the information provided in conversations with the program representative. As shown in top left pie chart in Figure 5, 83% of respondents reported discussing energy-saving tips with the implementation team, and close to 80% of these found this information to be very useful (e.g., a 5 on a scale of 1 to 5 where 1 is "not at all useful" and 5 is "very useful") in helping them save energy (top right pie chart).

In addition, as shown in the pie chart on the bottom left, 76% of respondents said that they received educational materials during their home visit. Of those, almost 70% ranked the usefulness of the brochure at a 4 or 5 where 1 is "not at all useful" and 5 is "very useful" (bottom right pie chart).

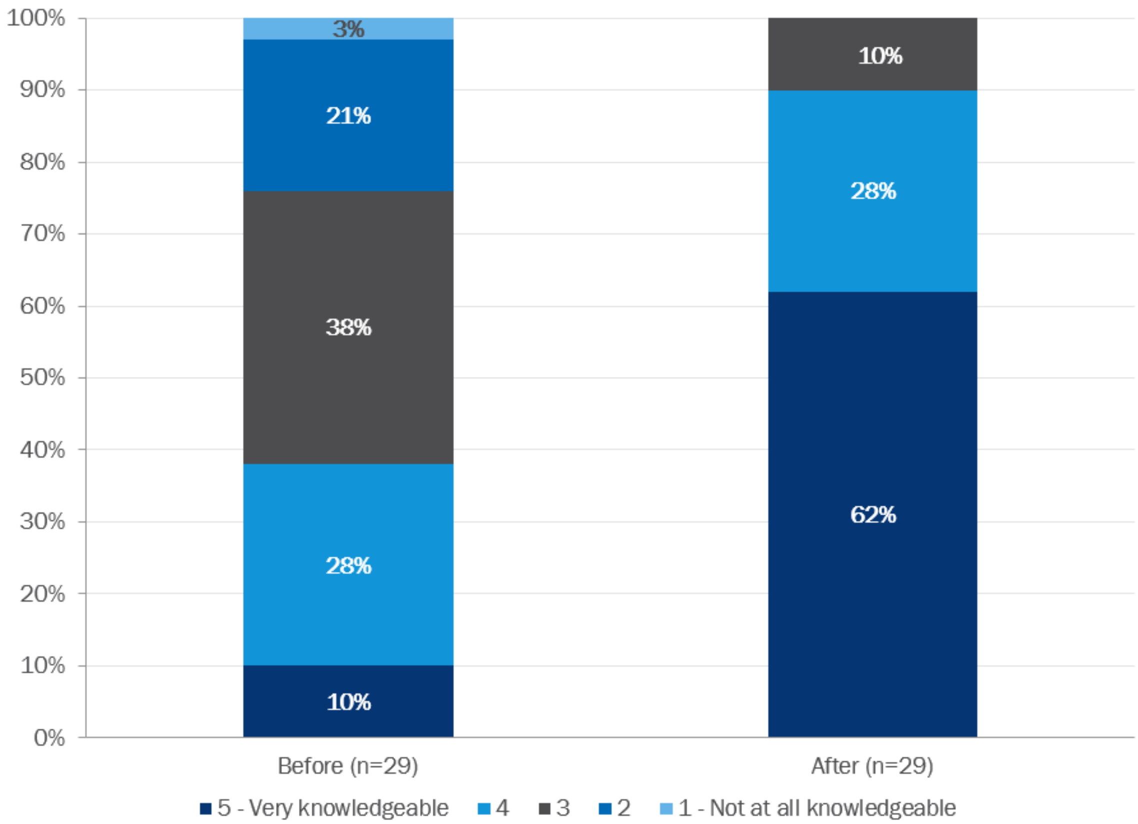
Figure 5. Energy Information from Program Representatives Received and Its Usefulness



Note: The energy information participants received included a brochure or booklet that was provided by the NES representative during their home visits.

Interviewed participants also reported that their knowledge increased after their enrollment in the NES Program. Prior to participation, 38% of participants rated their knowledge about ways to reduce energy usage in their homes either a 4 or a 5.[12] After participation, 90% of respondents gave a rating of 4 or 5 when asked the same question, indicating the effectiveness of the NES Program in increasing participants' perceived energy usage knowledge (see Figure 6).

Figure 6. Participant Knowledge of Ways to Save Energy



5.3.5 Barriers to Participation and Participants' Recommendations to Improve the Program

Respondents were asked whether they faced any barriers to participating in the program; notably, all said that they experienced none. Accordingly, most respondents did not offer any recommendations to improve the program when asked, though a few did make comments and provide suggestions. One respondent noted that he was not aware that the program was being offered until an NES representative knocked on his door, which is not unusual given the design of the program's outreach and the fact that 26% of participants first found out about the program when the representative came to their door. This respondent would have preferred to hear about the program ahead of time. When asked what additional measures they would like to see the program offer, two customers said they would like to see the program offer windows — a measure that is not consistent with direct install nature of the program.

[12] On a scale from 1 to 5, where 1 means "not at all knowledgeable" and 5 means "very knowledgeable."

6. Conclusions and Recommendations

Overall, the NES Program team implemented the program effectively and achieved its goal of serving 600 households through the program annually. Participation was strong with a total of 612 DEK customers from six different neighborhoods participating in the NES Program between June 1, 2018 through June 30, 2019. Though the number of households served surpassed the annual program goal, the program penetration rate was 53%, which falls below the goal to reach 65% of homes in neighborhoods served.

Using consumption analysis, the evaluation team found annual ex post net program savings of 892 kWh. The estimates include savings from equipment installed by program representatives, as well as savings from any additional behavioral changes and participant spillover attributable to the program.

The engineering analysis included development of in-service rates (ISRs) and a review of deemed savings values. ISRs were 90% or higher for all measures provided through the program. The engineering analysis also showed that low flow showerheads contributed the largest share of program savings (41%), followed by lighting (29%).

The process evaluation showed that outreach and educational efforts by the program were successful and that the program provided most participating households with a comprehensive package of energy savings measures. In addition, participation in other programs following participation in the NES Program was high (41%). Participants did not experience any barriers to participation, and customer satisfaction was high as well, with the program and all program components receiving average satisfaction ratings of 4.6 or higher (on a scale of 1 to 5).

Based on our evaluation, the DEK NES Program is operating successfully. We therefore recommend Duke Energy continue offering the program as it has been.

7. EM&V Summary Form

DUKE ENERGY KENTUCKY
NEIGHBORHOOD ENERGY SAVER PROGRAM
COMPLETED EM&V FACT SHEET

PROGRAM DESCRIPTION

The DEK Neighborhood Energy Saver (NES) Program provides one-on-one energy education, on-site energy assessments, and energy conservation measures to customers in selected low-income neighborhoods. These services are offered free of charge to all active DEK account holders who are individually metered homeowners and tenants living in predetermined income-qualified communities.

Date:	December 20, 2022
Region(s):	Duke Energy Kentucky
Evaluation Period:	June 1, 2018 – June 30, 2019
Annual kWh Savings (ex post net):	545,607 kWh
Coincident kW Impact (ex post net):	44.47 kW (Summer), 66.01 kW (Winter)
Measure Life:	Not Evaluated
Net-to-Gross Ratio:	N/A
Process Evaluation:	Yes
Previous Evaluation(s):	Not evaluated previously

EVALUATION METHODOLOGY

The evaluation team conducted a **consumption analysis**, using a Linear Fixed Effect Regression (LFER) model, to determine the overall ex post net program energy savings.

In addition, we conducted an **engineering analysis**, consisting of a deemed savings review and a survey-based ISR analysis. Based on the results of these two analyses, we calculated ex post gross energy and demand savings for measures provided through the DEK NES Program. The goal of the engineering analysis was to (1) develop a kW-to-kWh savings ratio, which we applied to the consumption analysis energy savings to estimate demand savings, and (2) provide insights into the relative contribution of each measure to overall savings.

We also conducted a **process evaluation** focused on participant satisfaction, marketing and outreach, cross participation in other Duke Energy programs, energy education received through the program, and barriers to participation. We based the process evaluation on an interview with the DEK Program manager, responses to a participant survey, and a review of program tracking data.

8. DSMore Table

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

Appendix A. Detailed Consumption Analysis Methodology

The evaluation team conducted a consumption analysis using a Linear Fixed Effect Regression (LFER) model, with the goal of determining the overall ex post net program savings. The model allows all household factors that do not vary over time to be absorbed by (and therefore controlled for) the individual constant terms in the equation. In other words, this method uses account-specific intercepts.

As part of the consumption analysis of Neighborhood Energy Saver (NES) program participants, the evaluation team followed a standard series of steps for data collection, data cleaning, model specification, and analysis.

Participant Data Preparation

The participant dataset contained a range of data fields with participation attributes including participant identifiers, participation dates, measure detail, and participant housing characteristics. The participant data set included customers who participated in the program between June 1, 2018, and March 31, 2020 (including both the treatment group and the comparison group of future participants). As part of our review of the participation data, we worked with Duke Energy to ensure that participation files were complete based on our explorations of participation trends over time and comparison of accounts in the participation and consumption data received.

Comparison Group Selection

A key challenge for estimating energy savings via consumption analysis is the identification of an appropriate comparison group to represent a baseline for how much energy the customers would have consumed in the absence of the program. We consider two main factors in the design of a comparison group. A comparison group must: (1) have similar energy usage patterns (compared to participants) before participation (i.e., pre-participation period) and (2) effectively address self-selection bias (the correlation between the propensity to participate in a program and energy use). In an ideal experimental design, we would use a randomized control group that would be equivalent to the treatment group in all aspects, save for the treatment being evaluated (in this case, participation in the NES Program). When a randomized control trial is not feasible, we use a matched comparison group based on usage and other characteristics. A perfect match is impossible when studying the effects of energy efficiency programs, since we cannot know if any group of non-participants is equivalent to the participant group, especially on the dimension of what the participants would have done absent the program. We generally cannot even know whether a “matched” customer might be in the market for relevant equipment. Achieving similarity on usage supports our aim that the estimates from our quasi-experiment are representative on usage patterns at least. Usage patterns reflect not only a household’s level of electricity use but also its energy-related responses to changes in the weather, economic, and political environment. It is more difficult to assure that the comparison group represents what the participants would have done absent the program. Another way to put it is that it is difficult to know whether we have captured factors involved in customers’ self-selection into the program, some of whom would have installed program-qualified measures without the program.

If we could establish a reasonable level of equivalency, we would rely on future participants as a comparison group for this analysis. The use of future participants allows us to better control for self-selection, because those customers choose to participate in the same program, just later. With the NES Program, wherein distinct neighborhoods with differing geographic and housing characteristics are targeted over time, leveraging future participants as a comparison group may not always be possible due to differences that targeting different neighborhoods over time may create in participant composition and their energy consumption.

To support the evaluation of this program, we attempted to construct a comparison group comprised of future participants who participated between July 1, 2019, and March 31, 2020.[13] Upon constructing this group, we encountered differences between the treatment and comparison group, leading to a conclusion of non-equivalence. This exploration is discussed further in the equivalency section. Although we attempted to control for the differences between the treatment and comparison group in modeling, we ultimately concluded that these differences were too substantial, and the use of a comparison group would not lead to the most rigorous or accurate savings estimates possible in this case.

Consumption Data Preparation

Upon merging participant and consumption data, we performed the following consumption data cleaning steps:

- **Duplicate records.** We explored duplicate records and made adjustments to arrive at a single bill per period.
- **Inadequate days.** We identified and dropped bill periods with zero or negative days.
- **Extremely low Average Daily Consumption.** We checked for and dropped bills with very low (less than 0 kWh) or missing average daily consumption.
- **Extremely high Average Daily Consumption.** We checked for customers with entire pre- or post-installation periods having very high (exceeding three times the standard deviation) average usage.
- **Inadequate billing history before or after program participation.** Many energy savings measures in these programs are expected to generate energy savings throughout the year. To assess changes in consumption due to program measures before and after installation, we need to ensure that participants have a billing history covering, at a minimum, nine months (or the 270-day equivalent) in the pre- and post-installation periods.
- **Insufficient billing history in the heating season before and after program participation.** We also required participants to have a billing history that included a minimum of 75% of the heating season (November through March) in the pre-participation and post-participation periods.
- **Insufficient billing history in the cooling season before and after program participation.** Similar to the heating season, we required participants to have a billing history that included a minimum of 75% of the cooling season (June through August) in the pre-participation and post-participation periods.
- **Removing consumption records for cross-participants.** We identified and removed NES Program treatment participants as well as future comparison group participants who cross-participated in one or more of seven programs administered by DEK following NES program participation. Customers were only removed if they cross-participated during the evaluation period. However, the average per-participant savings estimate was multiplied by the total number of evaluated participants, including those who participated in other programs, to determine total program savings.

[13] Often, we use future participants that participated a year after the end of the evaluation period as the comparison group. For this analysis, we shortened this time period to avoid confounding effects of the COVID-19 pandemic.

Data Cleaning Summary

Table 16 contains a summary of the accounts dropped as part of each cleaning step for treatment and comparison groups comprised of future participants. As these tables show, the largest drops are associated with insufficient pre-period and post-period consumption data as well as with cross-participation. Upon completing data cleaning, we retained over half of treatment group participants (58%) in our analysis and 72% of future comparison group participants.

Table 16. Summary of Data Cleaning Results

Drop Reason	Treatment Accounts Remaining		Comparison Accounts Remaining	
	N	%	N	%
Total	612	100%	367	100%
Duplicate Records	612	100%	367	100%
Inadequate Days	612	100%	367	100%
NA or Negative Usage	612	100%	367	100%
Outliers	612	100%	366	100%
Long Bills	612	100%	366	100%
Pre-Period Sufficiency	509	83%	321	87%
Post-Period Sufficiency	445	73%	321	87%
75% Heating Days in Pre	421	69%	305	83%
75% Heating Days in Post	390	64%	305	83%
75% Cooling Days in Pre	390	64%	304	83%
75% Cooling Days in Post	387	63%	304	83%
Gaps and Overlaps	387	63%	304	83%
Cross Participation	357	58%	265	72%

Weather Data Preparation

To include weather patterns in our model, we used daily weather data from numerous weather stations across the DEK territory, utilizing the site closest to each account's geographic location. By using multiple sites, we increased the accuracy of the weather data associated with each account. We obtained these data from the National Climatic Data Center (NCDC).

The daily data are based on hourly average temperature readings from each day. We calculated cooling degree day (CDD) and heating degree day (HDD) for each day (in the analysis based on average daily temperatures, using the same formula used in weather forecasting).[14] We merged daily weather data into the consumption dataset so that each billing period captures the HDD and CDD for each day within that billing period (including

[14] A "degree-day" is a unit of measure for recording how hot or how cold it has been over a 24-hour period. The number of degree-days applied to any particular day of the week is determined by calculating the mean temperature for the day and then comparing the mean temperature to a base value of 65 (HDD) and 75 (CDD) degrees Fahrenheit. (The "mean" temperature is calculated by adding together the high for the day and the low for the day, and then dividing the result by 2.) If the mean temperature for the day is 5 degrees higher than 75, then there have been 5 cooling degree-days. On the other hand, if the weather has been cool, and the mean temperature is 55 degrees, then there have been 10 heating degree-days (65 minus 55). "Degree Days," National Weather Service, https://www.weather.gov/ffc/degdays.

start and end dates).[15] For analysis purposes, we then calculated average daily HDD and average daily CDD, based on the number of days within each billing period.

Comparison Group Equivalency Assessment

Future Comparison Group Assessment

The appropriate use of the future participant comparison group design depends on its equivalency with the treatment group on as many dimensions as possible, including consumption during the pre-participation period, weather, program implementation, and available sociodemographic data for participants. Substantial differences between the treatment and comparison groups could lead to a misrepresentation of the baseline or point of comparison. As such, as part of our assessment of the comparison group equivalency, we explored the following dimensions:

- Pre-period consumption
- Weather
- Housing characteristics

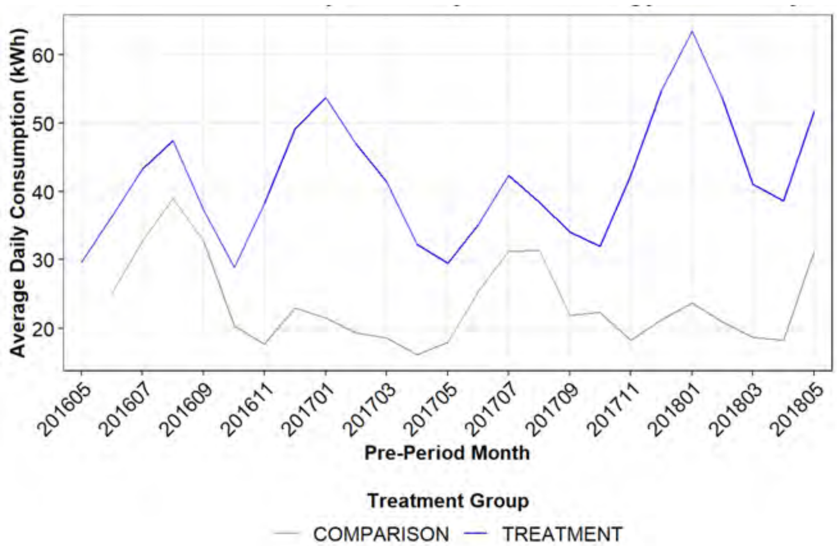
Pre-period Consumption

Participants enter the NES Program on a rolling basis, which means that each participant's pre- and post-period is defined by that customer's participation date and is specific to that participant's timing of program entry. Therefore, when assessing equivalency of the comparison and treatment groups' energy consumption, it is important to use a pre-period shared by both groups.

Figure 7 summarizes consumption trends (average daily consumption [ADC]) between treatment and comparison groups for DEK. As the figure shows, pre-participation energy usage of the comparison group followed a significant divergent pattern throughout the full pre-period, signifying underlying differences between these groups.

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

Figure 7. Participant and Comparison Group Usage During their Pre-Participation Period



Weather

Figure 8 and Figure 9 compare HDD and CDD between treatment and comparison groups for DEK. These figures show that weather patterns were very similar between treatment and comparison participants.

Figure 8. Average Heating Degree Days Experienced by Treatment and Comparison Groups

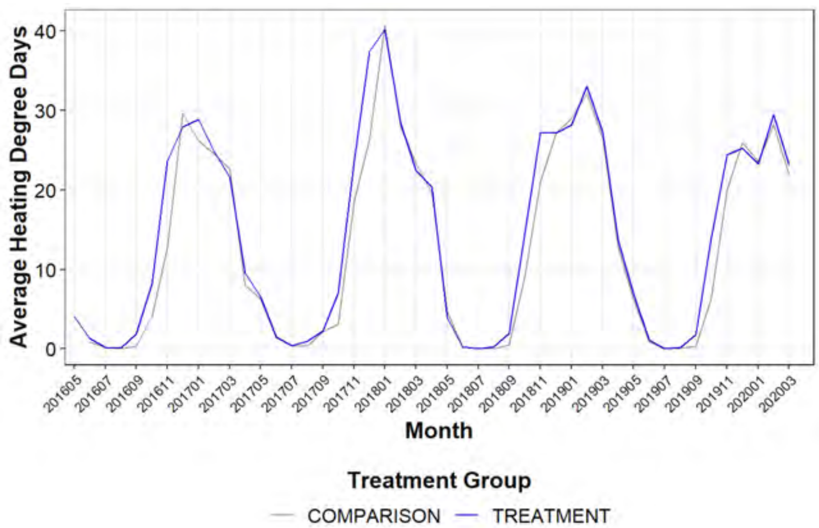
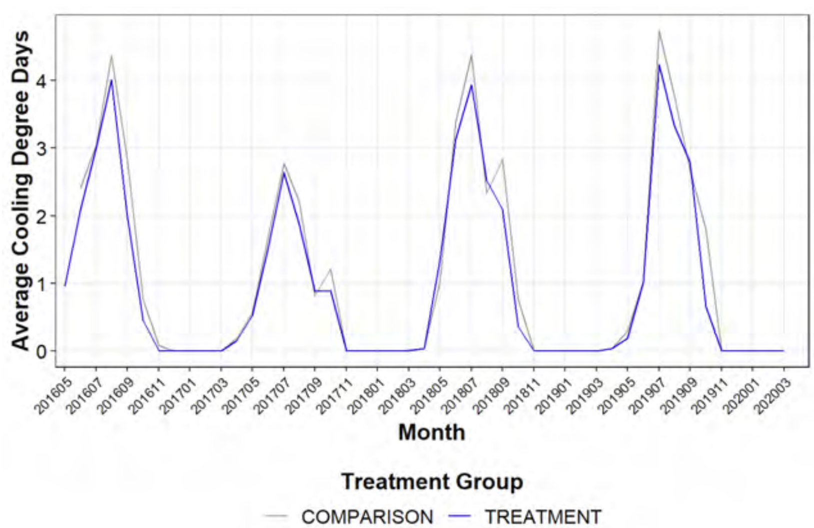


Figure 9. Average Cooling Degree Days Experienced by Treatment and Comparison Groups



Household Characteristics of Participants

Table 17 shows core available heating and housing characteristics of treatment and comparison group participants. As shown, DEK treatment and comparison group participants differ in terms of heat source and home type. While these time invariable differences should be captured and absorbed by the fixed effect in our model, our concern was that these differences in heating and housing characteristics could be associated with pre- to post- differences in consumption, (i.e., the housing characteristic can affect the impact “slope” in the model).

Table 17. Household Characteristics of Treatment and Comparison Groups

Characteristic	Treatment	Comparison
Heat Source [a]		
Electric	49%	20%
Gas	49%	78%
Home Type		
Manufactured Housing	78%	1%
Multi-Family	6%	24%
Single-family	17%	75%

[a] Values do not sum to 100% due to missing data for a small number of participants

Given both the housing and pre-period consumption differences observed between the treatment and future participant comparison group, we chose to exclude the comparison group from the model.

Model Specifications

To estimate savings for the NES Program, Opinion Dynamics specified a LFER model in a pre-post design that incorporated weather and interaction terms, showing the effect of weather in the post-installation period. The fixed effect for the model is set at the account level, which allows us to control for all household factors that do not vary over time. In the process of determining the appropriate model for the analysis, we specified a range of models from simple pre-post to more complex models incorporating a variety of terms and controls.

We judged our final models on several criteria. Primarily, we aimed to use a model that explained as much about changes in the dependent variable as possible. The most direct measure of this is the adjusted R-squared, which provides an estimate of the extent to which the model explains any difference between post-period usage and the baseline. We also compared Akaike Information Criterion (AIC) values of each model specification within the same sample. The AIC provides a measure of relative quality between models; a lower value indicates a relatively more efficient model. This method inherently incorporates explained variation as well as how many variables we use to achieve that level of explanation.

Equation 3 contains final model specifications for the DEK NES Program. Of all the models we tested, we found these to have the best overall fit and the most reasonable set of terms.

Equation 3. Final Model Specification – DEK

$$ADC_{it} = B_h + B_1 TreatPost_{it} + B_2 HDD_{it} + B_3 CDD_{it} + B_4 HDD_{it} \times Electric_i + B_{5-15} MonthDummies_t + \varepsilon_{it}$$

Where:

ADC_{it} = Average daily consumption (in kWh) for the billing period

$TreatPost$ = Indicator for DEK treatment group in post-installation period (coded “0” in the pre-participation period, coded “1” in post-installation period)

HDD = Average daily heating degree days from NCDC

CDD = Average daily cooling degree days from NCDC

$Electric$ = Indicator for Electric Heat Usage (0,1) that does not vary over time; interacted with HDD

B_h = Average household-specific constant

B_1 = Main program effect (change in ADC associated with being a participant in the post-installation program period)

B_2 = Increment in ADC associated with one-unit increase in HDD

B_3 = Increment in ADC associated with one-unit increase in CDD

B_4 = Increment in ADC associated with one-unit increase in HDD for customers who have electric usage

B_{5-15} = Increments in ADC associated with each calendar month, omitting April

ε_{it} = Error term

Table 18 provides the coefficients estimated using the above model specification. Virtually all coefficients were statistically significant at the 95% confidence level (i.e., p-value < 0.05).

Table 18. Final Model Coefficients

Variable	Estimate	Significant (p-value < 0.05)
TreatPost	-2.44251	Yes
HDD	0.009187	No
CDD	4.303664	Yes
February	0.927054	No
March	-3.40376	Yes
April	-7.01856	Yes
May	0.397063	No
June	-3.96094	Yes
July	-3.01196	Yes
August	-2.14896	Yes
September	-3.76764	Yes
October	-8.45564	Yes
November	-4.75298	Yes
December	-1.58358	Yes
HDD × Electric	1.468351	Yes

Savings Estimation

The regression model results presented in the section above show a statistically significant reduction in electric consumption in the DEK jurisdiction. Table 19 shows an estimate of the average daily savings, which reflect actual savings under actual weather conditions.

Table 19. Modeled Savings Estimates

Modeled Treatment Participants	Average Daily Savings Estimate (kWh)	Standard Error	Significant	90% Confidence Interval	
				Lower	Upper
357	2.44	0.24	Yes	2.05	2.83

To better facilitate comparisons of program performance, we also show savings here as a percentage of energy saved with respect to the modeled baseline. The baseline usage is calculated using the coefficients from the model and fixed effects. This calculation shows the energy that customers would have used, on average, if the program equipment had not been installed. To estimate the percent of savings from baseline energy consumption, we divided the change in daily electricity use for the program by the mean baseline ADC to arrive at the savings percentage. We annualized first-year savings by multiplying the daily savings estimate by 365 days. The annualized value represents average annual first-year savings. Table 20 shows estimated annualized savings, baseline consumption, and savings percentages. We used these values to determine the overall program level savings reported in the body of the report.

Table 20. Estimated Annual Savings from Consumption Analysis

Average Annual Baseline Energy Consumption per Participant (kWh)	Average Per Participant Ex Post Net Annual Savings (kWh)	Average Per Participant Savings Percentage	90% Confidence Interval	
			Lower	Upper
15,797	892	5.6%	749	1034

Appendix B. Final Deemed Savings Review Memorandum

The DEK Program Deemed Savings Review Revised Final Memorandum is provided as a separate attachment to this report.

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Duke Energy Kentucky Online Savings Store Program

2022 Evaluation Report – FINAL

October 6, 2022

Opinion Dynamics

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1. Evaluation Summary

This report provides results of an impact and process evaluation of the Duke Energy Kentucky (DEK) Online Savings Store (OSS) Program. The program period under evaluation is August 1, 2017 through June 30, 2021. We refer to this period as the evaluation period throughout the remainder of this report.

1.1 Program Summary

Duke Energy's OSS Program offers a wide range of point-of-sale (POS)-discounted specialty LED lighting and advanced thermostat products as well as several other water-saving measures and electric devices, including low-flow showerheads with thermostatic shower valves (TSVs), standalone TSVs, air purifiers, and dehumidifiers.[1] Incentivized LED lighting includes a variety of specialty bulb shapes and wattages and fixtures,[2] and advanced thermostats include a range of different models at different price points from leading brands. The non-lighting measures reflect an expansion of the Online Savings Store, which, up until July 2020, exclusively distributed energy-efficient lighting products.

1.2 Evaluation Objectives

This evaluation included process and impact assessments and had several key objectives:

- Estimate gross and net energy (kWh) and peak summer and winter demand (kW) savings and realization rates for the evaluation period.
  - Review program tracking data for completeness and accuracy and discuss implications of any errors or inconsistencies for program savings estimates.
  - Review deemed savings estimates used to track program performance and provide recommendations for updates to assumptions where necessary.
  - Verify product installation and persistence and estimate in-service rates (ISRs) by product category based on participant survey responses.
  - Develop net-to-gross ratios (NTGRs) based on participant survey responses.
- Gauge customer preferences as well as current and expected market trends to provide recommendations for how future implementation strategies can maximize customer engagement and minimize free ridership (FR).
- Assess the program's implementation processes and marketing strategies to identify key successes and opportunities for improvement.

[1] Zero dehumidifiers were sold during the evaluation period.
[2] The program discontinued offering standard LEDs in Q3 of 2020.

1.3 High Level Findings

From August 1, 2017 through June 30, 2021, Duke Energy's OSS Program sold 105,730 discounted energy-efficient products to DEK customers, achieving program-tracked ex ante energy savings of 3.9 GWh. Table 1 provides a summary of program sales and ex ante energy savings.

Table 1. Online Savings Store Program Performance by Product Category

Product Category	Units Sold	% of Sales	Ex Ante Gross kWh Savings	% of Savings
Specialty LED	49,474	47%	925,040	24%
Reflector LED	43,560	41%	2,162,702	55%
Standard LED	11,526	11%	280,082	7%
LED Fixture	38	<1%	4,920	<1%
Advanced Thermostat	1,122	1%	558,734	14%
Showerhead with TSV	5	<1%	1,393	<1%
Air Purifier	4	<1%	1,612	<1%
Standalone TSV	1	<1%	73	<1%
Total	**105,730**	**100%**	**3,934,555**	**100%**

Note: Specialty LEDs include globe, decorative, and three-way bulbs; reflector LEDs include both indoor and outdoor bulbs; LED fixtures include portable, direct wire, and photocell products.

1.3.1 Impact Evaluation

The DEK program realized 3.3 GWh in ex post gross energy savings, 0.56 MW in summer peak demand savings, and 0.64 MW in winter peak demand savings during the evaluation period. Gross realization rates for the DEK program are 85% for energy savings, 243% for summer peak demand savings, and 275% for winter peak demand savings. Realization rates for LED lighting, which accounts for more than 90% of ex post gross energy and winter peak demand savings and 75% of summer peak demand savings, ranged from 91% for energy savings to 250% for winter peak demand savings. High realization rates for demand savings are in part driven by recessed outdoor LEDs, globe LEDs, and three-way LEDs, for which ex ante demand savings were not claimed. For advanced thermostats, which account for 8% of ex post gross energy savings, the energy realization rate was around 50%.[3] Advanced thermostats also account for 25% of ex post gross summer demand savings and 9% of ex post gross winter demand savings, but were not assigned ex ante demand savings, and therefore contribute to high overall demand realization rates.

After applying NTGRs, developed based on responses to the participant survey, the DEK offering achieved 1.2 GWh in ex post net energy savings, 0.25 MW in ex post net summer peak demand savings, and 0.24 MW in ex post net winter peak demand savings.

[3] In the absence of additional information on the sources of ex ante assumptions, the reasons for differences between advanced thermostat ex ante and ex post per-unit savings estimates remain unknown.

Table 2 summarizes total ex ante, ex post gross, and ex post net savings.

Table 2. Online Savings Store Program Performance Summary

Metric	Ex Ante	Gross RR	Ex Post Gross	Effective NTGR	Ex Post Net
Energy Savings (kWh)	3,934,555	85%	3,334,127	0.372	1,241,646
Summer Peak Demand Savings (kW)	232	243%	563	0.448	252
Winter Peak Demand Savings (kW)	232	275%	637	0.377	240

Note: NTGR values were developed by product category. While NTGRs do not vary across energy and demand savings, the effective NTGRs (estimated as ex post net savings divided by ex post gross savings) do as a result of varying contributions of each product category to energy and summer and winter demand savings.

Table 3 provides NTGR results by product category. The evaluation team produced NTGR estimates that account for both FR and participant spillover (PSO). We estimated FR separately for each product category and developed PSO estimates for the program population overall. The NTGR results shown here are applied to ex post gross savings to produce ex post net savings estimates.

Table 3. NTGR Results

Product Category	FR	PSO	NTGR
LED Lighting[A]	0.672	0.005	0.333
Advanced Thermostats	0.205		0.800
Showerheads with TSVs and Standalone TSVs[B]	N/A	N/A	0.979
Air Purifiers[C]	0.146	0.005	0.859

[A] Due to limited participation, the survey did not include FR questions for standard LEDs or LED fixtures. FR for LED lighting therefore reflects the averages of lighting categories that were included.

[B] Due to limited participation, the survey did not include FR questions for showerheads with TSVs or standalone TSVs. We instead defer to the ex ante NTGR provided by Duke Energy staff.

[C] Due to limited participation, the survey did not include FR questions for air purifiers, and no ex ante alternative was available. FR values for this measure therefore reflects the average of other non-lighting product categories, leveraging survey results collected from both DEK and DEI participants.

1.3.2 Process Evaluation

The evaluation team identified the following high-level process findings based on research conducted as part of this evaluation:

- Participants are highly satisfied with program-discounted products, key program elements, and the program overall, contributing to an image of a smoothly functioning program that consistently delivers on customer expectations.
- More than half of all participants first learned of the OSS offering from a bill insert or mailing (56%) and one-third found out about the offering on the Duke Energy website (33%).
- The continued increase in LED lighting FR indicates the approach of market transformation and reflects an increase in customer knowledge of and preference for LED bulbs paired with the increased availability and steadily decreasing prices of these products. Most of the remaining program influence (i.e., non-FR) identified by the current evaluation for these products is attributable to the program's role in motivating customers to replace still-working less efficient lighting with LEDs sooner than they otherwise would have.

- Just over half of participants are unsure whether they had received free or reduced shipping (52%), but among those who were aware, nearly 80% considered it highly influential on their decision to purchase program-discounted products, suggesting it may be an especially valuable point of emphasis for future program marketing and an effective tool for encouraging energy-efficient purchases.
- Among advanced thermostat participants responding to the survey, two-thirds replaced a previously installed programmable thermostat (67%), while the remaining one-third replaced a manual thermostat (33%). Although many surveyed participants replaced another programmable thermostats, nearly all reported they primarily relied on manual adjustments or set the thermostat to a single temperature for entire seasons. Meanwhile, a majority of respondents reported they primarily use a programmed schedule and/or self-optimization features on their new thermostat (60%).
- First-year ISRs of less than 75% for advanced thermostats indicate that substantive portions of participants are not installing their program-discounted products within several months of purchase. Among respondents who did not have their new products installed, most indicated that they had not yet needed or had not yet gotten around to installing them.
- At least half of surveyed participants with advanced thermostats installed reported noticeable benefits of their new program-discounted products in terms of increased comfort (55% during summer; 50% during winter). Among LED lighting participants, a majority suggested the quality of light in their home had been improved (58%).

1.4 Evaluation Recommendations

Based on the findings of this evaluation, the evaluation team identified the following opportunities for program improvement:

- Although there is a high rate of customer uncertainty regarding whether they received discounted shipping, those who are aware of the discount reported that it influenced their decision to purchase a program-discounted product. Therefore, we recommend that program marketing continue to promote discounted or free shipping, when available, both in outreach materials and on the program website.
- To support increases in first-year ISRs, we recommend that the program continue to include collateral with orders encouraging customers to install their new energy-efficient products as quickly as possible. The program could also consider additional outreach to recent participants encouraging them to install their new products, particularly for advanced thermostats. This has the potential to help the program maximize first-year savings. For LED lighting specifically, reducing the current limit from 36 discounted bulbs per customer could also help increase ISRs given those purchasing larger quantities are less likely to immediately install most or all of their new products.
- We recommend the program continue to explore possible expansions of the OSS Program and continue using the offering to promote less common energy-efficient products, some of which have already been introduced to the program (including faucet aerators, advanced power strips, air purifiers, dehumidifiers, or other household appliances). Our evaluation found that participants often purchase these types of products as a direct result of information made available by the OSS offering, as exhibited by their relatively low rates of FR.

2. Program Description

This section provides an overview of the design, implementation, and performance of the DEK OSS Program. The program period under evaluation is August 1, 2017 through June 30, 2021.

2.1 Program Design

Duke Energy's OSS Program offers a wide range of POS-discounted LED lighting and advanced thermostat products as well as several other water-saving measures and electric devices, including low-flow showerheads, TSVs, air purifiers, and dehumidifiers.[4] Incentivized LED lighting includes a variety of specialty bulb shapes and wattages as well as several types of fixtures,[5] and advanced thermostats include a range of different models at varying price points from leading brands. The non-lighting measures reflect an expansion of the OSS Program, which exclusively distributed energy-efficient lighting between the launch of the program in 2017 through July of 2020. Customers can purchase the discounted products online through a designated website operated by EFI.

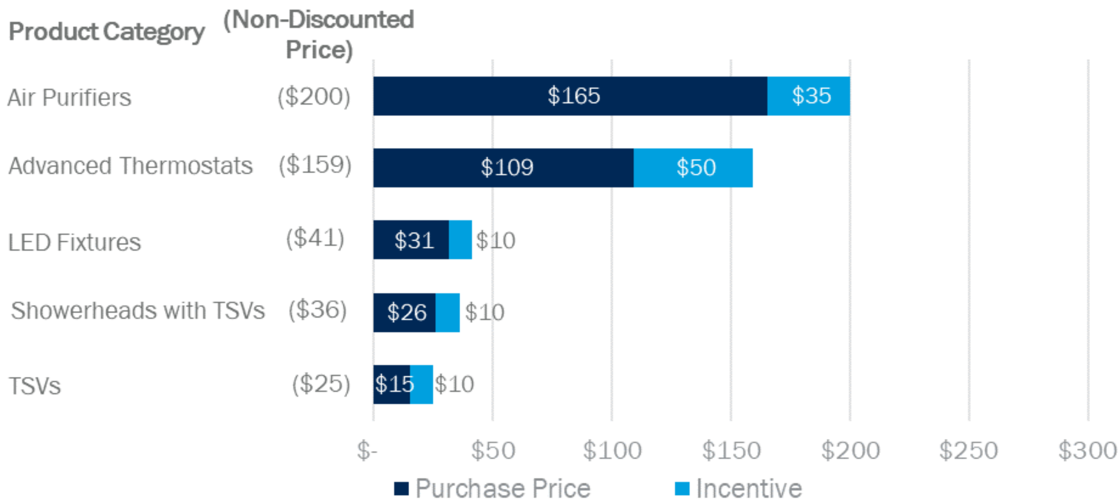
Program discounts varied considerably across products and over the course of the evaluation period. Among incented LED bulbs, average discounts amounted to more than 50% of non-discounted pricing for each category, with discounts averaging as high as 85% of non-discounted pricing for reflector bulbs. Figure 1 shows average per-unit pricing and incentive amounts by type of LED bulb sold through the program.

Figure 1. LED Bulb Per-Unit Pricing

[4] Zero dehumidifiers were sold during the evaluation period.
[5] The program discontinued offering standard LEDs in Q3 of 2020.

Figure 2 shows the average per-unit costs and program discounts associated with various other product categories. The program offered $50 incentives on advanced thermostats, $10 incentives on low-flow showerheads with TSVs and standalone TSVs, and $35 incentives on air purifiers. LED fixture discounts ranged from $5 for lower-cost portable fixtures to $12 for direct wire fixtures, averaging $10 per-unit.

Figure 2. Non-Lighting and LED Fixture Per-Unit Pricing



2.2 Program Implementation

Duke Energy staff manage the OSS Program and are responsible for overseeing program design, marketing, and operations. EFI has implemented the offering on behalf of Duke Energy since the program's inception. EFI is responsible for facilitating customer orders, warehousing products, maintaining inventory, handling order fulfillment and shipping logistics, and managing program invoicing and data tracking.

2.3 Program Performance

From August 1, 2017 through June 30, 2021, Duke Energy's OSS Program sold 105,730 discounted energy-efficient products to DEK customers, achieving ex ante gross energy savings of 3.9 GWh. LED lighting dominated the OSS Program sales, representing 99% of total units sold and 86% of ex ante gross energy savings. Non-lighting measures were first distributed by the program in July 2020, and standard LEDs were dropped from the list of available products in Q3 of 2020. Advanced thermostats accounted for 1% of sales but for 14% of ex ante energy savings. Other non-lighting products accounted for a small share of sales and savings (less than 1%).

Table 4 provides a summary of program sales and ex ante energy savings.

Table 4. Online Savings Store Program Performance by Product Category

Product Category	Units Sold	% of Sales	Ex Ante Gross kWh Savings	% of Savings
Specialty LED	49,474	47%	925,040	24%
Reflector LED	43,560	41%	2,162,702	55%
Standard LED	11,526	11%	280,082	7%
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Air Purifier	4	<1%	1,612	<1%
Standalone TSV	1	<1%	73	<1%
Total	**105,730**	**100%**	**3,934,555**	**100%**

Note: Specialty LEDs include globe, decorative, and three-way bulbs; reflector LEDs include both indoor and outdoor bulbs; LED fixtures include portable, direct wire, and photocell products.

Some OSS Program participants also purchased non-discounted products from the OSS website in addition to program-discounted ones. Participants who reached the program's limit of 36 bulbs or 8 fixtures were able to purchase additional LED products at non-discounted prices, amounting to 1,924 units. Additionally, one customer purchased a non-discounted advanced thermostat. These non-discounted OSS purchases are not included in program sales summaries or considered part of program ex ante or ex post gross savings, but are instead evaluated as potential PSO (see discussion in Sections 5.1.2 and 5.2.2).

3. Overview of Evaluation Activities

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

- Program staff interviews
- Data and deemed savings review
- Participant survey
- Engineering analysis

3.1 Program Staff Interviews

The evaluation team conducted an in-depth qualitative telephone interview with Duke Energy program staff in July 2021 to (1) obtain a full understanding of the OSS Program, including implementation processes, eligibility requirements, and available program-tracked participant information; (2) obtain program staff's perspective on current and past program successes and challenges; and (3) identify program staff's priorities for the process evaluation, including researchable questions.

3.2 Data and Deemed Savings Review

As part of this evaluation, we reviewed program tracking data, assessed its completeness and accuracy, and identified errors or inconsistencies. We performed manual lookups of product specifications in a small number of cases where the necessary detail was unavailable from the tracking database or where information in the data appeared inconsistent and used those lookups to inform the development of ex post savings assumptions. We discuss our findings and their implications for program-tracked savings in Section 4.2 of this report.

We also conducted a detailed review of deemed savings values, assumptions behind those values, and sources of those assumptions. To develop ex post deemed energy and demand savings for each measure, we leveraged, in order of preference, program tracking data, participant survey results, and Technical Reference Manuals (TRMs). We delivered a memorandum presenting the findings of this review and recommended updates to per-unit savings, which is included in Appendix B.

3.3 Participant Survey

The evaluation team conducted an online survey with a sample of OSS participants to gauge installation and usage of products purchased through the OSS offering, solicit feedback regarding experiences with the program, and collect information relevant to estimating gross and net savings not available from program tracking data or applicable secondary sources. This included key household characteristics, the presence and type of heating and cooling equipment, and information needed to develop estimates of ISR, FR, and PSO.

Sample Design and Fielding

We designed the survey sample to enable the development of robust ISR and FR estimates by product category, where possible. To avoid participant recall issues, we limited the sample frame for the survey to participants who made their purchase no more than twelve months prior to survey fielding.

We stratified the sample by product category and randomly selected up to 500 participants with purchases of each product category to include in the sample. For specialty and reflector LEDs, we attempted a census of all participants with available contact information. We excluded standard LEDs, LED fixtures, showerheads, TSVs, and air purifiers given their very limited or non-existent participation during the twelve months preceding survey fielding. We reached out to each sampled participant up to three times via email inviting them to complete the online survey between October 4, 2021, and October 18, 2021.

In total, 87 DEK participants completed the survey. Table 5 summarizes the total count of participants and the number of survey respondents by product category.

Table 5. Participant Survey Sample Summary

Product Category	Participants in Population	Participants in Sample	Survey Completes
Specialty LEDs[A]	386	386	33
Reflector LEDs[A]	301	301	21
Advanced Thermostats	927	500	35
Total[B]	**1,600**	**1,176**	**87**

[A] We attempted a census of specialty and reflector LEDs.

[B] Totals represent unique participants. Counts of individual product categories do not sum to totals because some participants purchased multiple types of products.

3.4 Engineering Analysis

We estimated annual energy and demand savings for each product sold through the OSS Program by applying the outputs of our deemed savings review (i.e., product category-specific per-unit savings) and ISR analysis to product quantities in the program tracking database.

4. Gross Impact Evaluation

The gross impact evaluation of the DEK OSS Program consisted of two distinct steps: (1) review of per-unit deemed savings values for incented products; and (2) verification of product installation and continued operation. This section describes the methodologies and results of both steps.

It should be noted that this evaluation did not include a consumption analysis of advanced thermostats given the timing of evaluation activities relative to the measure's introduction to the program. We will consider conducting a consumption analysis as part of the next evaluation, when sufficient post-installation consumption data is available for participants who installed program-discounted advanced thermostats.[6]

4.1 Methodology

We employed the research methods described in this section to validate program tracking data, review and update deemed savings assumptions, verify product installation and persistence, and calculate ex post gross energy and demand savings for products sold through the DEK OSS Program.

4.1.1 Data and Deemed Savings Review

We began by reviewing all available program tracking data, assessing its completeness and accuracy, and identifying all available information relevant for estimation of per-unit savings. To develop ex post per-unit savings for each program measure, we reviewed measure-level savings algorithms and parameters and revised input assumptions, as needed. We leveraged the following sources in our review:

- **Program tracking data:** Where available, we used program tracking data to inform product-specific parameters, including LED wattages, showerhead flow rates, and sizing of air purifier clean air delivery rates. Since program tracking data is available for the population, it is the most reliable and evaluation-specific source of information.
- **Participant survey data:** Where not available from program tracking data, we used survey data to update household characteristics such as the average square footage of homes, number of people per household, and percentage of homes with specific heating, cooling, and water heating equipment. Since survey data is specific to the program's participants, it is preferable over deemed assumptions from TRMs.
- **Technical Reference Manual (TRM) assumptions:** We used algorithms and parameters from various TRMs. The preferred TRMs were Version 10.0 of the Illinois TRM and Version 2.2 of the Indiana TRM. We also leveraged the Mid-Atlantic TRM Version 10.0 in select cases where assumptions from the preferred TRMs were not applicable or not available.

For more information on the algorithms and inputs used to develop deemed per-unit savings estimates for each product category, see Appendix B.

[6] Our ability to conduct a consumption analysis will depend on sufficient participation and evaluation budget that can support this more expensive approach.

4.1.2 In-Service Rate

To develop first-year ISR estimates, we relied on responses to the participant survey that asked customers to verify receipt and installation of purchased products. For lighting purchases, most products not installed at the time of the survey are placed in storage and installed in future years, so the ISR analysis used a discounted savings approach to claim savings associated with those future installations. The following sections detail the methods employed to estimate first-year and effective ISRs for both lighting and non-lighting products sold through the DEK OSS Program.

LED Bulb First-Year ISRs

The evaluation team calculated ISRs for LED bulbs using responses to a series of survey questions that asked respondents to report the number of bulbs they received, the number of bulbs they installed, and the number of bulbs that were installed and then removed. We calculated the received rate as the number of bulbs received divided by the number of bulbs appearing in program tracking data, the installed rate as the number of bulbs installed divided by the number of bulbs received, and the persistence rate as the number of bulbs still installed divided by number of bulbs initially installed. The first-year ISR is a product of the receipt, installation, and persistence rates, as shown in Figure 3.

Figure 3. LED Bulb First-Year ISR Development

Reported	# of bulbs purchased according to program tracking data
%Received	# of bulbs confirmed received by customers / # reported
%Installed	# of bulbs confirmed installed by customers / # received
%Persisting	# of bulbs confirmed remaining installed / # initially installed
First-Year ISR	%Received x %Installed x %Persisting

LED Bulb Future Installations

Research studies across the country have found that residential customers often purchase more LED bulbs than immediately needed and continue to install these bulbs from storage in subsequent years. The two main approaches to claiming savings from these later installations are (1) staggering the savings over time and claiming some in later years, and (2) claiming the savings in the evaluation period the product was sold but discounting savings by a societal or utility discount rate. While the “staggered” approach allows program administrators to more accurately capture the timing of the realized savings, the “discounted savings” approach allows for the simplicity of claiming all costs and benefits during the evaluation period and eliminates the need to keep track of savings from future installations and claim them in future evaluations.

The evaluation team used a discounted savings approach to account for savings from future installations. To allocate installations over time, we relied on the installation trajectory recommended by the Uniform Methods Project (UMP) whereby 24% of remaining bulbs are installed in each subsequent year, for a total of five years.

For example, if the Year 1 ISR is 80%, an additional 4.8% of bulbs would be installed in Year 2 ([1 – 80%] × 24%; or 20% × 24%) and an additional 3.6% of bulbs would be installed in Year 3 ([1 – 80% - 4.8%] × 24%; 15.2% × 24%).

These future installations are then discounted using Equation 1 to derive the net present value (NPV) of savings associated with future installations of LED bulbs.

Equation 1. Net Present Value Formula for Future LED Bulb Savings

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

Where:

R = Savings
i = Discount rate
t = Number of years in the future that savings take place

Non-Lighting First-Year ISRs

The evaluation team developed ISRs for non-lighting products based on two sets of survey questions asking respondents to confirm the number of products received and to report the number of those products installed at the time of the survey. We calculated the receipt rate as the number of units received by the customer divided by the number appearing in program tracking data and the installation rate as the number of units installed at the time of the survey divided by the number received. The first-year ISR is a product of the receipt and installation rates, as shown in Figure 4.

Figure 4. Non-Lighting First-Year ISR Development

Reported	# of units purchased according to program tracking data
%Received	# of units confirmed received by customers / # reported
%Installed	# of units confirmed currently installed by customers / # received
First-Year ISR	%Received x %Installed

4.2 Gross Impact Results

This section provides gross energy and demand savings estimates for each product category offered by the DEK OSS Program and program-level savings, during the evaluation period.

4.2.1 Program Tracking Data Review

Opinion Dynamics received two types of program tracking data extracts. One type contained product and shipment information while the other contained customer contact information and product pricing. We combined the two sets of data extracts and analyzed the combined dataset for gaps and inconsistencies. As part of the analysis, we performed the following steps:

- Checked core data fields for missing values
- Checked data for temporal gaps
- Checked key data fields for reasonableness and consistency

In reviewing the data, we found the data fields were clean and fully populated for the most part. Program tracking data included the necessary product specifications to inform TRM-based savings calculations for all product categories. Notably, it did not include information about participant households, which is pertinent for advanced thermostats (heating and cooling equipment, square footage) and water-saving measures (water heating equipment, people per household).[7] Among records where pricing information was provided, we did not observe any anomalous incentive amounts or total non-discounted pricing.

4.2.2 Per-Unit Deemed Savings

Duke Energy provided per-unit ex ante savings values in the form of spreadsheets containing DSMore outputs for each product category. Savings values were provided as energy, summer peak, and winter peak demand savings across six LED bulb types, three LED fixture types, and five non-lighting product categories.

Ex ante savings for standard and recessed LED bulbs are drawn directly from the prior evaluation of the DEK OSS Program.[8] These values reflect average per-unit ex post savings across the mix of products included in that product category during the prior evaluation period and incorporate ISRs from the prior evaluation. To allow for a better comparison of engineering assumptions, we backed out the embedded ISRs for these products to develop ex ante values that are comparable to ex post per-unit values, which are also exclusive of ISRs.[9] For other product categories, exact parameters and sources used to develop ex ante per-unit savings were not available.

[7] In the absence of program-tracked participant characteristics, we relied on participant survey responses to establish their incidences for impact evaluation purposes.

[8] TecMarket Works. Process and Impact Evaluation of the Residential Energy Efficient Appliance and Devices: Lighting - Specialty Bulbs Program in Kentucky and Ohio. Prepared for Duke Energy. June 22, 2015.

[9] For A-line and recessed LED bulbs, the prior evaluation from which ex ante values are drawn applied an ISR of 70.4%. We therefore divided ex ante values provided by program staff by 70.4% for these two product categories to produce the ex ante values (net of ISR) shown here.

The product categories with the largest differences between ex ante and ex post gross per-unit savings are recessed outdoor LEDs, globe LEDs, three-way LEDs, and advanced thermostats, for which ex ante demand savings were not claimed, and TSVs, where ex ante savings are between three and five times ex post per-unit savings. In the absence of additional information on the sources of ex ante assumptions, the reasons for differences between these products' ex ante and ex post per-unit savings estimates remain unknown.

Table 6 provides ex ante and ex post per-unit savings for all products sold through the DEK OSS Program. Additional detail on parameters and algorithms used to develop per-unit savings are provided in the deemed savings review memorandum included in Appendix B.

Table 6. Comparison of Per-Unit Deemed Savings (Net of ISR)

Product Category	Energy (kWh)		Summer Demand (kW)		Winter Demand (kW)	
	Ex Ante	Ex Post	Ex Ante	Ex Post	Ex Ante	Ex Post
A-Line LED[A]	34.52	23.54	0.0040	0.0033	0.0040	0.0045
Recessed LED[A]	61.19	43.39	0.0055	0.0060	0.0055	0.0082
Recessed Outdoor LED	118.30	40.60	0.0000	0.0056	0.0000	0.0077
Globe LED	17.54	29.59	0.0000	0.0041	0.0000	0.0056
Decorative LED	18.06	24.75	0.0017	0.0034	0.0017	0.0047
Three-Way LED	43.14	47.42	0.0000	0.0066	0.0000	0.0090
LED Fixture – Direct Wire	37.57	34.43	0.0052	0.0048	0.0043	0.0065
LED Fixture – Portable	19.86	23.74	0.0027	0.0033	0.0023	0.0045
LED Fixture – Photocell	227.91	220.81	0.0000	0.0000	0.0050	0.0082
Advanced Thermostat	497.98	339.05	0.0000	0.1692	0.0000	0.0732
Showerhead with TSV	278.58	149.28	0.0890	0.0115	0.0890	0.0231
Air Purifier	403.00	570.30	0.0462	0.0651	0.0462	0.0651
Standalone TSV	73.31	19.64	0.0234	0.0043	0.0234	0.0086

[A] Ex ante per-unit values shown here for A-line and recessed LEDs have been adjusted to omit ISR, whereas original ex ante values provided by program staff and shown elsewhere in this report have ISRs embedded.

4.2.3 In-Service Rates

Table 7 summarizes survey-based first-year ISRs for LED bulbs. The first-year ISR is a product of the receipt, installation, and persistence rates, as detailed in Section 4.1.2. Analysis results show that participants confirmed receipt of all discounted LED purchases (100%) and that once installed, LED bulbs generally remained in place (90%). However, consistent with typical trends for this type of product, substantially fewer than 100% of bulbs are installed within the first year (69%), resulting in an overall first-year ISR of 63%. It is worth noting that customers were allowed to purchase up to 36 program-discounted LEDs, and those who purchased larger quantities tended to exhibit lower ISRs (57% among those who purchased fewer than 15 bulbs; 68% among those who purchased 15 or more). On average, each lighting participant purchased approximately 10 LEDs over the course of the evaluation period.

Table 7. LED Bulb First-Year ISR Development

Metric	Rate (n=54)
% Received	100.0%
% Installed	69.4%
% Persisting	90.4%
First-Year ISR	**63.2%**

Table 8 provides cumulative installations of LED bulbs by year using the discounted approach discussed above (i.e., incremental installations of 24% of bulbs that remain uninstalled for a total of five additional years). The values shown here are discounted to represent the net present value of installations that occur in each year. The resulting effective ISRs is 86.6%,

Table 8. LED Bulb Cumulative Discounted ISR

Year	Cumulative Discounted ISR
2021 (Year 1)	63.2%
2022 (Year 2)	71.5%
2023 (Year 3)	77.3%
2024 (Year 4)	81.5%
2025 (Year 5)	84.5%
2026 (Year 6)	86.6%
Total	**86.6%**

Table 9 provides the survey-based values used to calculate first-year ISRs for advanced thermostats. First-year ISRs for non-lighting products are calculated by multiplying the percent of the program-tracked quantity confirmed received by the percent of received units confirmed installed at the time of the survey.

Table 9. Non-Lighting First-Year ISR Development

Metric	Advanced Thermostats (n=34)
% Received	100.0%
% Installed	73.0%
First-Year ISR	**73.0%**

Table 10 summarizes effective ISR values by product category. The effective ISR for LED bulbs is reflective of the discounted savings approach detailed above, while other values either reflect survey-based estimates of first-year ISR or are deemed at 100% (in cases where products are assumed to be installed or participation levels did not support survey sampling). Relative precision around the point estimates for product categories where sampling error applies was 13.4% for advanced thermostats.

Table 10. Final Effective ISR Summary

Product Category	ISR	n	Relative Precision
LED Bulbs[A]	86.6%	54	N/A
LED Fixtures[B]	100.0%	N/A	N/A
Advanced Thermostats	73.0%	34	13.4%
Showerheads with TSVs and Standalone TSVs[C]	100.0%	N/A	N/A
Air Purifiers[B]	100.0%	N/A	N/A

[A] Due to limited participation, the survey did not include installation verification for standard LEDs. ISRs for LED lighting therefore reflects the averages of lighting categories that were included. Because we attempted a census of lighting participants, the concept of sampling error does not apply.

[B] ISR is assumed to be 100% for LED fixtures and air purifiers.

[C] Due to limited participation, the survey did not include installation verification for showerheads with TSVs and standalone TSVs. ISRs for these measures therefore rely on ex ante assumptions provided by Duke Energy staff.

As expected, lighting participants who did not have all of their new LED products installed at the time of the survey (64%) overwhelmingly reported that they had not yet needed them and were waiting for other bulbs to burn out (92%). The remaining 8% reported that the new LEDs were the wrong size for the intended socket (4%), that they did not like the light quality (3%), or that they were waiting for installation assistance (1%).

Among surveyed advanced thermostat participants, just over one-quarter (27%) had not installed their new thermostat(s) at the time of the survey. Reasons included that the thermostat was not compatible with their current set-up (38%), that they did not know how to install the unit (25%), that they had not gotten to it yet (24%), and that the item was broken or defective (13%).

These advanced thermostat ISRs indicate that a substantive portion of participants who purchase these products have yet to install or use them several months after purchasing. Additional outreach or prompts to future participants may help encourage installation of these products and improve first-year ISRs and, subsequently, first-year savings from these products.

4.2.4 Ex Post Gross Savings Summary

Table 11 and Table 12 present total ex ante and ex post gross energy, summer peak demand, and winter peak demand savings and realization rates, by product category. The DEK program realized 3.3 GWh in ex post gross energy savings, 0.56 MW in summer peak demand savings, and 0.64 MW in winter peak demand savings during the evaluation period.

Gross realization rates for the DEK program are 85% for energy savings, 243% for summer peak demand savings, and 275% for winter peak demand savings. Realization rates for LED lighting, which accounts for more than 90% of ex post gross energy and winter peak demand savings and 75% of summer peak demand savings, ranged from 91% for energy savings to 250% for winter peak demand savings. High realization rates for demand savings are in part driven by recessed outdoor LEDs, globe LEDs, and three-way LEDs, for which ex ante demand savings were not claimed. For advanced thermostats, which account for 8% of ex post gross energy savings, the energy realization rate was around 50%.[10] Advanced thermostats also account for 25% of ex post gross summer demand savings and 9% of ex post gross winter demand savings, but were not assigned ex ante demand savings, and therefore contribute to high overall demand realization rates.

Table 11. Detailed Energy Savings Gross Impacts Results

Product Category	Ex Ante kWh	Gross RR	Ex Post Gross kWh
Specialty LED	925,040	128%	1,186,604
Reflector LED	2,162,702	75%	1,627,094
Standard LED	280,082	84%	234,904
LED Fixture	4,920	97%	4,775
Advanced Thermostat	558,734	50%	277,702
Showerhead with TSV	1,393	54%	746
Air Purifier	1,612	142%	2,281
Standalone TSV	73	27%	20
Total	**3,934,555**	**85%**	**3,334,127**

Table 12. Detailed Demand Savings Gross Impacts Results

Product Category	Summer Peak Demand			Winter Peak Demand		
	Ex Ante kW	Gross RR	Ex Post Gross kW	Ex Ante kW	Gross RR	Ex Post Gross kW
Specialty LED	44	379%	165	44	516%	224
Reflector LED	155	146%	226	155	199%	308
Standard LED	32	101%	33	32	138%	44
LED Fixture	<1	99%	<1	<1	163%	<1
Advanced Thermostat	0	N/A	139	0	N/A	60
Showerhead with TSV	<1	13%	<1	<1	26%	<1
Air Purifier	<1	141%	<1	<1	141%	<1
Standalone TSV	<1	18%	<1	<1	37%	<1
Total	**232**	**243%**	**563**	**232**	**275%**	**637**

[10] In the absence of additional information on the sources of ex ante assumptions, the reasons for differences between advanced thermostat ex ante and ex post per-unit savings estimates remain unknown.

Table 13 summarizes per-unit ex post gross energy, summer peak demand, and winter peak demand savings by product category. These values are reflective of ex post deemed per-unit savings presented in Section 4.2.2 adjusted to apply effective ISR values presented in Section 4.2.3.

Table 13. Per-Unit Savings Gross Impact Results (Inclusive of ISR)

Product Category	Energy (kWh)	Summer Demand (kW)	Winter Demand (kW)
A-Line	20.38	0.0028	0.0039
Recessed	37.56	0.0052	0.0071
Recessed Outdoor	35.15	0.0049	0.0066
Globe	25.62	0.0036	0.0048
Candelabra	21.43	0.0030	0.0041
3-Way	41.06	0.0057	0.0078
LED Fixture - Direct Wire	34.43	0.0048	0.0065
LED Fixture - Portable	23.74	0.0033	0.0045
LED Fixture - Photocell	220.81	0.0000	0.0082
Advanced Thermostat	247.51	0.1235	0.0534
Showerhead with TSV	149.28	0.0115	0.0231
Air Purifier	570.30	0.0651	0.0651
Standalone TSV	19.64	0.0043	0.0086

4.3 References

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5. Net-to-Gross Analysis

This section describes our approach for estimating the net savings for the DEK OSS Program and presents the resulting NTGRs and net impacts.

5.1 Methodology

The NTGR represents the portion of the gross energy savings associated with a program-supported measure or behavior change that would not have been realized in the absence of the program. In other words, the NTGR represents the share of gross savings that can be considered program-induced or attributed to the program. The NTGR consists of FR and SO and is calculated as (1 – FR + PSO).

FR is the proportion of the program-achieved verified gross savings that would have been realized absent the program. PSO occurs when participants take additional energy-saving actions that are influenced by program interventions but that did not receive program support. The scope of this evaluation included estimation of FR and PSO.

Both FR and PSO components of the NTGR are derived from self-reported information from the participant web survey. The final NTGR is the percentage of gross program savings that can be attributed to the program. The following sections provide a general overview of the methods for developing FR and PSO estimates. Appendix C and Appendix D contain the participant survey instrument and additional detail behind FR algorithms and PSO estimation.

5.1.1 Free Ridership

As part of the participant survey, we asked a series of structured and open-ended questions about the influence of the program on customers' decisions to purchase and install program-discounted products. The survey questions gauged program influence in the following areas:

- Influence on efficiency: whether participants would have purchased comparably energy-efficient products without the program
- Influence on quantity: for relevant measures where participants purchased multiple units, whether participants would have purchased the same quantity without the program
- Influence on timing: whether participants would have delayed their purchase in the absence of the program-discounted products

We developed FR scores by product category. All respondents who provided valid responses to FR questions were assigned a FR score ranging from 0 (non-free rider) to 1 (full free rider). In addition, we asked customers to provide an open-ended response summarizing how the program influenced their purchase decisions, which we reviewed to identify contradictory responses and adjust FR scores as needed. Appendix D provides additional detail on the methods employed to develop FR estimates for both lighting and non-lighting products. It should be noted that, due to limited participation, the survey did not include FR questions for standard LEDs, LED fixtures, showerheads, TSVs, or air purifiers. For standard LEDs and LED fixtures, we relied on the average for lighting categories that were included in the survey. For showerheads with TSVs and standalone TSVs, we deferred to the ex ante NTGR provided by Duke Energy staff. For air purifiers, an ex ante alternative was not available, and we therefore relied on survey results collected from both DEK and DEI participants for non-lighting product categories.

5.1.2 Participant Spillover

As a result of positive experience with program-discounted products or information from program marketing, some participants purchase additional energy-efficient products on their own. PSO represents energy savings from such additional energy-saving actions taken by participants (expressed as a percent of total program savings) who were influenced but not directly incentivized by the program. This evaluation quantified PSO savings from two different categories of spillover purchases:

1. **Additional energy-efficient products purchased outside the OSS offering.** The participant survey contained a series of questions designed to gauge the impact of the program on participants' subsequent purchases of energy-efficient products made outside of the OSS offering. Participants who reported a high level of program influence on non-discounted energy-efficient purchases made at other retailers were considered candidates for PSO. In these cases, the survey asked participants to provide additional detail on the non-discounted products they purchased and explain how their experience with the program influenced the purchase. Appendix D provides additional detail on survey-based methods employed to identify and quantify PSO.

2. **Non-discounted energy-efficient purchases made through the OSS offering.** Some OSS Program participants also purchased non-discounted products from the OSS website in addition to program-discounted ones. Participants who reached the program's limit for discounted products per-customer were able to purchase additional products at non-discounted prices. These non-discounted OSS purchases are not considered part of program gross savings but do represent a source of potential PSO. For these sales, we developed estimates of total ex post gross savings associated with the products and adjusted those savings based on product category-specific FR estimates established by the current evaluation to represent the portion of these sales attributable to the OSS Program.

5.2 NTG Results

The evaluation team developed NTGR estimates that account for both FR and PSO. We estimated FR separately for each product category and developed PSO estimates at the program level. Table 14 summarizes NTGR results by product category.

Table 14. NTGR Results

Product Category	FR	PSO	NTGR
LED Lighting[A]	0.672	0.005	0.333
Advanced Thermostats	0.205		0.800
Showerheads with TSVs and Standalone TSVs[B]	N/A	N/A	0.979
Air Purifiers[C]	0.146	0.005	0.859

[A] Due to limited participation, the survey did not include FR questions for standard LEDs or LED fixtures. FR for LED lighting therefore reflects the averages of lighting categories that were included.

[B] Due to limited participation, the survey did not include FR questions for showerheads with TSVs or standalone TSVs. We instead defer to the ex ante NTGR provided by Duke Energy staff.

[C] Due to limited participation, the survey did not include FR questions for air purifiers, and no ex ante alternative was available. FR values for this measure therefore reflects the average of other non-lighting product categories, leveraging survey results collected from both DEK and DEI participants.

5.2.1 Free Ridership

Table 15 below summarizes FR results for each product category, which include 67% for LED lighting, 21% for advanced thermostats, and 15% for air purifiers. Relative precision around the point estimate for the product category where sampling error applies was 12.3% for thermostats. Due to limited participation, the survey did not include FR questions for standard LEDs, LED fixtures, showerheads, TSVs, or air purifiers. For standard LEDs and LED fixtures, we relied on the average for lighting categories that were included in the survey. For showerheads and TSVs, we deferred to the available ex ante NTGR provided by Duke Energy staff. For air purifiers, we used a value of 14.6%, leveraging survey results collected from both DEK and DEI participants for non-lighting product categories.

Table 15. FR Results

Product Category	Respondents	FR	Relative Precision
LED Lighting[A]	28	0.672	N/A
Advanced Thermostats	36	0.205	12.3%
Air Purifiers[B]	N/A	0.146	N/A

[A] Due to limited participation, the survey did not include FR questions for standard LEDs or LED fixtures. FR for LED lighting therefore reflects the averages of lighting categories that were included. Because we attempted a census of lighting participants, the concept of sampling error does not apply.

[B] Due to limited participation, the survey did not include FR questions for air purifiers. FR values for this measure therefore reflects the averages of other non-lighting product categories, leveraging survey results from both DEK and DEI participants.

LED lighting participants purchased an average of approximately 10 bulbs over the course of the evaluation period. The survey therefore asked LED lighting participants what they would have purchased in the absence of discounts provided by the OSS offering. Nearly all respondents claimed that without the program discounts they would have bought fewer LED bulbs than they did (94%). However, among these respondents, nearly three-fifths claimed they still would have purchased LEDs the next time they needed bulbs (59%).

Figure 5 summarizes participant responses regarding the portion of program-discounted bulbs they would have purchased at full price (i.e., without the program discount), and Figure 6 provides the type of bulbs they would have expected to buy instead.

Figure 5. Portion of Program LEDs Participants Would Have Purchased Without Program Discount

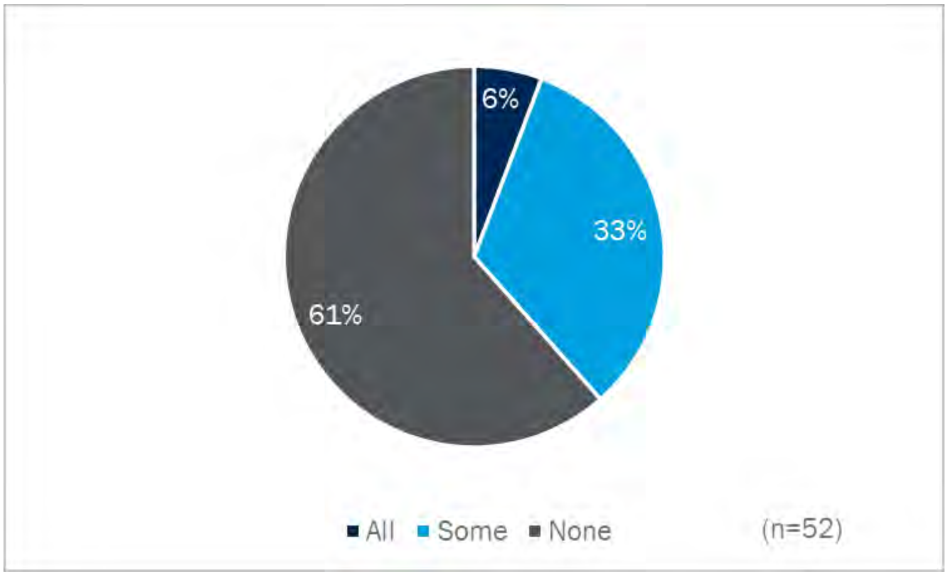
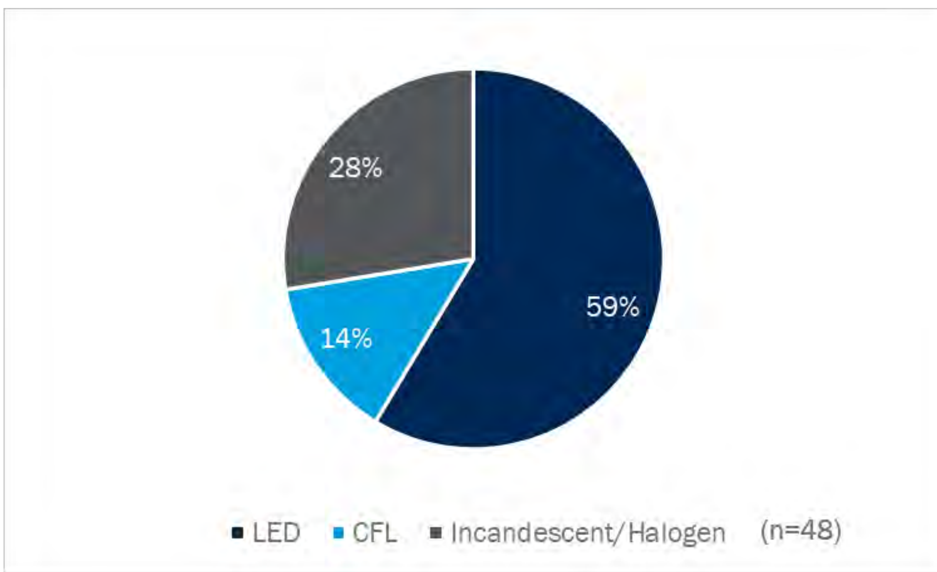


Figure 6. Types of Bulbs Customers Would Have Purchased if Not Buying Program LEDs



The survey also asked thermostat participants whether they had been looking to purchase a comparable product prior to learning of the available Duke Energy discounts; if they had not previously considered such a purchase, they are assumed to be non-free riders. Just over half of advanced thermostat participants indicated they had not been planning to purchase a similar product prior to learning about the available Duke Energy discounts (52%) and were therefore assigned a FR value of zero.

5.2.2 Participant Spillover

One DEK survey respondents qualified for PSO by purchasing additional energy-efficient products outside of the OSS since participating in the program and attributing these purchases to their experience with the OSS offering. Table 16 summarizes the survey-reported spillover, including the quantity purchased and the associated savings.

Table 16. Survey-Based PSO Savings

Product Type	Purchase Quantity	kWh
Refrigerator	1	50.21
Total	**1**	**50.21**

Table 17 outlines the calculation of PSO rates based on self-reported qualifying purchases, where spillover savings associated with the purchase made outside of the OSS are divided by total savings associated with participants responding to the survey.

Table 17. Survey-Based PSO Results

Spillover Category	Value
Spillover Savings from Non-OSS Purchases (kWh)	50.21
Total Respondent Savings (Ex Post Gross kWh)[A]	54,116
Survey-Based PSO Rate	0.09%

[A] Represents total ex post gross savings associated with respondents who provided valid responses to PSO survey questions, including those who did not report a spillover purchase.

Table 18 summarizes the calculation of PSO attributable to non-discounted purchases made on the OSS website,[11] where total program-attributable savings from non-discounted purchases are divided by total program-wide gross savings. Program-attributable spillover savings from non-discounted OSS purchases reflect ex post gross savings assumptions, including deemed savings updates and ISR application, adjusted to account for program influence by excluding the portion of savings attributable to FR (67.2% for lighting, 20.5% for thermostats).

Table 18. Non-Discounted OSS Sales PSO Results

Spillover Category	Value
Spillover Savings from Non-Discounted OSS Sales (kWh)	12,177
Total Program Savings (Ex Post Gross kWh)	3,334,127
Non-Discounted OSS Sales PSO Rate	0.37%

[11] Includes 1,924 lighting units and 1 advanced thermostat

We reviewed program tracking data associated with survey respondents who reported spillover-qualifying purchases to ensure no overlap existed between survey-based PSO and non-discounted OSS purchases. In the absence of any overlap, the two sources of spillover can be summed without additional adjustment. The sum of the survey-based PSO rate and the PSO rate associated with non-discounted OSS sales is 0.46%, as shown in Table 19.

Table 19. Combined PSO Results

Survey-Based PSO	Non-Discounted OSS Sales PSO	Final PSO
0.09%	0.37%	0.46%

5.3 Net Impact Results

Table 20 and Table 21 present the ex post net impacts for energy savings and summer and winter peak demand savings, respectively, that result from applying the evaluation NTGRs to ex post gross savings. The DEK program realized 1.2 GWh in net energy savings, 0.25 MW in net summer peak demand savings, and 0.24 MW in net winter peak demand during the evaluation period.

Table 20. Detailed Energy Savings Net Impact Results

Product Category	Ex Post Gross kWh Savings	NTGR	Ex Post Net kWh Savings
Specialty LED	1,186,604	0.333	395,139
Reflector LED	1,627,094		541,822
Standard LED	234,904		78,223
LED Fixture	4,775		1,590
Advanced Thermostat	277,702	0.800	221,884
Showerhead with TSV	746	0.979	731
Air Purifier	2,281	0.859	1,960
Standalone TSV	20	0.979	19
Total	**3,334,127**	**0.372**	**1,241,646**

Note: Overall NTGRs are estimated as ex post net savings divided by ex post gross savings.

Table 21. Detailed Peak Demand Savings Net Impacts Results

Product Category	Summer Peak Demand			Winter Peak Demand		
	Ex Post Gross kW Savings	NTGR	Ex Post Net kW Savings	Ex Post Gross kW Savings	NTGR	Ex Post Net kW Savings
Specialty LED	165	0.333	55	224	0.333	75
Reflector LED	226		75	308		102
Standard LED	33		11	44		15
LED Fixture	<1		<1	<1		<1
Advanced Thermostat	139	0.800	111	60	0.800	48
Showerhead with TSV	<1	0.979	<1	<1	0.979	<1
Air Purifier	<1	0.859	<1	<1	0.859	<1
Standalone TSV	<1	0.979	<1	<1	0.979	<1
Total	**563**	**0.448**	**252**	**637**	**0.377**	**240**

Note: Overall NTGRs are estimated as ex post net savings divided by ex post gross savings.

6. Process Evaluation

This section details research questions, evaluation activities, and key findings from the process evaluation of the DEK OSS Program.

6.1 Research Questions

The evaluation team developed the following process-oriented research questions with input from OSS program staff.

- How effective are program implementation and data-tracking practices?
- How do participants learn about the program?
- Are participants satisfied with their program experience?
- What factors, if any, are preventing customers from installing program-discounted products or prompting their removal?
- How do customers use program-discounted products, and what are the implications for savings attributable to those measures, for advanced thermostats in particular?
- Which measures or customer segments can the program target to maximize its influence and minimize free ridership?
- What role does free or discounted shipping play in motivating customers to purchase program-discounted products?
- What information is currently collected from program participants, and what participant information or eligibility requirements would enable the program to maximize savings for measures where household characteristics are especially relevant?
- What other energy-efficient measures could the program consider offering?
- What are the program's strengths or key successes and in what areas are there potential opportunities for improvement?
- What non-energy impacts, if any, do OSS participants realize as a result of their participation?

6.2 Methodology

The process evaluation relied on the following data collection and analytic activities:

- In-depth interviews with program staff
- Analysis of program tracking data
- Participant survey (n=87)

6.3 Key Findings

The following sections present key findings regarding the evaluation's process-oriented research questions.

6.3.1 Thermostat Usage Behavior

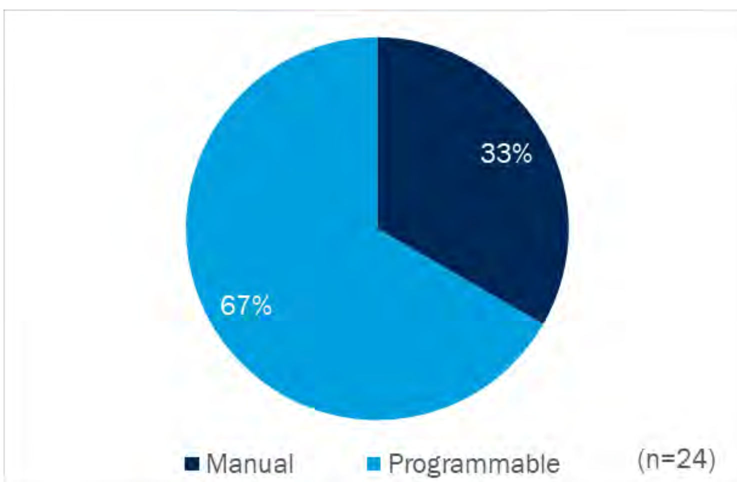
Since their introduction in mid-2020, thermostats have become a key measure for the OSS Program, accounting for 8% of ex post gross energy savings and 25% of ex post gross summer peak demand savings during the evaluation period. Given the timing of evaluation activities relative to the measure's introduction to the program, we estimated savings using an engineering approach. However, we will consider conducting a consumption analysis as part of the next evaluation, when sufficient post-installation consumption data is available for participants who installed program-discounted advanced thermostats.[12]

In addition to the type of systems controlled (i.e., electric heating system and/or central cooling system), two key determinants of savings from advanced thermostats are (1) the type of thermostat participants used prior to the installation of their program-discounted thermostats and (2) how participants used their old thermostats and are using their new ones. Our engineering analysis addresses the first determinant but not the second. The participant survey, however, explored both topics, providing insights into potential savings that might be expected from future consumption analyses for this program.

Two-thirds of respondents reported that their new smart thermostats replaced a programmable thermostat (67%), and the remaining one-third indicated they replaced a manual thermostat (33%). No advanced thermostat participants reported replacing a previously owned advanced thermostat.

Figure 7 summarizes the types of thermostats being replaced by program-discounted advanced thermostats.

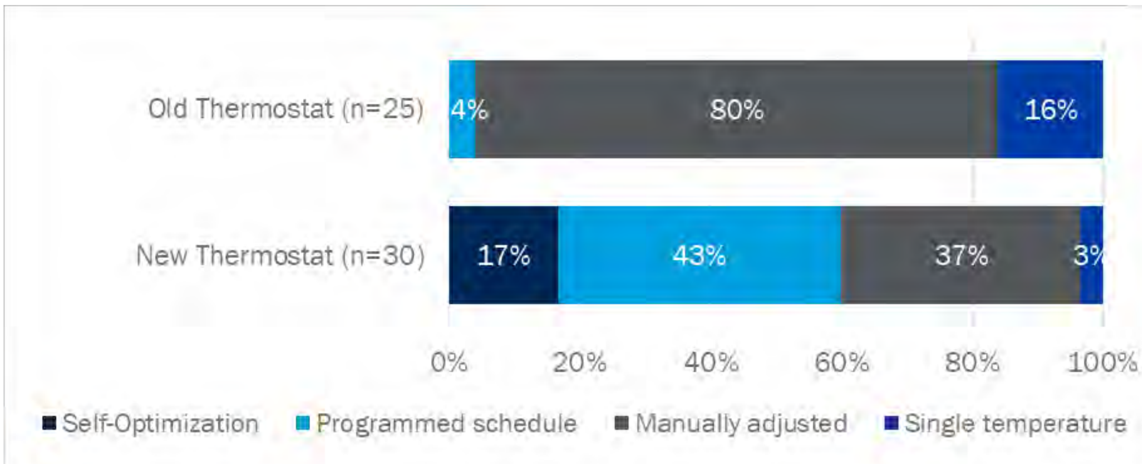
Figure 7. Previous Thermostat Replacement



[12] Our ability to conduct a consumption analysis will depend on sufficient participation and evaluation budget that can support this more expensive approach.

Thermostat usage patterns are often varied and dependent on a variety of factors, making them challenging to gauge via survey self-report. The participant survey nevertheless explored how customers typically set the temperature on their previous and new thermostats in the summer months to get a sense of how their behavior may have changed. Perhaps most notably, just 4% of the survey respondents typically had a programmed schedule set on their previous thermostat despite most of them having programmable thermostats installed. Conversely, a majority of these respondents (60%) claimed that they were either programming their new thermostat on a schedule (43%) or taking advantage of their new advanced thermostat's self-optimization function (17%), which offers some support for savings assumptions being applied to these measures as part of the current evaluation. Figure 8 illustrates these findings regarding how thermostat participants most typically used their previous and program-discounted thermostats.

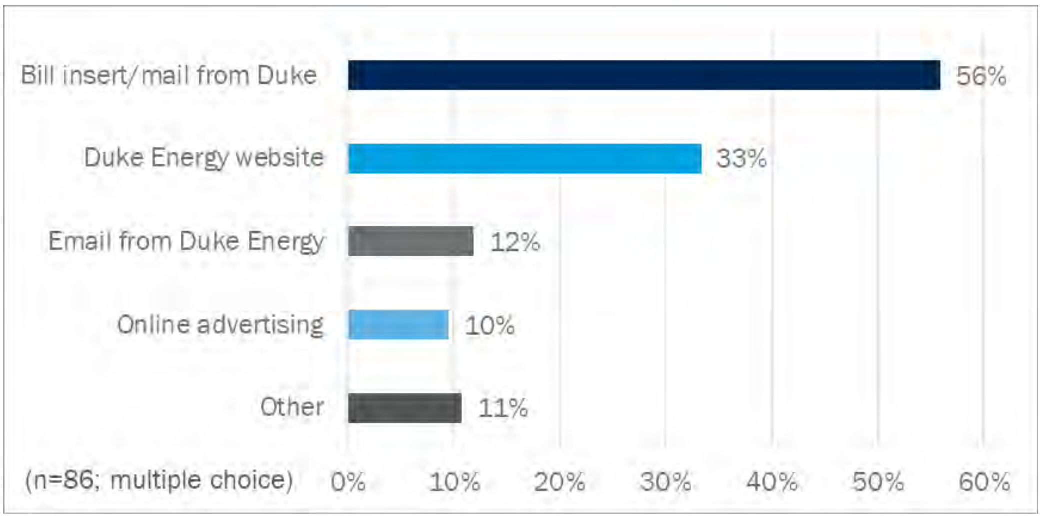
Figure 8. Thermostat Usage Behavior



6.3.2 Program Marketing and Outreach

The OSS program team uses a variety of marketing and outreach strategies, including mailings, email campaigns, website banners, and other online advertisements. Based on results from the participant survey, direct mailings or bill inserts were most successful during the evaluation period with 56% of participants learning about the program through the channel. Many participants also reported learning about the program from advertisements on the Duke Energy website (33%) and email outreach (12%). Additional common sources of program awareness included family and friends, social media, and hired contractors. Figure 9 summarizes how participants first heard about the OSS offering.

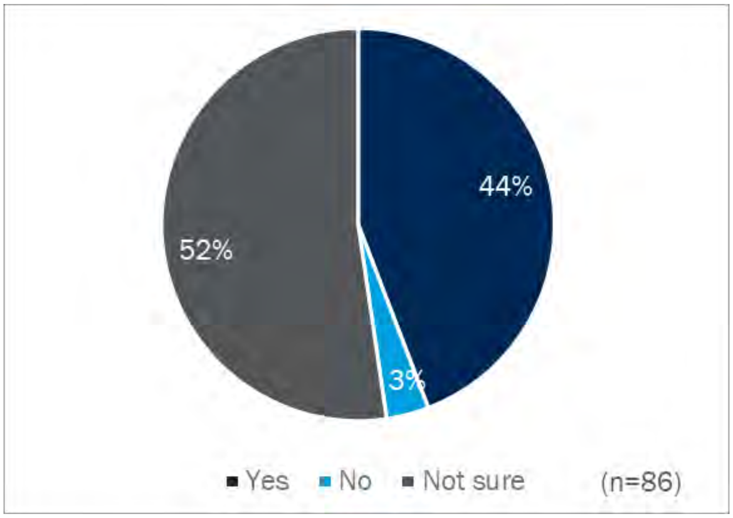
Figure 9. Sources of Awareness



6.3.3 Value of Discounted Shipping

As part of the participant survey, the evaluation sought to gauge the importance of discounted shipping to respondents and better understand the role it plays in motivating customers to purchase program-discounted products. Almost half of survey respondents (44%) reported receiving discounted shipping for the OSS purchase, but even more than half (52%) indicated they were unsure whether they received free or discounted shipping. Figure 10 illustrates these responses, highlighting a high degree of participant uncertainty as to whether they received free or reduced shipping.

Figure 10. Discounted Shipping Breakdown

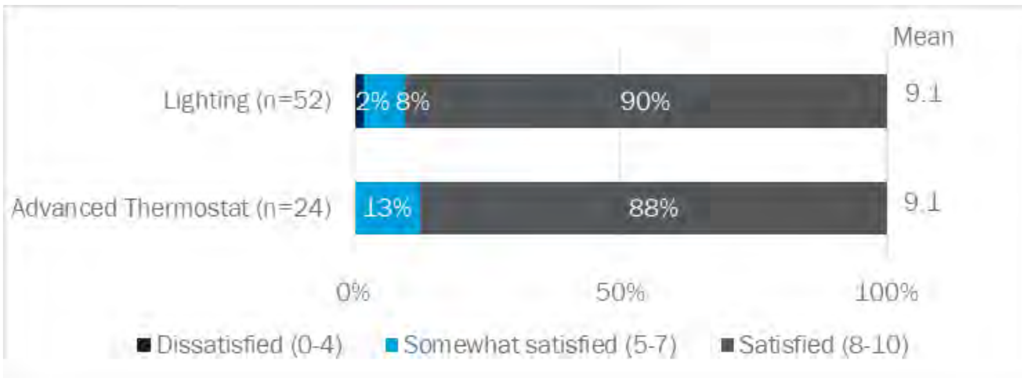


Most respondents who did recall receiving free or discounted shipping indicated that it was highly influential in their decision to purchase a product through the program, with 79% rating the influence at least 8 on a zero to ten scale (where zero means “Not at all influential” and ten means “Extremely influential”). Sixteen percent of respondents gave a score between 5 and 7 and just 5% rated the influence of discounted shipping between 0 and 4.

6.3.4 Program Delivery and Participant Satisfaction

Across the board, participants indicated high satisfaction with their discounted products, with average ratings of 9.1 for both LED lighting and advanced thermostats.[13] The only specific complaint was from one respondent who thought the color of their LEDs was "too bright." These findings suggest that the program is generally effectively targeting high-quality products that customers enjoy using. Figure 11 summarizes participant satisfaction with each type of program-discounted product.

Figure 11. Participant Satisfaction with Program-Discounted Products

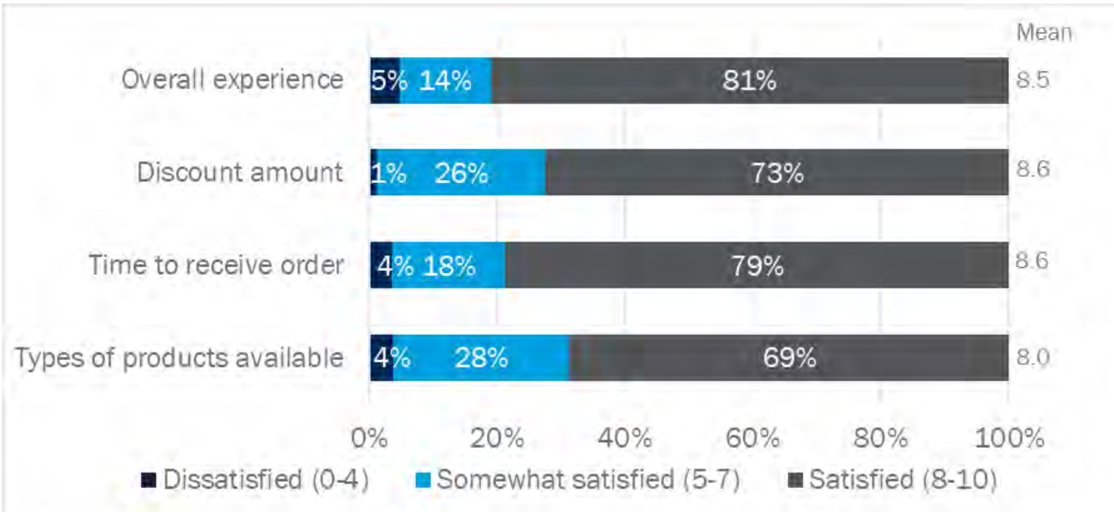


Satisfaction with various elements of the program's implementation was also exceptionally high with customers providing mean ratings of between 8.0 and 8.6, on the same 0 to 10 scale, for each aspect of the program and for the program overall. The only suggested improvements had to do with respondents' specific products, including one respondent who mentioned that their thermostat was incompatible with their heating system, one respondent who had issues attempting to exchange their thermostat, and one who reported their thermostat stopped working after two months. These high satisfaction ratings contribute to an image of a smoothly functioning program that consistently delivers on customer expectations.

[13] On a scale of 0 to 10, where 0 means "extremely dissatisfied" and 10 means "extremely satisfied."

Figure 12 provides participant satisfaction ratings associated with key program elements.

Figure 12. Participant Satisfaction with Key Program Elements



6.3.5 Non-Energy Impacts

Non-energy impacts (NEIs) include a range of occupant health, safety, and economic outcomes that participants may realize beyond the energy and cost savings of energy-efficient upgrades. NEIs can provide significant additional benefits to participants and can be a powerful motivator for program participation.

The participant survey included questions about changes in electricity bills and in different aspects of the home's comfort following program participation, and while less than one-third noticed changes to their bills, the majority experienced other benefits. Among those who purchased and installed new advanced thermostats, 29% claimed their summer electricity bills were lower and 18% reported lower electricity bills in the winter. Conversely, at least half of advanced thermostat participants reported their home was more comfortable since installing the new thermostat in both summer and winter months (55% and 50%, respectively). Among respondents who purchased LED lighting, a majority reported that the quality of lighting in their homes had improved since installing the new products (58%).

Table 22 summarizes feedback from advanced thermostat and LED lighting participants regarding changes to their home's electricity bills, comfort, and lighting quality since installing program-discounted products.

Table 22. Impacts Reported by Participants

Impact	Positive Change	No Change	Negative Change
Advanced Thermostat Participants			
Electricity bills in summer (n=14)	29% *Bills are lower*	63%	8% *Bills are higher*
Electricity bills in winter (n=11)	18% *Bills are lower*	64%	18% *Bills are higher*
Home comfort in summer (n=20)	55% *More comfortable*	40%	5% *Less comfortable*
Home comfort in winter (n=12)	50% *More comfortable*	50%	0% *Less comfortable*
LED Lighting Participants			
Lighting quality (n=97)	58% *Better*	42%	0% *Worse*

These findings suggest the OSS Program provides value to participants beyond energy savings. Increased home comfort relating to temperature control could be beneficial for customer health and safety. Improved lighting also provides a higher sense of safety in and around the home. Lower energy bills can also help alleviate energy burdens and allow customers to spend their money on essential items, such as food or medicine.

7. Conclusions and Recommendations

This section presents conclusions and recommendations resulting from the process and impact evaluations of the DEK OSS Program.

7.1 Conclusions

From August 1, 2017, through June 30, 2021, Duke Energy's OSS Program sold 105,730 discounted energy-efficient products to DEK customers, achieving ex ante gross energy savings of 3.9 GWh. LED lighting dominated OSS Program sales, representing 99% of total units sold and 86% of ex ante gross energy savings. Non-lighting measures were first distributed by the program in July 2020, and standard LEDs were dropped from the list of available products in Q3 of 2020. Advanced thermostats accounted for 1% of sales but for 14% of ex ante energy savings. Other non-lighting products accounted for a small share of sales and savings (less than 1%). Table 23 provides a summary of program sales and ex ante energy savings.

Table 23. Online Savings Store Program Performance by Product Category

Product Category	Units Sold	% of Sales	Ex Ante Gross kWh Savings	% of Savings
Specialty LED	49,474	47%	925,040	24%
Reflector LED	43,560	41%	2,162,702	55%
Standard LED	11,526	11%	280,082	7%
LED Fixture	38	0%	4,920	<1%
Advanced Thermostat	1,122	1%	558,734	14%
Showerhead with TSV	5	<1%	1,393	<1%
Air Purifier	4	<1%	1,612	<1%
Standalone TSV	1	<1%	73	<1%
Total	**105,730**	**100%**	**3,934,555**	**100%**

Note: Specialty LEDs include globe, decorative, and three-way bulbs; reflector LEDs include both indoor and outdoor bulbs; LED fixtures include portable, direct wire, and photocell products.

The program realized 3.3 GWh in ex post gross energy savings, 0.56 MW in summer peak demand savings, and 0.64 MW in winter peak demand savings during the evaluation period. Gross realization rates for the DEK program are 85% for energy savings, 243% for summer peak demand savings, and 275% for winter peak demand savings. Realization rates for LED lighting, which accounts for more than 90% of ex post gross energy and winter peak demand savings and 75% of summer peak demand savings, ranged from 91% for energy savings to 250% for winter peak demand savings. High realization rates for demand savings are in part driven by recessed outdoor LEDs, globe LEDs, and three-way LEDs, for which ex ante demand savings were not claimed. For advanced thermostats, which account for 8% of ex post gross energy savings, the energy realization rate was around 50%.[14] Advanced thermostats also account for 25% of ex post gross summer demand savings and 9% of ex post gross winter demand savings, but were not assigned ex ante demand savings, and therefore contribute to high overall demand realization rates.

[14] In the absence of additional information on the sources of ex ante assumptions, the reasons for differences between advanced thermostat ex ante and ex post per-unit savings estimates remain unknown.

After applying NTGRs, developed based on participant survey responses, the DEK offering achieved 1.2 GWh in ex post net energy savings, 0.25 MW in ex post net summer peak demand savings, and 0.24 MW in ex post net winter peak demand savings. Table 24 summarizes total ex ante, ex post gross, and ex post net savings.

Table 24. Online Savings Store Program Performance Summary

Metric	Ex Ante	Gross RR	Ex Post Gross	NTGR	Ex Post Net
Energy Savings (kWh)	3,934,555	85%	3,334,127	0.372	1,241,646
Summer Peak Demand Savings (kW)	232	243%	563	0.448	252
Winter Peak Demand Savings (kW)	232	275%	637	0.377	240

Note: NTGR values were developed by product category. While NTGRs do not vary across energy and demand savings, the effective NTGRs (estimated as level ex post net savings divided by ex post gross savings) do as a result of varying contributions of each product category to energy and summer and winter demand savings.

Implementation and Data Tracking

Program implementation processes appear to run smoothly and effectively, as evidenced by high levels of customer satisfaction with the products offered and the program overall. In particular, participants expressed high degrees of satisfaction with the size of discounts being offered, the speed with which they received purchased products, and the range of products available through the program. Program tracking data was generally clean, accurate, fully populated, and included the necessary product specifications to inform TRM-based savings calculations for all products. Notably, it did not include information about participant households, which is pertinent for advanced thermostats (heating and cooling equipment, square footage) and water-saving measures (water heating equipment, people per household).

Marketing and Outreach

Despite the OSS Program being implemented as an online platform, more than half of participants learned about the offering through a bill insert or physical mailing from Duke, suggesting these outreach channels remain an effective method of communicating the program's availability.

Discounted shipping may be an especially valuable point of emphasis for program marketing and an effective tool for encouraging energy-efficient purchases. Many customers expressed uncertainty about whether their order received discounted shipping, but those who did recall receiving it often indicated that it was highly influential in their decision to purchase a product through the program.

Program Influence

The OSS Program provides an easily accessible platform for encouraging customers to consider adopting energy-efficient household items. Participant feedback suggests that many of those who purchased less widely popular measures only considered purchasing that type of product because of information they received about program offerings. This finding suggests that other less common products that have very recently or not yet been introduced to the program may be especially good candidates for promotion through the program, including faucet aerators, advanced power strips, air purifiers, dehumidifiers, or other household appliances.

Conversely, the lighting market appears to be nearing transformation, and limited opportunity remains for program discounts to spur LED purchases that would not have occurred in their absence. Utility programs like this one have helped the lighting market near transformation with many customers indicating LEDs as their preferred product. As the market continues to shift, we expect LEDs will be an increasingly popular and affordable option, further limiting the power of program discounts to motivate LED purchases that would not have otherwise occurred. However, given continuing uncertainty surrounding potential federal legislation and the assumption among industry experts that any such legislation will allow ample lead time and an extended sell-through period for less efficient products, LEDs are not expected to become the de facto standard among specialty bulbs and fixtures in the immediately foreseeable future, therefore representing a continuing, albeit shrinking, program opportunity.

Thermostat Usage

While all interviewed advanced thermostat participants replaced previously installed programmable or manual thermostats, the majority of previously installed thermostats were programmable, suggesting there may be limited potential for savings if customers are already conserving energy by way of programmed thermostat schedules. However, almost none of these respondents reported primarily relying on a programmed schedule to set the temperature of their home with their previous thermostat, while a majority indicated that they do use a programmed schedule and/or advanced features of their new thermostat, which offers some support for savings assumptions being applied to these measures as part of the current evaluation.

Installation Behavior

First-year ISRs of less than 75% for advanced thermostats indicate that substantive portions of participants are not installing their program-discounted products several months after purchasing. Among those with uninstalled products, the vast majority report they have not yet gotten around to or have not yet needed to install their new products. The program may therefore be able to maximize savings by conducting additional outreach or providing materials to participants—especially those who purchased advanced thermostats—encouraging them or reminding them to install the new products.

Non-Energy Impacts

In addition to the energy savings achieved by the OSS Program, many customers reported other benefits of their new program-discounted products. More than half of LED lighting participants reported the quality of lighting in their home had been improved (58%) and many advanced thermostat participants suggested their homes were more comfortable (55% during summer; 50% during winter). A smaller portion of thermostat participants indicated that their electricity bills were lower since installing their new thermostats (29% during summer; 18% during winter).

7.2 Recommendations

Based on the findings of this evaluation, the evaluation team identified the following opportunities for program improvement:

- Although there is a high rate of customer uncertainty regarding whether they received discounted shipping, those who are aware of the discount reported that it influenced their decision to purchase a program-discounted product. Therefore, we recommend that program marketing continue to promote discounted or free shipping, when available, both in outreach materials and on the program website.
- To support increases in first-year ISRs, we recommend that the program continue to include collateral with orders encouraging customers to install their new energy-efficient products as quickly as possible. The program could also consider additional outreach to recent participants encouraging them to install their new products, particularly for advanced thermostats. This has the potential to help the program maximize first-year savings. For LED lighting specifically, reducing the current limit from 36 discounted

bulbs per customer could also help increase ISRs given those purchasing larger quantities are less likely to immediately install most or all of their new products.

- We recommend the program continue to explore possible expansions of the OSS Program and continue using the offering to promote less common energy-efficient products, some of which have already been introduced to the program (including faucet aerators, advanced power strips, air purifiers, dehumidifiers, or other household appliances). Our evaluation found that participants often purchase these types of products as a direct result of information made available by the OSS offering, as exhibited by their relatively low rates of FR.

8. Summary Form

DUKE ENERGY KENTUCKY
ONLINE SAVINGS STORE PROGRAM
COMPLETED EM&V FACT SHEET

PROGRAM DESCRIPTION

Duke Energy's Online Savings Store (OSS) Program offers a wide range of point-of-sale-discounted specialty LED lighting and advanced thermostats as well as several other water-saving measures and electric devices including, low-flow showerheads, TSVs, air purifiers, and dehumidifiers. The non-lighting measures reflect an expansion of the OSS Program, which began exclusively distributing energy-efficient lighting in 2017. Customers can purchase the discounted products online through a designated website operated by Energy Federation Inc. (EFI).

Date:	October 6, 2022
Region(s):	Duke Energy Kentucky (DEK)
Evaluation Period:	August 1, 2017–June 30, 2021
Annual kWh Savings (ex post net):	1,242 MWh
Coincident kW Impact (ex post net):	0.25 MW (Summer), 0.24 MW (Winter)
Measure Life:	Not Evaluated
Net-to-Gross Ratio:	0.372
Process Evaluation:	Yes
Previous Evaluation(s):	Evaluation of the Residential Energy Efficient Appliance and Devices: Lighting - Specialty Bulbs Program in Kentucky and Ohio. June 22, 2015.

EVALUATION METHODOLOGY

In support of the **gross impact evaluation**, we first reviewed program tracking data and ex ante per-unit deemed savings values for incented products. We then developed updated per-unit deemed savings based on review of secondary sources and results of a survey fielded with program participants. We also verified product installation and persistence based on participant survey responses. Based on these evaluated ex post per-unit deemed savings values and survey-based ISRs, we calculated ex post gross energy and demand savings for products sold through the DEK OSS Program.

The **net impact evaluation** relied on participant survey responses to quantify free ridership and participant spillover. We estimated free ridership by measure category and developed program-level participant spillover rates that account for non-discounted OSS purchases in addition to those made at other retailers. The resulting net-to-gross ratios were multiplied by ex post gross savings to determine net program impacts.

We also conducted a **process evaluation** focused on participant experiences and satisfaction with the program, product usage behaviors, program marketing and outreach, non-energy impacts, and implications of participant-reported influence of key program elements on their decision to purchase program-discounted energy-efficient products.

9. DSMore Table

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

Appendix A. Detailed Impacts Dataset

This Excel spreadsheet is provided as a separate file and contains detailed analysis of program gross and net impacts. The data in the file are provided by unique product and contains ex ante, ex post gross, and net savings.

Appendix B. Deemed Savings Review

The deemed savings review memorandum developed as part of this evaluation is provided as a separate file.

Appendix C. Participant Survey Instrument

The data collection instrument used for the participant survey effort conducted in support of this evaluation is provided as a separate file.

Appendix D. Net-to-Gross Algorithms and Additional Information

This appendix contains a detailed overview of the free ridership (FR) algorithms for lighting and non-lighting products and the development of participant spillover (PSO).

Free Ridership Algorithm

Participants in the OSS Program received discounts on energy-efficient products but some may have purchased the same products even without a discount. As such, we asked participants questions about their purchase behaviors and decisions they would like have made if program discounts had not been available. We aggregated respondent results to the program level by weighting individual participant responses by the energy savings associated with their purchased products.

Figure 13 contains a detailed overview of the LED lighting FR algorithm for the OSS Program used to develop respondent-level FR estimates for LED lighting participants. Because lighting is a commodified product that virtually all customers purchase as needed, the LED lighting algorithm focuses on what customers would have purchased in the absence of the program discount (Q.LFR2, Q.LFR3) and what they would have purchased the next time they needed bulbs in the event that they would not have purchased program-discounted LEDs at full price (Q.LFR4, Q.LFR5). The LED lighting algorithm also adjusts FR downwards in the event that the program encouraged them to replace still-working less efficient bulbs that otherwise would have remained in operation (Q.R2, Q.LFR7).

Figure 14 provides a detailed overview of the non-lighting FR algorithm for the OSS Program. We first asked participants if they were already planning to purchase a comparable energy-efficient product prior to learning about the program's discount (Q.FR1). Those who were not in the market for a similar product are assumed to be non-free riders. The subsequent survey questions ask participants who had already been considering comparable products to rate (1) the influence of the program on their decision to purchase an energy-efficient version over a less efficient alternative (Q.FR4) and (2) the likelihood of purchasing the product they did in the program's absence (Q.FR5). After using these ratings to establish a preliminary FR score, we then make adjustments to account their anticipated timing of the purchase in the program's absence (Q.FR2) and, if relevant, whether they would have purchased a smaller quantity of the products (Q.FR3). Responses to these questions inform timing and quantity adjustments that can reduce FR. Lastly, we asked all respondents a single open-ended question (Q.FR6) giving them the opportunity to explain in their own words how the program influenced their decision. In cases where other responses appear inconsistent, we reviewed responses to the open end to either adjust or omit a given response from the analysis.

Figure 13. LED Lighting FR Algorithm

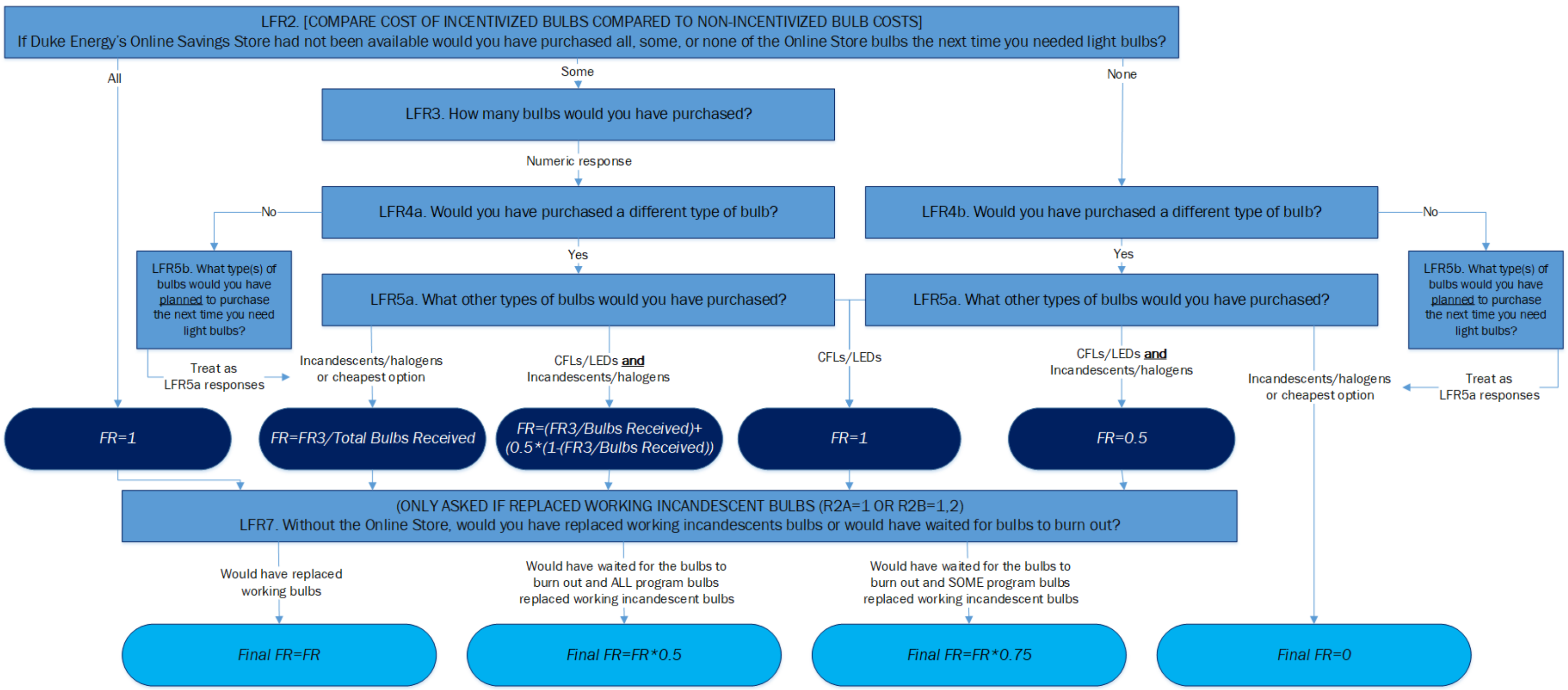
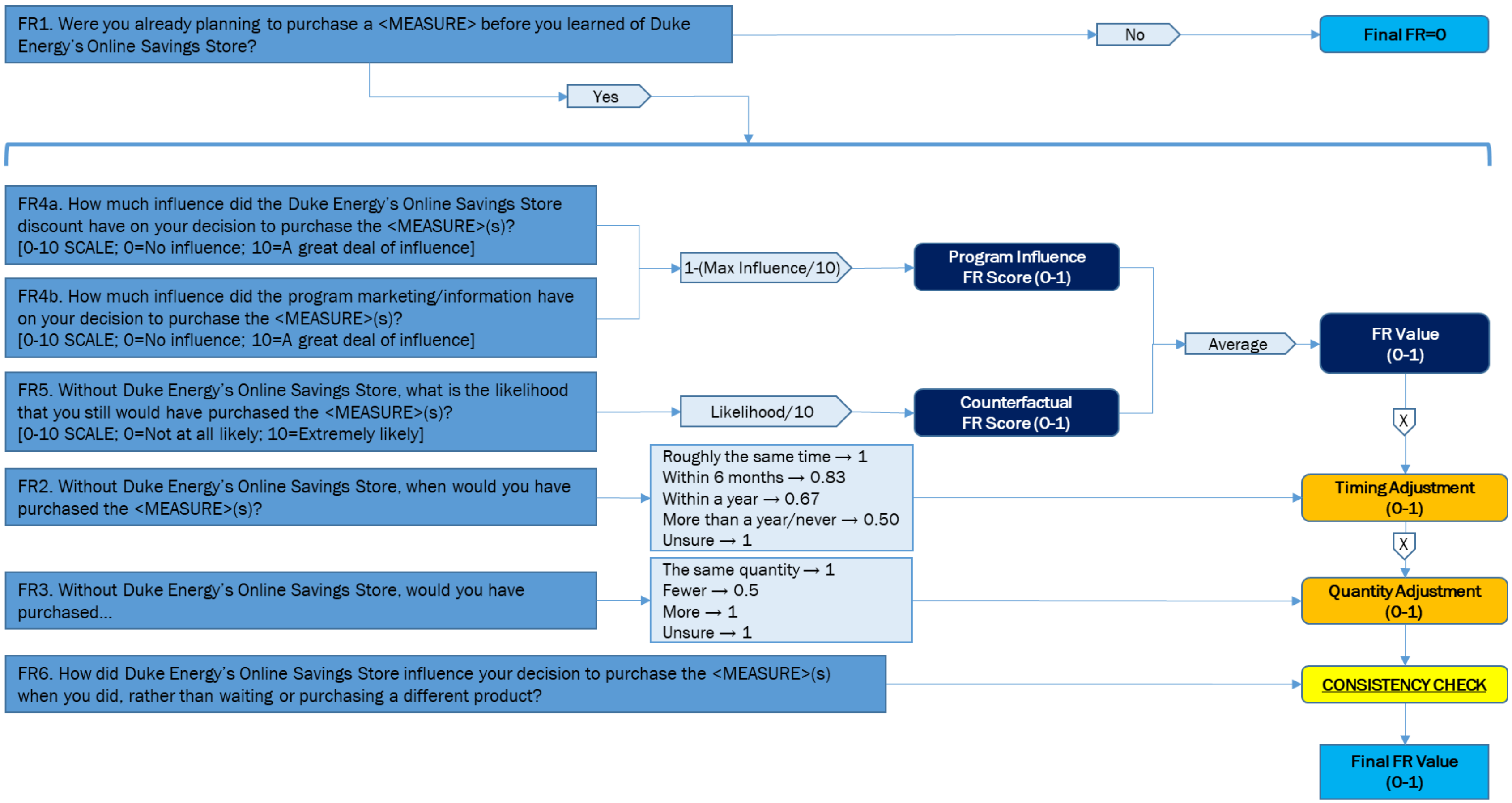


Figure 14. Non-Lighting FR Algorithm



Demographic Comparison of Free Ridership Results

In an effort to better understand how different groups of customers engage with and are influenced by the OSS Program, we compared FR rates across sociodemographic and household characteristics gathered as part of the survey effort. The analysis allowed us to explore differences in FR across customer demographic groups and investigate opportunities for the program to improve its efficacy by targeting customer groups with tendencies for lower FR. However, FR levels did not show clear patterns across customer characteristics. Figure 15 summarizes FR rates by sociodemographic group and product category for the DEK OSS offering. It should be noted that for some groups, sample sizes are extremely small, so results should be interpreted with caution.

Table 25. Comparison of FR Results by Sociodemographic Groups

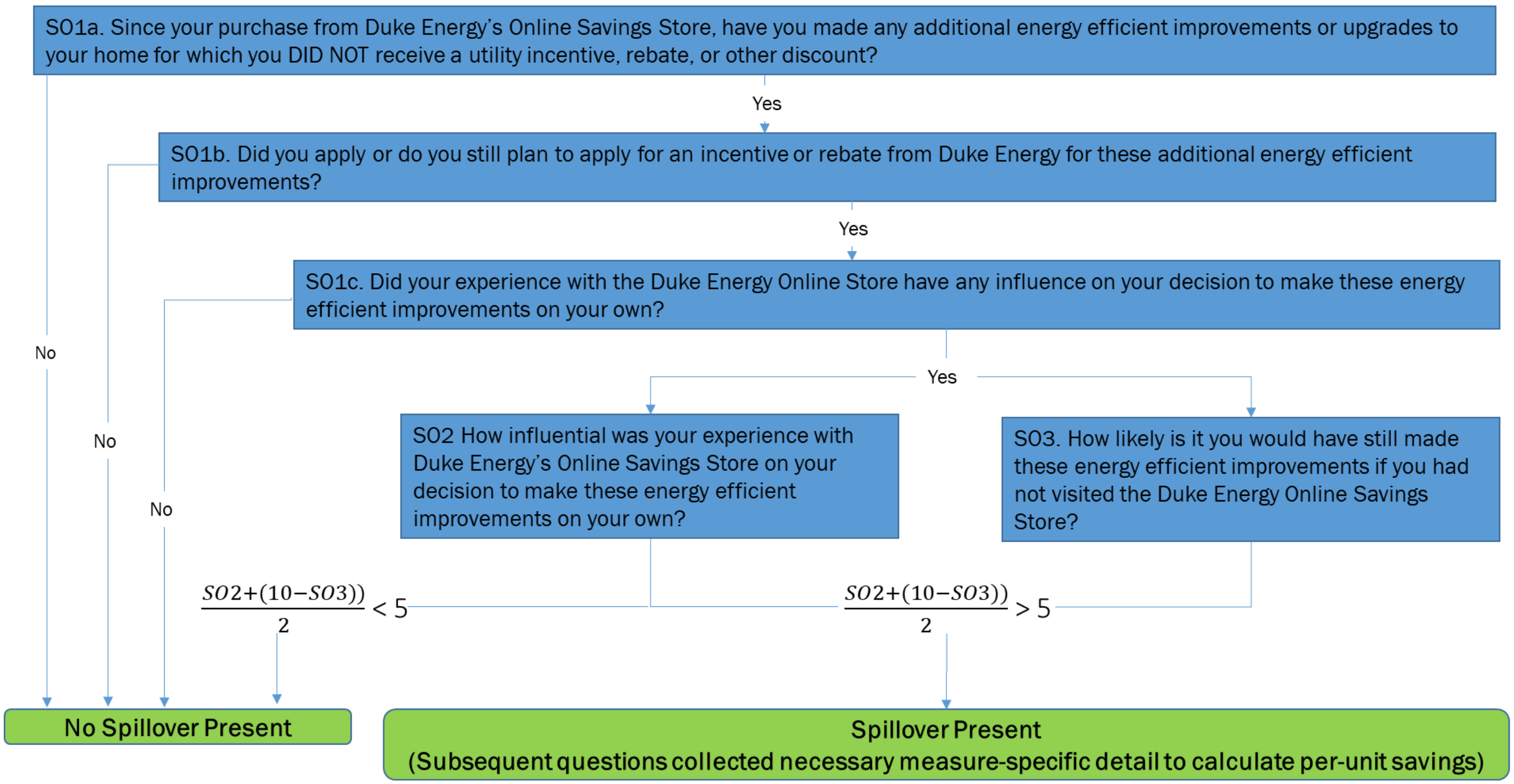
Characteristic	LED Lighting FR	% of Lighting Participants	Advanced Thermostat FR	% of Advanced Thermostat Participants
Age	n=28		n=33	
18–34	0.17	4%	0.00	6%
35–54	0.32	14%	0.31	18%
55+	0.75	82%	0.20	76%
Homeownership	n=28		n=33	
Own	0.69	97%	0.20	88%
Rent	0.25	3%	0.24	12%
Income	n=20		n=25	
Less than $50,000	0.24	35%	0.00	8%
$50,000–$99,999	0.57	40%	0.18	40%
$100,000+	0.92	25%	0.23	52%
Housing type	n=28		n=33	
Single-family	0.69	93%	0.16	79%
Non-SF	0.44	7%	0.37	21%

Spillover Algorithm

We explored non-program energy-efficient product purchases and the degree of program influence on those purchases through the participant survey. Participants were asked whether they purchased any energy-efficient products outside of the OSS offering since receiving their program-discounted products that did not receive a utility discount. Respondents who reported purchasing additional products received follow-up questions about the impact of the program on their purchase of the energy efficient products. Respondents who reported that the program influenced their decision were asked to provide a quantitative rating of the level of program influence as well as a qualitative explanation of the way(s) the program influenced their purchase decisions.

graphically depicts the survey-based spillover algorithm we deployed to identify and quantify spillover-qualifying purchases made outside of the OSS offering.

Figure 15. Survey-Based Spillover Algorithm



Participants who reported potential spillover purchases were asked to provide additional detail on the non-discounted products they purchased. Using these responses, we developed deemed savings values for each spillover measure, which were then aggregated to produce an estimate of total savings from spillover identified among participant survey respondents. We then divided those spillover savings by total ex post gross savings associated with participants who responded to the survey to produce a survey-based PSO rate that can be factored into the NTGR and effectively applied to program savings overall.

Some OSS Program participants also purchased non-discounted products from the OSS website in addition to program-discounted ones, which represent another potential source of PSO. We reviewed program tracking data associated with survey respondents who reported spillover-qualifying purchases to ensure no overlap existed between survey-based PSO and non-discounted OSS purchases and avoid double counting of PSO savings. We developed estimates of total ex post gross savings associated with these non-discounted OSS products and adjusted those savings based on product category-specific FR estimates established by the current evaluation to represent the portion of these sales attributable to the OSS Program. We then divided those spillover savings by the program's total ex post gross savings to produce a PSO rate associated with non-discounted OSS sales that can be factored into the NTGR and effectively applied to program savings overall.

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EM&V Report for the Duke Energy Small Business Energy Saver Program 2019-2021

Prepared for:

Duke Energy Kentucky (DEK)

FINAL

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1. Evaluation Summary

1.1 Program Summary

The Small Business Energy Saver (SBES) program is a direct install program offered to qualifying nonresidential customers in the Duke Energy Kentucky (DEK) jurisdiction with an average annual demand of 180 kW or less. Participating customers receive an energy assessment at their facility and subsequently a set of recommended energy efficient measure retrofits. Customers receive information about the proposed measure installation and project costs including utility incentives of up to 80 percent inclusive of both materials and installation for high-efficiency lighting, refrigeration, and HVAC equipment. Once approved, the direct installation is scheduled and completed with minimal disruption to business operations.

The following measures are currently included in the SBES program:

- Lighting Measures: LED interior and exterior lighting solutions.
- Refrigeration Measures: lighting, motors, and controls for refrigeration cases.
- HVAC Measures: HVAC controls, thermostats, and tune-ups.

Willdan Energy (Willdan) is the Implementation Contractor delivering the SBES program in DEK. Willdan provides integrated energy audits, equipment procurement, payment services, and financing options to participating customers. Measure installation is either performed by Willdan or a subcontractor to Willdan.

1.2 Evaluation Objectives

This evaluation, measurement and verification (EM&V) provides an independent assessment of program impacts and performance for participation that occurred between 8/1/2019 and 12/30/2021. This evaluation scope of work covered limited impact evaluation activities (deemed savings analysis without site or virtual verification), net-to-gross analysis, and process analysis of program performance and participant satisfaction.

Evaluation objectives included the following:

Impact Evaluation:

- Verify deemed savings estimates through review of measure assumptions and calculations.
- Estimate the amount of verified gross energy and peak demand savings (both summer and winter), net impacts by measure category, and overall program impacts.
- Collect program tracking data and perform engineering desk review of measure installations to inform data collection processes.

Net-to-Gross Analysis:

- Assess the Net-to-Gross (NTG) ratio by researching spillover and free-ridership via customer online surveys.

Process Evaluation:

- Conduct phone interviews with program management and implementation contractor(IC) for a current understanding of program operations, goals and challenges to inform our NTG and Process research.
- Conduct primary research to evaluate the strengths and weaknesses of program processes and customer perceptions through online surveys.

By performing both impact and process components of the EM&V effort, Guidehouse provides Duke Energy with verified energy and demand impacts, as well as a set of recommendations that are intended to aid Duke Energy with improving or maintaining satisfaction with program delivery while meeting energy and demand reduction targets in a cost-effective manner.

1.3 Evaluation Methods

Table 1-1 summarizes the evaluation activities conducted to achieve the evaluation objectives. These activities included an engineering review of measure deemed savings parameters and algorithms, and participant surveys to evaluate satisfaction and decision-making.

Table 1-1. Evaluated Parameters

Evaluation Activity	Evaluated Parameter	Description	Details
Impact	Savings & Efficiency Characteristics	Inputs and assumptions used to estimate energy and demand savings	1. Lighting wattage 2. Operating hours 3. In service rate 4. Coincidence factors 5. HVAC interactive effects 6. Baseline Characteristics 7. Desk File Review
Process	Satisfaction	Customer satisfaction	Participant survey
NTG	Free Ridership	Fraction of reported savings that would have occurred absent the program	Participant survey
	Spillover	Unincented savings influenced by the program	Participant survey

Source: Guidehouse

Table 1-2 shows the start and end dates of Guidehouse's sample period for evaluation activities.

Table 1-2. EM&V Sample Period Start and End Dates

Activity	Start Date	End Date
Program Impact	8/01/2019	12/30/2021
Process and NTG Surveys	3/17/2022	6/10/2022

Source: Guidehouse

1.4 Evaluation Findings and Recommendations

Guidehouse finds that Duke Energy is successfully delivering the SBES Program to customers. Participant satisfaction is generally favorable, and the reported measure installations are relatively accurate with some minor measure specific adjustments discussed below. For the evaluation period covered by this report, there were a total of 140 projects comprised of roughly 13,523 measures installed through the program.

Guidehouse calculated the realization rate for gross energy savings to be 106 percent,meaning that total verified gross energy savings were 106 percent of the claimed savings in the tracking database provided by Duke Energy. The realization rate for peak demand savings was 91 percent for the summer coincident peak demand and 55 percent for the winter coincident peak demand. The reported savings did not account for energy and demand HVAC interactive effects and coincidence factors when estimating savings for lighting measures. Guidehouse applied HVAC interaction factors to account for the reduced space cooling requirements due to the reduction of waste heat rejected by efficient lighting. The adjustments were the primary cause of the higher realization for gross energy savings. While the demand interactive factors increased the demand savings, the coincidence factors were lower, contributing to the lower realization of peak summer and winter demand savings.

The refrigeration measures produced 100 percent verified gross realization rates. No HVAC measures were implemented during the evaluation period. The verified gross and net impact evaluation results are provided in Table 1-3 and Figure 1-1.

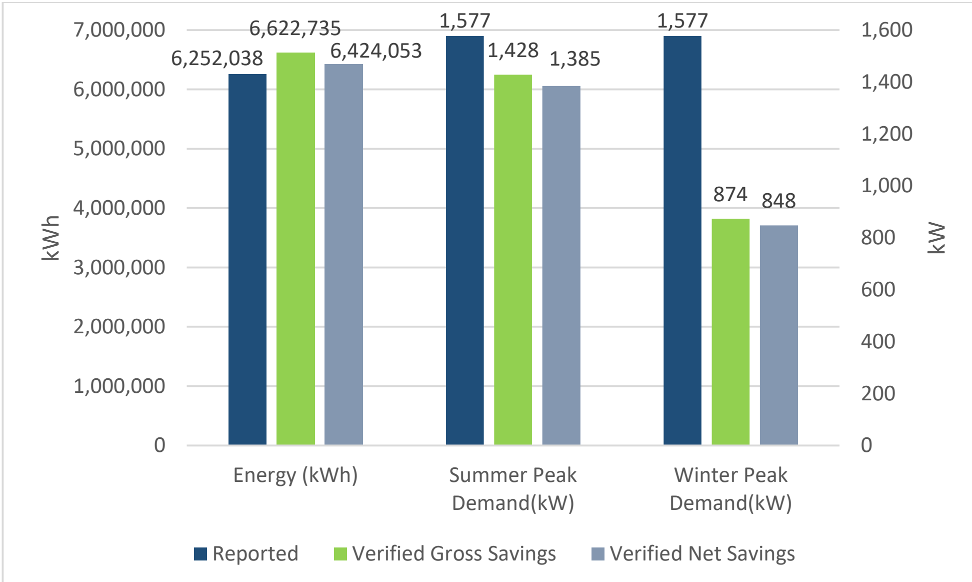
Guidehouse research produced the Net-To-Gross (NTG) ratio to be 0.97, meaning that for every 100 kWh of reported energy savings, 97 kWh can be attributed directly to the program. By multiplying the verified gross energy and demand savings by the NTG ratio, Guidehouse calculated the net energy and demand impacts shown in Table 1-3. These findings are expanded upon in greater detail throughout this report.

Table 1-3. SBES Reported, Verified Gross and Verified Net Savings

Parameter	Energy (kWh)	Summer Peak Demand (kW)	Winter Peak Demand (kW)
Reported Savings	6,252,038	1,577	1,577
Realization Rate	106%	91%	55%
Verified Gross Savings	6,622,735	1,428	874
Net-to-Gross	97%	97%	97%
Verified Net Savings	6,424,053	1,385	848

Source: Guidehouse analysis, values subject to rounding.

Figure 1-1. Reported, Verified Gross and Net Energy and Demand Savings



Source: Guidehouse analysis, values subject to rounding.

Guidehouse presents the following list of findings and recommendations to help improve program delivery and impacts:

Impact

1. **Consider employing aspects of the Maryland/Mid-Atlantic Technical Reference Manual (MA TRM).** The reported ex-ante savings did not include energy and demand interactive or coincidence factors. Guidehouse recommends that the IC use the energy and demand interactive factors and coincidence factors provided in the Mid-Atlantic TRM while calculating savings. Using the MA TRM provides the opportunity to map the tracking data SIC description or measure location to the energy and demand interactive factors by building type and space type provided in the TRM.
2. **Completely capture of all required inputs.** The initial and final tracking data provided for evaluation did not capture all requested inputs to calculate savings for electronically commutated motor (ECM) measure and the Cooler Door Kits (LED Case Lighting). Some projects had missing inputs such as quantity of lamps installed or replaced, rated wattage of baseline and efficient lamps, efficiency of the cooler/freezer compressor (kW/ton), load reduction or operating hours of the evaporator fan motor. Guidehouse verified these inputs through the additional file reviews and TRM assumptions. For the next evaluation, the IC should capture all necessary inputs in the tracking data to enable Guidehouse to effectively verify inputs and calculate savings in a timely manner.
3. **Ensure tracking inputs produce required savings.** Guidehouse found a project (DEK00011832.2) had replaced an incandescent 60W bulb with a 60W T8 LED Lamps with 60W. The evaluation assigned zero verified savings for this measure compared to the reported values 2,337 kWh and 0.54 KW, which means the gross realization rate is zero. Another project (DEK00004998.1) reported energy savings for an occupancy sensor was 676 kWh but the verified savings was 73 kWh, based on inputs provided in the tracking data. The measure gross energy realization rate is 11 percent (overall energy realization rate for occupancy sensors was 102 percent due to application of HVAC interactive factors).

Guidehouse recommends the IC ensure tracking savings inputs are applied consistently to produce the expected savings.

4. **Capture fuel type for participant buildings when applicable.** The tracking data did not capture HVAC fuel types for buildings participating in this program. When readily available Guidehouse recommends the IC capture the actual fuel type for participating buildings in the data tracking system. If the fuel type of any participating buildings is not readily available, Guidehouse recommends using an assumed fuel type of AC electric and non-electric gas heating based on the TRM.
5. **Confirm quantity of installed measures**. During the sample file review two projects had inconsistencies between the number of measures installed and the invoice that was used as the supporting document. The evaluation did not use the results from the documentation review to adjust savings since the sample size was too small to inform statistical adjustments at the population level. We recommend that the IC ensure consistency in tracking the number of efficient measures installed and invoiced to avoid potential risk of evaluation adjustment.

Process and NTG

6. **Satisfaction with the program is high**. The majority of respondents rated their satisfaction with the program overall as a 10 on a 0-10 scale, and 100 percent of respondents rated their overall satisfaction as an 8-10. Satisfaction has improved since the last evaluation period in 2017, when 74 percent rated their satisfaction as an 8-10.
7. **Structure Facility Assessment Reports for the layperson**. The Facility Assessment Reports were the most influential factor in driving program participation. When asked about challenges understanding or using elements of the program, some participants experienced the greatest challenge in using and understanding their facility assessment report. This was followed by determining how to finance their energy efficiency projects. The program should structure the Facility Assessment Reports to be easily understood by the non-engineer small business owners and decision makers.
8. **Phase in Non-Lighting measures.** When asked what additional equipment Duke should add to the program, respondents requested motors, water heaters, HVAC and additional refrigeration equipment. The Energy Independence and Security Act (EISA) rules will impact the savings Duke can achieve for lighting measures in the future. Guidehouse recommends phasing in more high impact non-lighting measures appropriate to the customer mix.
9. **Potentially expand consideration of Covid-19 impacts among DEK SBES-eligible customers**. Survey respondents did not forecast negative impacts to their business from Covid-19 disruptions to the economy. The respondents were all from industries less impacted by the pandemic than a typical small business mix, challenging our ability to determine how significant an impact Covid-19 is having on SBES-eligible customers. Analysis of SIC codes in tracking data suggest that participants overall may be more susceptable to economic impacts from Covid-19 than survey respondents. Examine self-report industries (SIC) participation compared to industry mix throughout jurisdiction to determine if additional research is recommended.
10. **Launch free ridership surveys shortly following project completion.** Survey response rates decline with time since the project completion. While it takes 1-2 years for spillover to develop, as time goes on program participants tend to forget details necessary to calculating accurate free ridership, such as program importance and prior plans. Guidehouse recommends launching free ridership surveys shortly after project completion and collect data for future analysis. Spillover surveys should continue to be fielded 1-2 years after project completion.

2. Program Design

The SBES Program is available to qualifying nonresidential customers with average annual demand of 180 kW or less. Willdan, the program implementation contractor (IC), markets and promotes the offer to eligible DEK customers. Following completion of a program application to assess participation eligibility, the IC delivers a free energy assessment to identify equipment for upgrade. The IC reviews the energy assessment results with the customer, who then chooses which equipment upgrades to perform. Measure installation is performed by Willdan, or a subcontractor to Willdan, at the convenience of the customer.

The SBES Program recognizes that small business customers may benefit from a streamlined, one-stop, turnkey delivery model and may require higher incentives and technical assistance to invest in energy efficiency compared to mid and large sized commercial customers. Independent small businesses generally lack internal staffing dedicated to energy management and therefore benefit from facility assessments, advice from energy efficiency experts, and installations performed by an outside vendor.

The Program offers Facility Assessment Reports and financial incentives in the form of a discount for the installation of measures, including high-efficiency lighting, refrigeration and HVAC equipment. These incentives are intended to increase adoption of efficient technologies beyond what would occur naturally in the market. During the period included in this evaluation, 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. The program did not realize savings from HVAC measures during the evaluation period.

The program offers a performance-based incentive of 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. The program offers one and two year interest-free financing as well as a discount for paying the project at the time of installation.

2.1 Reported Program Participation and Savings

Duke Energy and the IC 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 deemed savings values. In addition, this database contains measure level details that are useful for EM&V activities. Table 2-1 provides a summary of the gross reported energy and demand savings and participation for 2019-2021.

Table 2-1. Reported Participation and Gross Savings Summary

Reported Metrics	DEK
Projects	140
Measures Installed	13,450
Gross Annual Energy Savings (kWh)	6,252,038
Average Quantity of Measures per Project	8
Average Gross Savings Per Project (kWh)	44,657

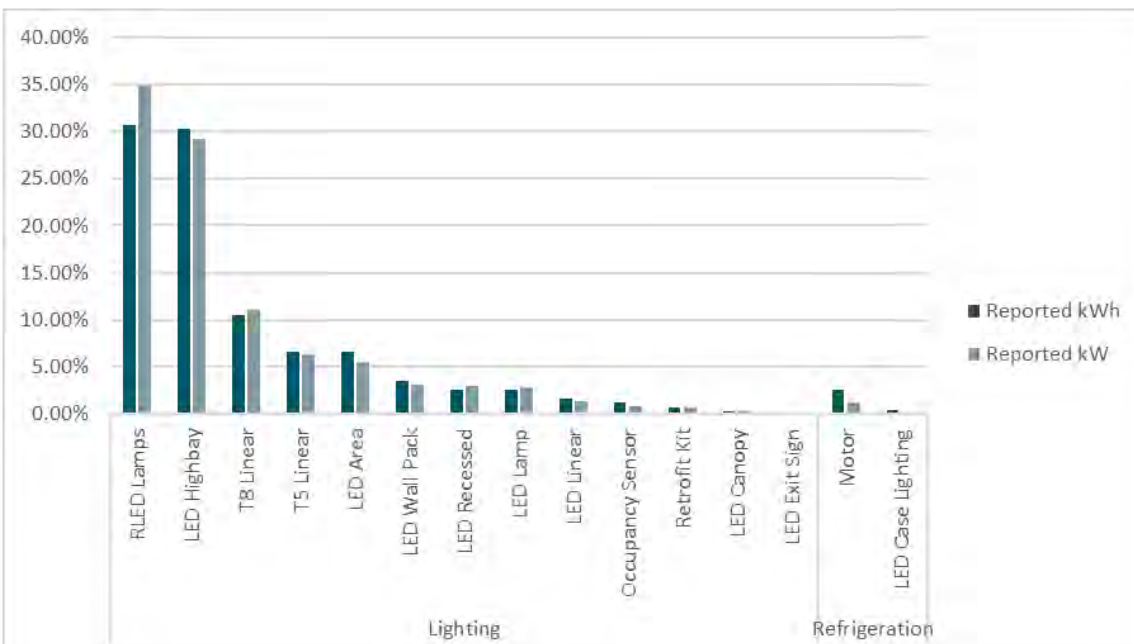
Source: SBES Tracking Database

The IC uses algorithms primarily from the Pennsylvania Technical Resource Manual[1] (TRM) as the basis for reported energy and demand savings calculations[2] for lighting. The IC also used the New York TRM for refrigeration measures. These TRMs are robust, well-established, and follow industry best practices for the measures found in the SBES program. The evaluation team believes the Mid-Atlantic TRM[3] is an appropriate basis for estimating lighting savings in the DEK jurisdiction based on Guidehouse's assessment of the underlying energy savings assumptions, involving HVAC interactive effects by building type, location and fuel type.

2.1.1 Program Savings by Measure

Efficient recessed LED (RLED) lamps were the highest contributor to program energy savings in 2019 -2021, followed by LED Highbay lighting measures. In addition, refrigeration measures (including EC motors, LED case lighting), and occupancy sensors also contributed to savings. Overall, lighting measures contribute 97 percent of reported program energy savings, refrigeration measures contribute the remaining 3 percent.

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



Source: SBES Tracking Database

2.1.2 Program Savings by Facility Type

Guidehouse reviewed the business type information in the tracking database to understand the participant demographics. The tracking data included Standard Industrial Classification (SIC) codes for each project and the business location, resulting in many unique detailed building

[1] New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs - Residential, Multi-Family, and Commercial/Industrial, known as the Technical Resource Manual (TRM), Version 8, January 1, 2021

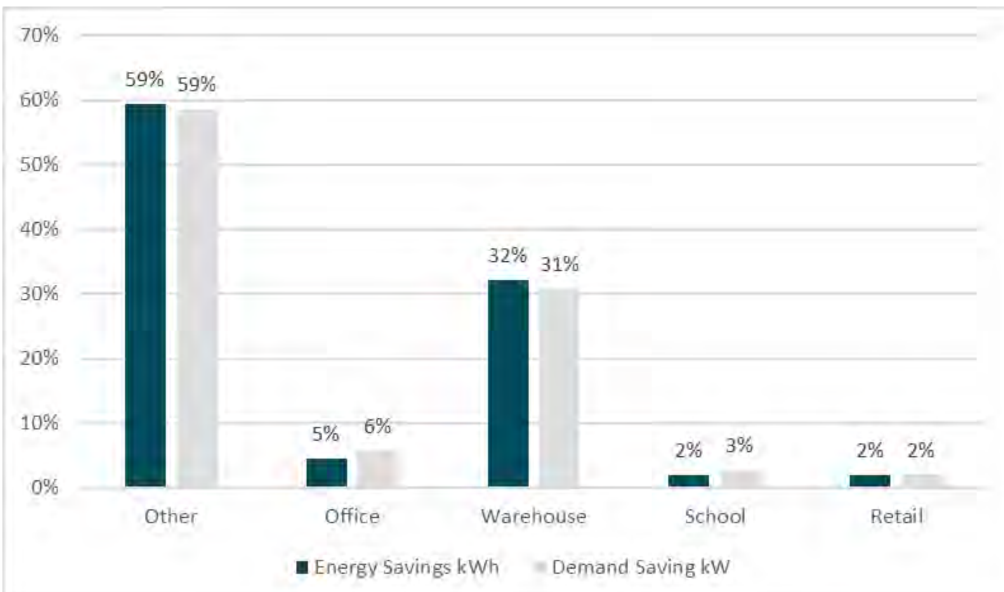
[2] The Pennsylvania Technical Reference Manual, 2021 is used for the lighting algorithms

[3] NEEP TRM (April 2020, v10), https://neep.org/sites/default/files/media-files/trmv10.pdf

types. As part of the engineering analysis for this evaluation, Guidehouse used the Maryland/Mid-Atlantic TRM[4] to make impact adjustments to account for factors such as HVAC interactive effects and coincidence factors. To accomplish this, Guidehouse mapped the SIC codes and location types from the tracking data to the facility types detailed in the MA TRM.

These facility types are shown below in Figure 2-2. Note that the largest category is "other", which indicates either the SIC code was not populated or a suitable TRM facility type was not found. 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 "other", office and warehouse facilities represent the largest contributors of energy and demand savings. Facilities that fell under the "other" building type include but not limited to; auto repair shops, eating and drinking places, legal and health services, and hotel rooming and houses.

Figure 2-2. Reported Energy Savings by Facility Type



Source: SBES Tracking Database

[4]North East Efficiency Partnership - Maryland/Mid-Atlantic TRM (April 2020, v10), https://neep.org/sites/default/files/media-files/trmv10.pdf

3. Impact Evaluation

The impact evaluation focuses on quantifying the magnitude of verified energy savings and peak demand reductions. This section outlines the impact results, methodologies and the assumptions used to calculate the verified program impacts.

3.1 Impact Evaluation Results

Table 3-1 shows the program-level results for gross and net energy and demand savings for DEK. The subsequent Table 3-2, Table 3-3, and Table 3-4 break down gross energy and demand savings by measure type. Guidehouse estimates gross realization rates of 106%, 91% and 55% for energy, summer coincident demand, and winter coincident demand, respectively.

Table 3-1. Reported and Verified Program-Level Impacts

Parameter	Energy (kWh)	Summer Coincident Peak Demand (kW)	Winter Coincident Peak Demand (kW)
Reported Savings	6,252,038	1,577	1,577
Realization Rate	106%	91%	55%
Verified Gross Savings	6,622,735	1,428	874
Net-to-Gross	97%	97%	97%
Verified Net savings	6,424,053	1,385	848

Source: Guidehouse analysis, values subject to rounding

Table 3-2. Reported and Verified Lighting Impacts

Parameter	Energy (kWh)	Peak Demand Savings (kW)	Summer Peak Demand Savings (kW)	Winter Peak Demand Savings (kW)
Reported Savings	6,068,435	1,557	1,557	1,557
Realization Rate	106%	N/A	90%	55%
Verified Gross Savings	6,439,133	N/A	1,407	854
Net-to-Gross	97%	97%	97%	97%
Verified Net Savings	6,245,959	N/A	1,365	828

Source: Guidehouse analysis, values subject to rounding

Table 3-3. Reported and Verified LED Case Lighting Impacts

Parameter	Energy (kWh)	Summer Coincident Peak Demand (kW)	Winter Coincident Peak Demand (kW)
Reported Savings	26,077	2.83	2.83
Realization Rate	100%	100%	100%
Verified Gross Savings	26,077	2.83	2.83
Net-to-Gross	97%	97%	97%
Verified Net Savings	25,295	2.74	2.74

Source: Guidehouse analysis, values subject to rounding

Table 3-4. Reported and Verified Refrigeration ECM Motors Impacts

Parameter	Energy (kWh)	Summer Coincident Peak Demand (kW)	Winter Coincident Peak Demand (kW)
Reported Savings	157,526	17.98	17.98
Realization Rate	100%	100%	100%
Verified Gross Savings	157,525	17.98	17.98
Net-to-Gross	97%	97%	97%
Verified Net Savings	152,799	17.44	17.44

Source: Guidehouse analysis, values subject to rounding

Table 3-5 and Table 3-6 present the energy, summer peak and winter peak impacts by the different measure categories in the DEK SBES program.

Table 3-5. Reported and Verified Gross Measure-Level Impacts

Measure	Reported Savings (kWh)	Verified Gross kWh Savings	kWh Realization Rate	Reported Demand Savings (kW)	Verified Gross Summer Demand Savings (kW)	Verified Gross Winter Demand Savings (kW)	kW Realization Rate (Summer)	kW Realization Rate (Winter)
LED Area Light	275,437	297,592	108%	58.1	11.4	33.7	20%	58%
LED Case Lighting	26,077	26,077	100%	2.8	2.8	2.8	100%	100%
LED Exit Sign	6,447	6,963	108%	0.7	0.6	0.3	86%	40%
LED Flood Light	153,563	165,851	108%	33.3	5.5	19.2	17%	58%
LED Highbay	1,893,021	1,995,505	105%	460.4	457.5	285.5	99%	62%
LED Lamp	157,775	168,548	107%	44.1	39.9	21.1	90%	48%
LED Linear	100,183	108,431	108%	21.2	21.7	12.3	103%	58%
LED Recessed	161,735	171,366	106%	46.2	41.6	19.2	90%	42%
LED Wall Pack	220,245	237,865	108%	47.9	12.6	27.4	26%	57%
ECM Motor	157,526	157,525	100%	18.0	18.0	18.0	100%	100%

Measure	Reported Savings (kWh)	Verified Gross kWh Savings	kWh Realization Rate	Reported Demand Savings (kW)	Verified Gross Summer Demand Savings (kW)	Verified Gross Winter Demand Savings (kW)	kW Realization Rate (Summer)	kW Realization Rate (Winter)
Occupancy Sensor	75,067	76,323	102%	12.4	12.8	12.5	103%	101%
Retrofit Kit	38,524	40,690	106%	9.8	8.2	4.1	84%	42%
RLED Lamps	1,918,388	2,043,329	107%	550.4	528.1	269.3	96%	49%
T5 Linear	409,623	425,922	104%	99.1	97.8	57.4	99%	58%
T8 Linear	658,429	700,749	106%	173.0	169.3	91.5	98%	53%
Total	6,252,038	6,622,735	106%	1,577	1,428	874	91%	55%

Source: Guidehouse analysis, values subject to rounding

Table 3-6. Reported and Verified Net Measure-Level Impacts

Measure	Verified Gross kWh Savings	Net-to-Gross	Net Verified kWh Savings	Verified Gross Summer Peak Demand Savings (kW)	Verified Gross Winter Peak Demand Savings (kW)	Net Verified Summer Peak Demand Savings (kW)	Net Verified Winter Peak Demand Savings (kW)
LED Area Light	297,592	97%	288,664	11.4	33.7	11.0	32.7
LED Case Lighting	26,077	97%	25,295	2.8	2.8	2.7	2.7
LED Exit Sign	6,963	97%	6,754	0.6	0.3	0.6	0.3
LED Flood Light	165,851	97%	160,876	5.5	19.2	5.4	18.6
LED Highbay	1,995,505	97%	1,935,640	457.5	285.5	443.7	276.9
LED Lamp	168,548	97%	163,492	39.9	21.1	38.7	20.5
LED Linear	108,431	97%	105,178	21.7	12.3	21.1	12.0
LED Recessed	171,366	97%	166,225	41.6	19.2	40.3	18.6
LED Wall Pack	237,865	97%	230,729	12.6	27.4	12.2	26.6
Motor	157,525	97%	152,799	18.0	18.0	17.4	17.4
Occupancy Sensor	76,323	97%	74,033	12.8	12.5	12.4	12.2
Retrofit Kit	40,690	97%	39,469	8.2	4.1	7.9	4.0
RLED Lamps	2,043,329	97%	1,982,029	528.1	269.3	512.3	261.2
T5 Linear	425,922	97%	413,144	97.8	57.4	94.8	55.7
T8 Linear	700,749	97%	679,726	169.3	91.5	164.2	88.8
Total	6,622,735	97%	6,424,053	1,428	874	1,385	848

Source: Guidehouse analysis, values subject to rounding

3.2 Impact Evaluation Methodology

The following subsections describe the methodology used for each element of the impact evaluation process. The results are discussed in detail in Section 3.3.

3.2.1 Deemed Savings Review

Guidehouse evaluated all program measures and supporting data parameters during the time period covered by this evaluation cycle. We replicated impact estimates using engineering calculations based on algorithms provided by the IC and using measure parameters from the tracking data, where available. Guidehouse calculated verified savings impacts for lighting measures that included modifications to the algorithm to include HVAC interactive effects and coincidence factors using the Mid-Atlantic TRM based on building type, location of installation, and heating fuel type. The IC provided supplemental Excel workbook that showed how the NY TRM was applied to calculate savings for the ECM measure. Guidehouse verified the ECM as well as the LED case lighting methodologies to be consistent with the NY TRM and reasonable.

3.2.2 Desk File Review

Guidehouse drew a random sample of 13 projects to assess a range of project documentation (e.g., specs, invoices, photos, etc.). The objective was to compare the project documentation with inputs in the tracking data to inform improvement of data collection for future programs. The evaluation did not use the results from the documentation review to adjust savings since the sample size was too small to inform statistical adjustments at the population level.

During the engineering desk file review, Guidehouse found discrepancies in the measure count for two projects. The reported measure count for all 13 projects was 953, while the verified measure count was 931. The tracking data did not provide the SIC code for all projects. Through the file review process, Guidehouse was able to use the invoices to identify building and space type of the missing SIC codes. Table 3-7 shows the reported and verified measure quantities as found from the project file reviews.

Table 3-7. Desk File Review Summary by Measure

Measure	Reported Measure Quantity	Verified Measure Quantity
RLED	690	668
T8 Linear	77	76
LED Lamp	60	60
LED Recessed	38	38
LED Area Light	29	29
ECM Motor	26	26
LED Wall Pack	12	12
LED Flood Light	11	11
LED Linear	8	8
LED Exit Sign	0	0
LED Highbay	0	0
Occupancy Sensor	0	0
Retro Kit	0	0
T5 Linear	0	0
Total	**953**	**931**

Source: Guidehouse desk file review

3.3 Algorithms and Parameters

Below are the algorithms that the evaluation team used to calculate verified savings for lighting measures and refrigeration measures. The impact evaluation effort focused on verifying the inputs for these algorithms. Detailed descriptions of each parameter and any related assumption are outlined in the following section, along with relevant findings.

3.3.1 Electronically Commutated Motors and Refrigerated LED Case Lighting

The IC calculated the ECM for Walk-In/Reach-In units measure savings using the algorithms from the New York TRM. Guidehouse verified the savings inputs and algorithms and calculated 100% verified gross realization rates for both energy and demand savings.

Table 3-8. Engineering Algorithms for Refrigeration Measures

Measure	Energy Savings Algorithm	Coincident Peak Demand Savings Algorithm
Refrigeration ECM Motors	$\Delta \text{kWh} = \Delta kWh_{EFan} + \Delta kWh_{RH}$	$\Delta \text{kW} = \Delta kW_{EFan} + \Delta kW_{RH}$
Savings due to Evaporator Fan Motor Replacement (ΔkWh_{EFan})	$\Delta kWh_{EFan} = \text{units} \times \left(\frac{A_{EFan} \times V_{EFan} \times \sqrt{Phase_{EFan}}}{1000}\right) \times F_{PA} \times F_{EFan} \times hrs_{EFan}$	$\Delta kW_{EFan} = \text{units} \times \left(\frac{A_{EFan} \times V_{EFan} \times \sqrt{Phase_{EFan}}}{1000}\right) \times F_{PA} \times F_{EFan} \times CF$
Savings due to Reduced Heat from Evaporator Fan Motor Replacement (ΔkWh_{RH})	$\Delta kWh_{RH} = \Delta kWh_{EFan} \times Comp_{EFF} \times 0.284$	$\Delta kW_{RH} = \Delta kW_{EFan} \times Comp_{EFF} \times 0.284$
LED Cooler Kits/LED Case Lighting	$kWh = \frac{((Qty_{base} * W_{base}) - (Qty_{ee} * W_{ee}))}{1000} * HOU * \left(1 + (Comp_{eff} * 0.284)\right)$	$kW = \frac{((Qty_{base} * W_{base}) - (Qty_{ee} * W_{ee}))}{1000} * CF * \left(1 + (Comp_{eff} * 0.284)\right)$
AEFan = Nameplate amperage of existing evaporator fan motor		
VEFan = Nameplate voltage of existing evaporator fan motor		
PhaseEFan= Phase of existing evaporator fan		
FPA = Power factor		
FEFan = Reduction of load by replacing evaporator fan motor		
hrsEFAN = Evaporator fan annual operation hours		
CompEff = Efficiency of the cooler/freezer compressor (kW/Ton). Value = 1.00 for refrigerated case		
CF = coincidence factor. Value = 0.948		
0.284 = Conversion factor from kW to Tons of refrigeration (Tons/kW)		

Source: New York TRM (v7.0)

3.3.2 Lighting Controls

The algorithm used to calculate the lighting control measure energy savings was taken from the MA TRM:

$$kWh = \left[\left(kW_{before} * Qty - kW_{after} * Qty\right) * \left(Hours * (1 - ReductionFactor)\right)\right] * ISR * WHFe$$

$$kW = \left[\left(kW_{before} * Qty - kW_{after} * Qty\right) * \left((1 - ReductionFactor)\right)\right] * ISR * WHFd$$

3.3.3 Lighting Retrofit Measures

Table 3-9 shows the algorithms used by Guidehouse to calculate the savings for the lighting measures. These algorithms are similar to those commonly found in technical reference manuals for commercial lighting measures and match the methodology outlined in the Mid-Atlantic TRM. The IC followed similar algorithms to calculate lighting measure savings but did not include HVAC interactive effects or coincidence factors (for demand savings only). A discussion on each impact parameter is included after the table.

Table 3-9. Engineering Algorithms for Lighting Measures

Measure	Energy Savings Algorithm	Coincident Peak Demand Savings Algorithm
Lighting	$\Delta kWh = \frac{(Watts_b * Qty_b)-(Watts_{ee} * Qty_{ee})}{1000} * HOU * WHFe * ISR$	$kW = \frac{(Watts_b * Qty_b) - (Watts_{ee} * Qty_{ee})}{1000} * CF * WHFd * ISR$
Qty_b = baseline quantity of equipment		
Qty_ee = efficient quantity of equipment		
HOU = operating hours		
Watts_b = baseline watts		
Watts_ee = efficient watts		
CF = coincidence factor		
ISR = In Service Rate		
WHFe = heating, ventilating, and air conditioning (HVAC) interaction factor for energy savings calculations		
WHFd = interaction factor for demand savings calculations		

*Guidehouse did not apply an ISR to the preliminary ex post impacts. ISRs were applied based on findings from evaluation activities.
Source: Guidehouse analysis

3.3.3.1 Baseline and Efficient Wattage

Based on the lighting retrofit measure descriptions in the tracking database, estimates for baseline and efficient wattage appeared to be reasonable and are accurate records of project equipment and specifications. Guidehouse collaborated this finding from the desk file review of a sample of 13 projects.

3.3.3.2 Hours of Use (HOU)

Guidehouse determined that the tracking data hours of use (HOU) should be used to calculate verified savings instead of the MA TRM values. We found the implementation approach in tracking HOU is reasonable and therefore relied on the tracking HOU compared to MA TRM hours for all the lighting retrofits and exit signs, also for the lighting occupancy sensor measures.

3.3.3.3 In Service Rate (ISR)

Guidehouse did not conduct onsite or virtual verification of measure installation. We assumed a TRM deemed ISR of 1.00 for the savings verification.

3.3.3.4 HVAC Interactive Factors

HVAC interactive effects are the lighting-HVAC interaction factors that represent the reduced space cooling requirements due to the reduction of waste heat rejected by efficient lighting. Note that the implementor did not apply HVAC interactive effects for any of the lighting measure savings claimed in the program year. The HVAC interactive effects shown in Table 3-9 are sourced from Appendix E (Commercial & Industrial Lighting Waste Heat Factors) in the MA TRM and are based on building type[5].

The evaluation team applied the HVAC interactive effects to both the energy and demand savings calculations for both interior and exterior lighting measures. HVAC fuel types were not provided to the evaluation team, however Guidehouse, upon further review of the previous 2017 DEK evaluation onsite survey which found that 96 percent of DEK participating buildings had HVAC systems with air-conditioning and non-electric or gas heating, felt comfortable assuming gas heating for all building fuel types for the current evaluation. From Table 3-10, we used AC/Non Electric (gas heating) for the energy interactive factors. This assumption is consistent with the MA TRM to assume gas heating if fuel type is unknown. We relied on the AC (utility) demand waste heat factors for the summer peak demand. Winter demand waste heat factor is 1.00 for all building types per MA TRM.

Table 3-10. Maryland/Mid-Atlantic TRM HVAC Interactive Factors

Building Type	Demand Waste Heat Factor (WHFd)		Annual Energy Waste Heat Factor by Cooling/Heating Type (WHFe)				
	AC (Utility)	AC (PJM)	AC/Non Elec	AC/Elec Res	Heat Pump	NoAC/ElecRes	NoAC/Non Elec
Office	1.36	1.32	1.10	0.85	0.94	0.75	1.00
Retail	1.27	1.26	1.06	0.83	0.95	0.77	1.00
School	1.44	1.44	1.10	0.81	0.96	0.71	1.00
Warehouse	1.23	1.24	1.02	0.75	0.89	0.73	1.00
Other	1.35	1.33	1.08	0.82	0.93	0.74	1.00

Winter demand waste heat factor is 1.00 for all building types.
Source: NEEP Mid-Atlantic TRM (v10).

3.3.3.5 Coincidence Factors

Coincidence Factor (CF) represents the portion of installed lighting that is on during the utility peak hours. It is only relevant for demand savings, not energy savings. The tracking database included a single demand savings field for lighting measures, which does not incorporate a coincidence factor. Guidehouse interpreted the demand impacts in the tracking data as non-coincident impacts, and the evaluation incorporated summer and winter coincidence factors to calculate verified demand impacts. Table 3-11 present the summer and winter peak coincident factors that were used in the calculation of the verified demand savings stemming from the engineering review.

[5] NEEP TRM (April 2020, v10), https://neep.org/sites/default/files/media-files/trmv10.pdf . The HVAC interactive effects (or waste heat factors) used are for Maryland buildings.

Table 3-11. Coincidence Factors for Lighting from the Maryland/Mid-Atlantic TRM

Building Type	Space Type	Summer CF	Winter CF
Other	Auto Repair Workshop	0.89	0.61
Other	Commercial work (High Bay)	0.91	0.82
Other	Conference Room	0.30	0.16
Other	Dining Area	0.53	0.51
Other	Hallways	0.86	0.73
Other	Kitchen/Break room & Food Prep	0.74	0.42
Other	Library	0.46	0.31
Other	Lobby (Main Entry)	0.82	0.71
Other	Lobby (Office Reception/Waiting)	0.87	0.49
Other	Mechanical Room	0.74	0.46
Other	Office (General)	0.67	0.43
Other	Office (Open Plan)	0.82	0.49
Other	Office (Private)	0.44	0.20
Other	Other	0.64	0.40
Other	Outside	0.11	0.58
Other	Patient, Break Room	0.61	0.41
Other	Restroom	0.42	0.30
Other	Retail Sales/ Showroom	0.97	0.78
Other	Storage (Conditioned)	0.84	0.82
Other	Storage (Other Conditioned)	0.81	0.44
Office	Hallways	0.64	0.71
Office	Lobby (Main Entry)	0.91	0.80
Office	Office (General)	0.70	0.48
Office	Storage	0.69	0.48
Retail	Lobby (Main Entry)	0.99	0.63
Retail	Office (General)	0.73	0.40
Retail	Retail Sales/ Showroom	0.98	0.64
School	Classroom	0.22	0.20
School	Computer Room/Storage	0.34	0.35
School	Hallways	0.78	0.75
School	Office (General)	0.67	0.46
School	Office (Open plan)	0.70	0.54
School	Office (Private)	0.57	0.26
Warehouse	Commercial Work (High Bay)	0.94	0.86
Warehouse	Commercial work (Precision)	0.69	0.44
Warehouse	Office (General)	0.74	0.36
Warehouse	Restroom	0.53	0.47
Warehouse	Vacant Storage (Conditioned)	0.69	0.44

Source: Maryland/Mid-Atlantic TRM (V10)

3.4 Impact Evaluation Summary Findings

From the engineering analysis of the lighting impact, Guidehouse found a project (DEK00011832.2) had replaced an incandescent 60W bulb with a 60W T8 LED Lamps. The evaluation assigned zero verified savings for this measure compared to the reported values 2,337 kWh and 0.54 KW. For project (DEK00004998.1), the reported savings for the occupancy sensor was 676 kWh but the verified savings was 73 kWh, based on inputs provided in the tracking data. This produced gross energy realization rate of 11% for the measure (overall energy realization rate for occupancy sensors was 102 percent due to application of HVAC interactive factors).

Overall, Guidehouse calculated the realization rate for gross energy savings to be 106 percent, meaning that total verified gross energy savings were 106 percent of the claimed savings in the tracking database provided by Duke Energy. The realization rate for peak demand savings was 91 percent for the summer coincident peak demand and 55 percent for the winter coincident peak demand. The reported savings did not account for energy and demand HVAC interactive effects and coincidence factors when estimating savings for lighting measures. Guidehouse applied HVAC interaction factors to account for the reduced space cooling requirements due to the reduction of waste heat rejected by efficient lighting. The adjustments were the primary cause of the higher realization for gross energy savings. While the demand interactive factors increased the demand savings, the coincidence factors were lower, which contributed to the lower realization of peak summer and winter demand savings. The refrigeration measures all produced 100 percent realization rates. No HVAC measures were implemented during the evaluation period.

Using the MA TRM provides the opportunity to map the tracking data SIC description or measure location to the energy and demand interactive factors by building type and space type provided in the TRM for the estimation of the lighting savings.

4. Net-to-Gross Analysis

The impact analysis described in the preceding sections addresses *gross program savings*, based on program records and verified by Guidehouse. *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 net-to-gross (NTG) ratio applied to the verified gross savings values to get the net impact savings.

Table 4-1 shows the results of Guidehouse' s NTG research.

Table 4-1. 2019-2021 Net-to-Gross Results

Parameter	Lighting	Refrigeration	Program
Estimated Free Ridership	0.03	NA	0.03
Estimated Spillover	0.00	NA	0.00
Estimated NTG	**0.97**	**NA**	**0.97**

Note: Respondents to the free rider survey all installed lighting projects. No SO was reported. Research therefore focused only on lighting measures.
Source: Guidehouse analysis, totals subject to rounding.

4.1 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 (FR) 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, refrigeration, and HVAC 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 some high efficiency equipment without assistance from the program.

Spillover (SO) captures savings influenced by the program but without assistance from the program or other utility or government entities. Spillover adds to a program's measured savings by incorporating indirect (i.e., absent program incentive or assistance) 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 actions taken at the project site itself (*inside spillover*) and at other sites (*outside spillover*). Each type of spillover is meant to capture a different aspect of the energy savings influenced by the program, but not included in program records.

The **NTG ratio** incorporates free ridership and spillover. The basic equation is shown in Equation 1.

Equation 1. Net-to-Gross Ratio

$$NTG = 1 - Free\ Ridership + Spillover$$

When the NTG ratio is applied to the verified gross program savings the result is an estimate of the net energy savings attributable to the program.

4.2 Free Ridership and Spillover Research

Guidehouse conducted primary NTG research using participant self-reports collected through an online survey. Guidehouse surveyed program participants from 2019-2021 with realized savings. We employed the survey to research NTG, process, and organizational and facility characteristics. The NTG portion of the survey offered separate free rider and spillover batteries, permitting us to deliver the FR battery exclusively to 2021 participants and the SO battery to 2019-2020 participants.

Guidehouse addressed potential respondent fatigue by keeping the average survey response time under a target of 15 minutes by offering a limited number of batteries to each respondent that addressed fewer topics.

Concurrently, the quality of collected data was improved by presenting respondents with the most appropriate questions: we asked the more recent participants free ridership questions about their decision-making process prior to participating in the program, and asked respondents with sufficient time for for spillover to develop (12-24 months since participation) about installation of additional energy saving equipment absent of the program's incentives or assistance.

The participant population included 140 projects. Of those, we found 112 unique participants with complete contact information.

The survey was launched on May 17, 2022, following a brief testing period that started on May 10. Three reminder emails were sent, with the first two going out 3 and 6 business days following the initial invitation, and the last going out on June 8, 2022. The survey closed on June 10, 2022.

The survey achieved an overall response rate of 14% and a completion rate of 10%. Of those who completed the survey, four participated in 2020 and seven in 2021.

4.2.1 Free Ridership Survey

The Free Ridership survey battery was offered to 2021 participants to leverage their more recent exposure to the program and recall of their decision-making process.

The FR battery was offered to 62 unique participants from 2021 with lighting and refrigeration projects. All respondents participated in lighting projects. Disposition of the survey is offered in Table 4-2.

Table 4-2. Disposition of Free Rider Survey

Survey Battery	Sample	Bounces	Opened Survey	Average Time to Complete (Minutes)	Completed Survey
Free Ridership	62	4	11	14*	7†

*Two respondents left the survey open (one for 48 hours, one for 1.5 hours) and are not included in the average
†All respondents participated in lighting projects.

4.2.2 Estimating Free Ridership

Guidehouse asked questions to research free ridership that fell into the following categories:

Program Importance on the Decision to Participate

- We asked respondents to rate the importance of various program factors (i.e., rebate, financing, assessment report) and non-program factors (i.e., non-energy benefits not promoted through the program) on their decision to participate in the program. High ratings for the importance of program factors suggests lower free ridership.

Prior Planning for a Similar Project

- We asked respondents to rate the degree of planning to implement the project on their own, prior to participating in the program, on two facets: identification of an installation contractor and measures and securing funds to pay for the project. Respondents reporting that they had already allocated funds for the project and/or selected the measures and a contractor suggest a high level of free ridership.

Likelihood to Install Similar Measures

- We asked respondents who reported a likelihood to install a portion of their project's measures on their own to tell us what percentage of the measures installed through the program they would have installed without benefit of the program. Respondents reporting that they would have installed a high percentage of the same energy efficient measures absent the program suggests a high level of free ridership.

Timing for Installation of Similar Measures

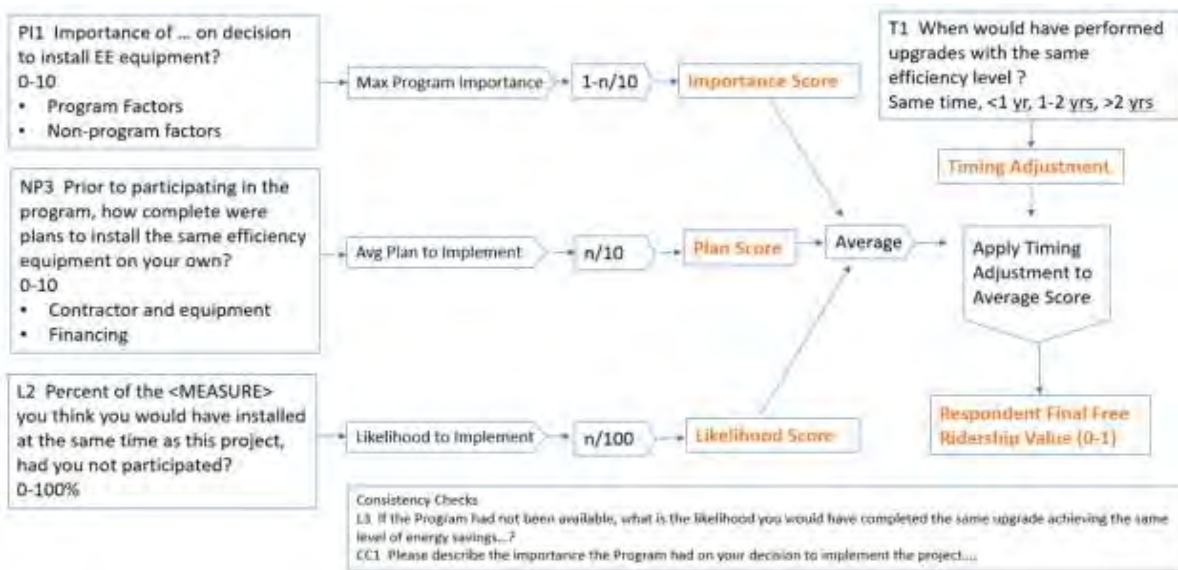
- We asked when respondents would have implemented a project to achieve the same level of efficiency without assistance from the program. We assigned scores based on the time to install on their own: 1.0 for the same time as the project through the program; 0.67 for within one year; 0.33 for 1-2 years following the project; 0 for installation more than 2 years post their project through the program.

Consistency Check

- We asked respondents to rate the likelihood that they would have completed the same project at the same time absent the program and to describe the influence the program had on their decision to participate. Neither data point was used to calculate their FR score, but both offered a check on the consistency of their answers and our resulting analysis. These questions permit additional quality assurance that the respondent understood the questions asked, answered appropriately, and that our analysis is reflective of the respondent's report.

Guidehouse calculated raw free ridership scores for each respondent following the algorithm in Figure 4-1.

Figure 4-1. Free Rider Algorithm



To arrive at a free ridership score for the program, Guidehouse weighed each individual raw free rider score by that project's contribution of savings to the total sample savings.

4.2.3 Free-Ridership Results

Guidehouse analyzed the results of the FR survey and found the following:

Program Importance on the Decision to Participate

- Importance of the program factors on the decision to install energy efficient equipment through the program was high, with six respondents giving maximum scores of 10, and one respondent giving a maximum score of 6.

Prior Planning for a Similar Project

- Three out of seven respondents indicated they had prior plans to install energy efficient equipment at their facilities before participating in the program.
    - o One of these respondents indicated that their plans were well-developed, with a high score of 10 for identifying an installation contractor, equipment of the same efficiency and financing the project.
    - o The other two offered a 0 or 2 rating for how well their plans were developed.

Likelihood to Install Similar Measures

- Of the three respondents reporting any plans to install energy efficient equipment, one respondent rated their likelihood to install the same quantity of measures with the same efficiency as a 10, while the other two rated it a 0, saying they definitely would NOT have installed measures with the same efficiency without the program's assistance.

Timing for Installation of Similar Measures

- One respondent reported the potential timing of planned projects would have been within one year of the program's project, and 2 reported it would have been more than two years after the program's project.

Consistency Check

- The consistency check questions aligned with the responses and our calculated raw FR scores.

Guidehouse found a program level free ridership of 0.03, weighted by each respondent's verified gross savings over the total sample verified savings. The free ridership was estimated at a 90% confidence interval at a 12% relative precision.

4.2.4 Spillover Research

The Spillover battery was offered to 2019 and 2020 participants to allow time for spillover to develop. The SO battery was offered to 50 unique participants. Disposition of the SO survey is shown in Table 4-3.

Table 4-3. Disposition of the Spillover Survey

Survey Battery	Sample	Bounces	Opened Survey	Average Time to Complete (Minutes)	Completed Survey
Spillover	50	7	5	11	4

Source: Guidehouse research

4.2.5 Estimating Spillover

Guidehouse asked questions to research spillover that addressed the following:

Implementation of Energy Efficient Improvements Since Participation

- We asked respondents if they had implemented any additional energy efficient equipment or operational improvements since their program participation at either the facility where the program project occurred or another facility within the DEK jurisdiction.

Assistance from Utility or Government for Additional Project

- If prior participants had implemented any other projects or saving measures, we asked if they received assistance (rebates, incentives, financing or information) from Duke Energy, any other utility or government agency.

Influence of Prior Program Participation on Decision to Implement

- If respondents reported both that they implemented another project without assistance, we asked them to rate the importance of their experience with the DEK SBES program on their decision to install the project.

- If respondents rated the influence of their prior participation at an 7-10 on a 0-10 scale where 0 means not at all important and 10 means extremely important, we would consider SO to have occurred and continue the research.

Measures Implemented

- If respondents qualified for SO, we asked them for measure type, quantity and project cost to allow us to quantify the reported SO.

No respondent reported implementing energy efficient measures or operational practices since participation in the SBES program.

Guidehouse therefore found that no spillover occurred during the research period.

4.2.6 Net-to-Gross Ratio

As stated above in Equation 1 the NTG ratio is defined as:
NTG = 1 – Free Ridership + Spillover

Table 4-4. SBES Free Ridership, Spillover, and NTG Ratio

NTG Survey Sample	NTG Parameters
Unique Sample (N)	112
Completed Surveys (free rider + spillover)	11
Verified Gross Savings (kWh) for the Sample (free rider + spillover)	540,043
Free Rider Verified Gross Savings (kWh) for the Sample	418,477
Spillover Verified Gross Savings (kWh) for the Sample	121,566
Free Ridership	0.03
Spillover	0.00
NTG Ratio	**0.97**
Precision	12%*

*Based on Free Ridership population. The free ridership of 0.03 was based on respondents weighted verified gross savings over the total sample verified savings (418,477), estimated at 90% confidence interval at 12% relative precision.
Source: Guidehouse analysis.

Guidehouse recommends the resulting NTG value of 0.97 should be applied to the program net impacts.

4.2.7 Net Energy and Demand Savings

The verified net savings resulting from the application of the impact realization rate and NTG ratio for energy and demand savings are shown below in Table 4-5.

Table 4-5. SBES Verified Net Savings

Parameter	Energy (kWh)	Summer Peak Demand Savings (kW)	Winter Peak Demand Savings (kW)
Reported Savings	6,252,038	1,577	1,577
Realization Rate	106%	91%	55%
Verified Gross Savings	6,622,735	1,428	874
Net-to-Gross	97%	97%	97%
Verified Net Savings	6,424,053	1,385	848

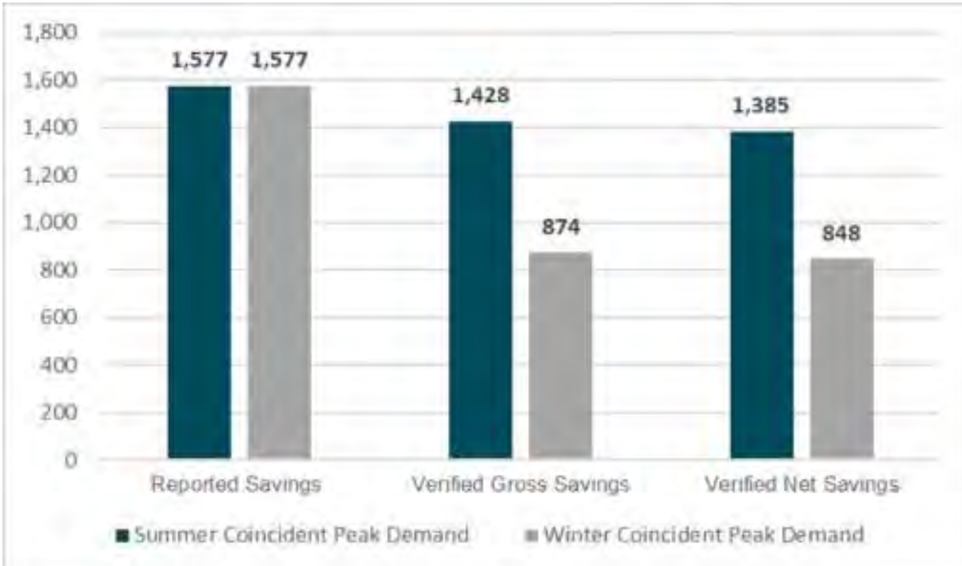
Source: Guidehouse analysis, totals subject to rounding.

The net energy savings and peak demand savings after the application of the NTG ratio to the gross savings are shown below respectively in Figure 4-2 and Figure 4-3.

Figure 4-2. Energy Savings

Source: Guidehouse analysis.

Figure 4-3. Peak Demand Savings



Source: Guidehouse analysis.

5. Process Evaluation

The purpose of the process evaluation is to understand, document and provide feedback on the program implementation components and customer experience.

5.1 Process Methodology

Guidehouse interviewed SBES program managers and implementation contractors to understand program operations and delivery. Guidehouse designed a participant survey instrument and administered it as part of the NTG survey for program participants with projects that realized savings between August 2019 and December 2021. The survey disposition is offered below in Table 5-1.

Table 5-1. Number of Completed Surveys

Survey Battery	Sample	Bounces	Opened Survey	Average Time to Complete (Minutes)	Completed Survey
Process	112	11	16	13*	11

*Two respondents left the survey open (one for 48 hours, one for 1.5 hours) and are not included in the average

Source: Guidehouse research

5.2 Participant Survey

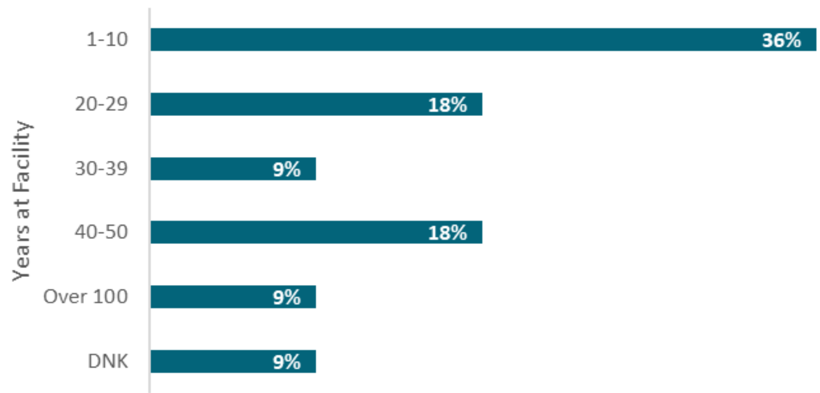
Guidehouse designed the survey to address research questions detailed in the Evaluation Plan, including:

- Are Duke Energy customers satisfied with the program?
- How do customers learn about the program, and how can participation be increased?
- Has the COVID-19 impacted the way participating businesses are using energy?
- Are there any barriers to participation by eligible customers, and how can those barriers be addressed? Are these barriers associated with the COVID-19 pandemic?
- Are there any areas where program delivery and implementation could be improved?
- What additional measures, if any, could be incorporated into the program?

5.2.1 Respondents

Respondents represent mature businesses, with the majority (64 percent) in business at the project facility for more than ten years, as shown in Figure 5-1.

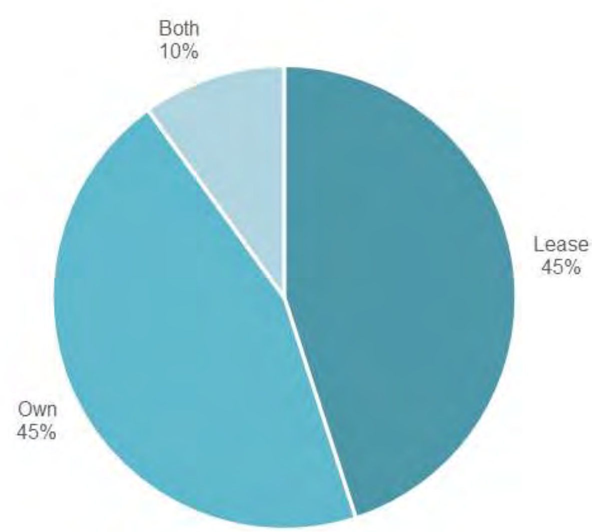
Figure 5-1. Years in Business at Project Facility, n=11



Source: Guidehouse research

Facility ownership is high, with 45 percent of respondents reporting that they owned their facility, as shown in Figure 5-2 below. The majority (60 percent) of businesses leasing their facility have been in the project location less than 10 years.

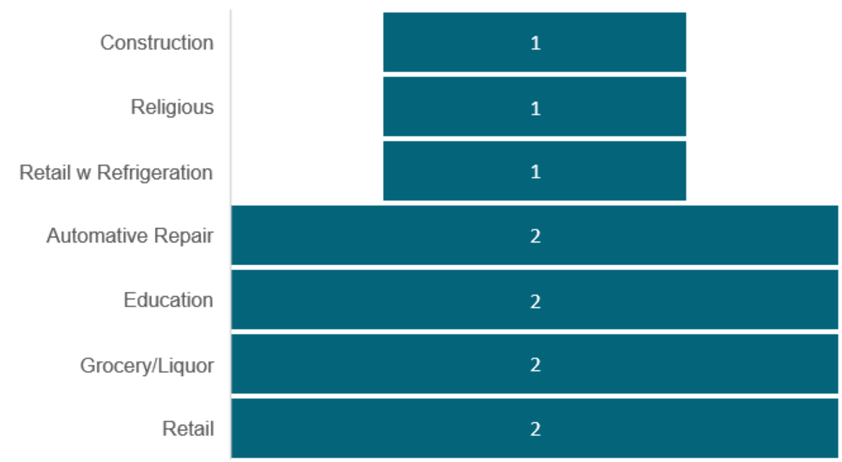
Figure 5-2. Ownership Status of Facility, n=11



Source: Guidehouse research

Survey respondents represent a cross section of industries, as shown below in Figure 5-3. Guidehouse notes that the industry segments represented by survey respondents, in general, have been less impacted by Covid-19 than other common small business industries, such as restaurants, leisure industries including lodging, and service industries such as dry cleaning.

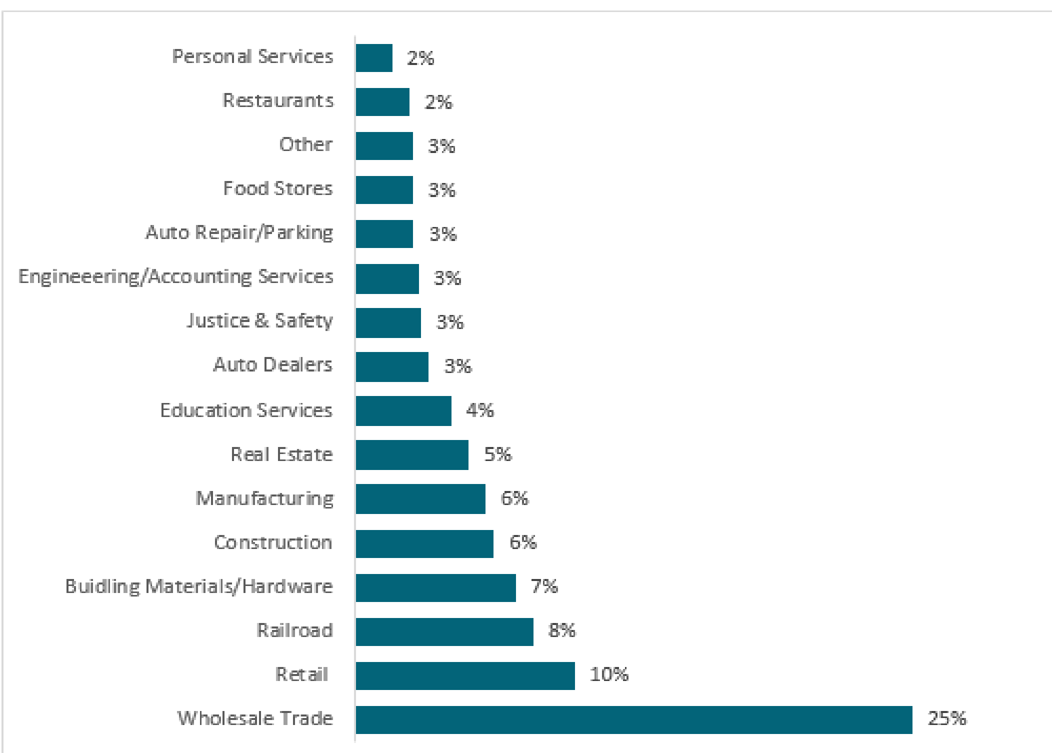
Figure 5-3. Industry Types by Respondent, n=11



Source: Guidehouse research

Guidehouse analyzed the industry groups participating in SBES to compare to those who responded to the survey. Using the SIC codes offered in the tracking data, we found that 35 percent of program participants are from the wholesale or retail trades, as shown in Figure 5-4.

Figure 5-4 Program Savings by Industry Group



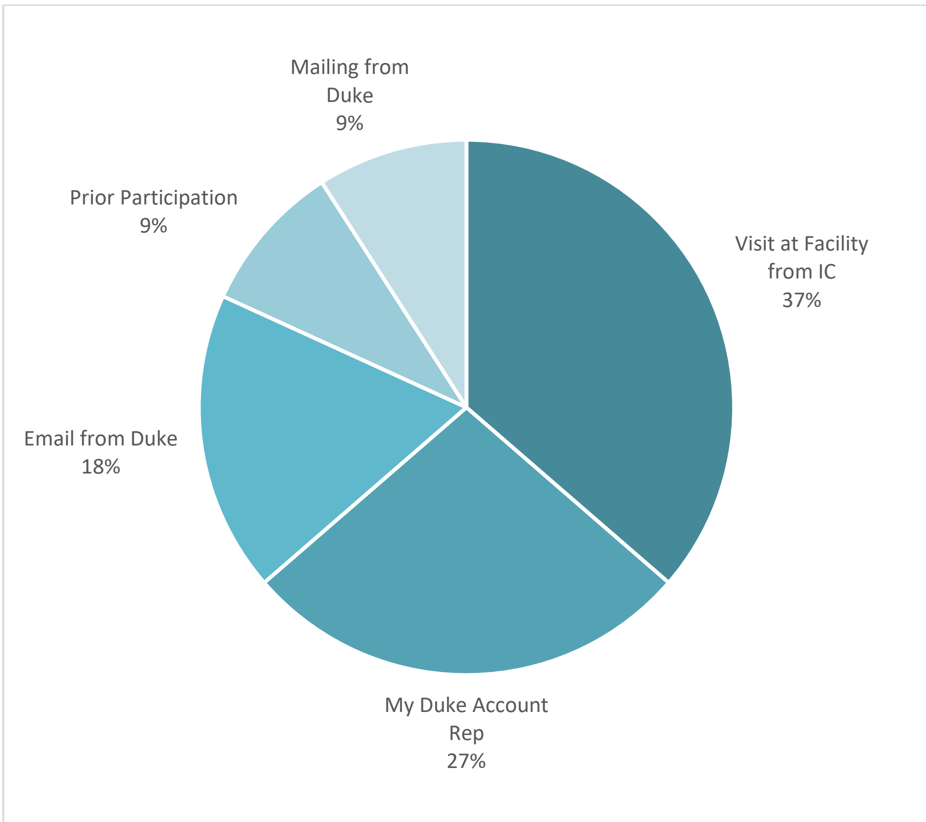
Excludes industry groups totalling less than 2%
Source: Guidehouse analysis of DEK tracking data

5.2.2 Program Awareness

Respondents learned about the program through a variety of Duke efforts. A plurality (37 percent) learned about the program through a visit at their facility by the IC. Duke account representatives introduced another 27 percent of respondents to the program, as shown in Figure 5-5.

Nine percent of respondents reported that they had participated in the program previously.

Figure 5-5. How Respondents Learned About the Program, n=11

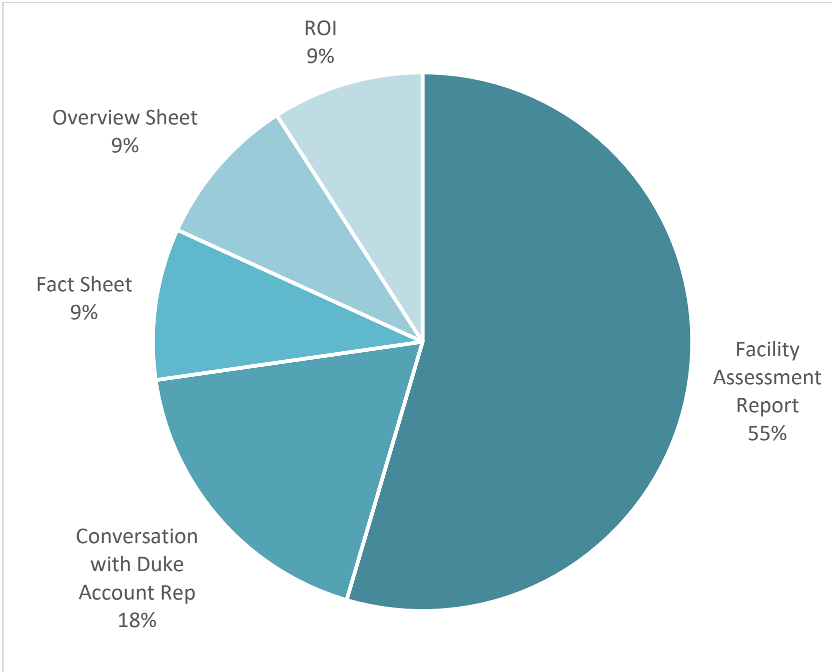


Source: Guidehouse research

Respondents offered various thoughts on how to make other small businesses aware of the program, but the program already employs most of them, including door-to-door visits, assessment reports and account reps referring their customers to the program. One respondent thought that direct mailers highlighting prior program project details, including savings, would be productive.

The Facility Assessment Report was most cited (55 percent) with persuading Duke customers to participate in the program, followed by conversations with the Willdan representative (18 percent), as shown below in Figure 5-6.

Figure 5-6. Most Persuasive Element in Decision to Participate, n=11



Source: Guidehouse research

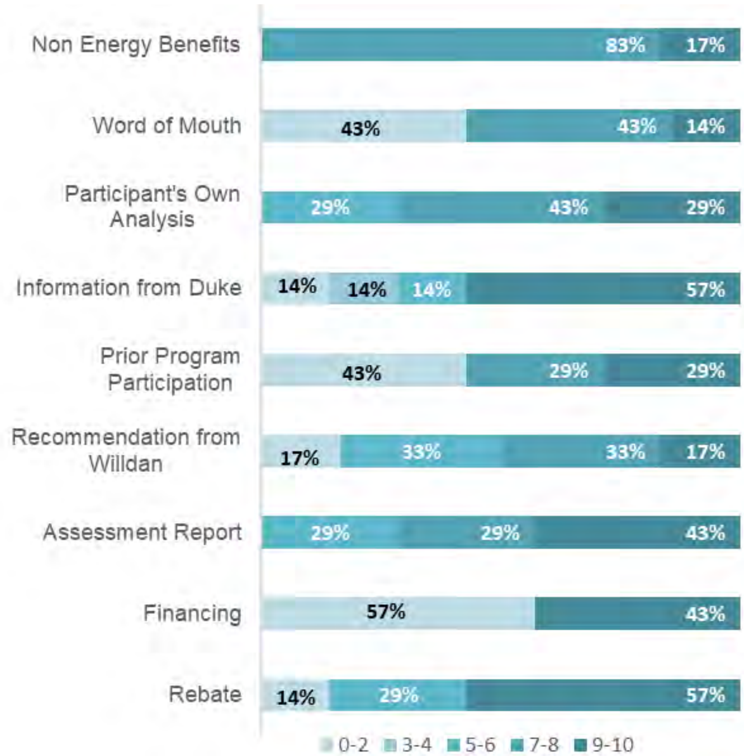
5.2.3 Importance of Program Factors

Guidehouse leveraged the Free Ridership battery to consider the importance of various program factors in customer's decision to participant in the program, with results shown in Figure 5-7. On average, the rebate, participant's own analysis and the Assessment Report were the most important factors driving participation.

Project financing through the program received polar opposite ratings, with 43 percent of respondents rating it a 9 or 10, and the others rating it a zero. This disparity suggests that financing is vital for those interested in that option and irrelevant for those funding their projects with another source of capital.

Likewise, word of mouth referrals were highly important to a majority, rating it a 9 or 10, while the remaining respondents rated it a zero. Recalling that no respondents reported learning about the program through word of mouth, the disparity suggests that some potential participants find value in talking with their peers about energy efficiency programs, while others do not.

Figure 5-7. Importance of Factors in Decision to Participate, n=7



Source: Guidehouse research

5.2.4 The Impact of Covid-19 on How Customers Use Energy

Most respondents (63 percent) reported that they expect Covid-19 will have no impact on their business over the next 12-18 months.

As discussed previously, survey respondents represent industries that have not been as heavily impacted by Covid-19 related disruptions as many other small businesses have. We do not have insight into why participants with businesses that may have been more impacted by Covid-19 did not respond to the survey. It is therefore possible that the businesses most impacted by the pandemic did not respond to the survey.

Participants reporting that Covid-19 is likely to impact their business stated, for example:

> *"Longer run times on our HVAC equipment and higher rates have caused higher costs. Just a statement of facts."*

> *"Extended Use of Power due to meeting demand of Home Improvement and Outdoor Power."*

5.2.5 Participant Satisfaction

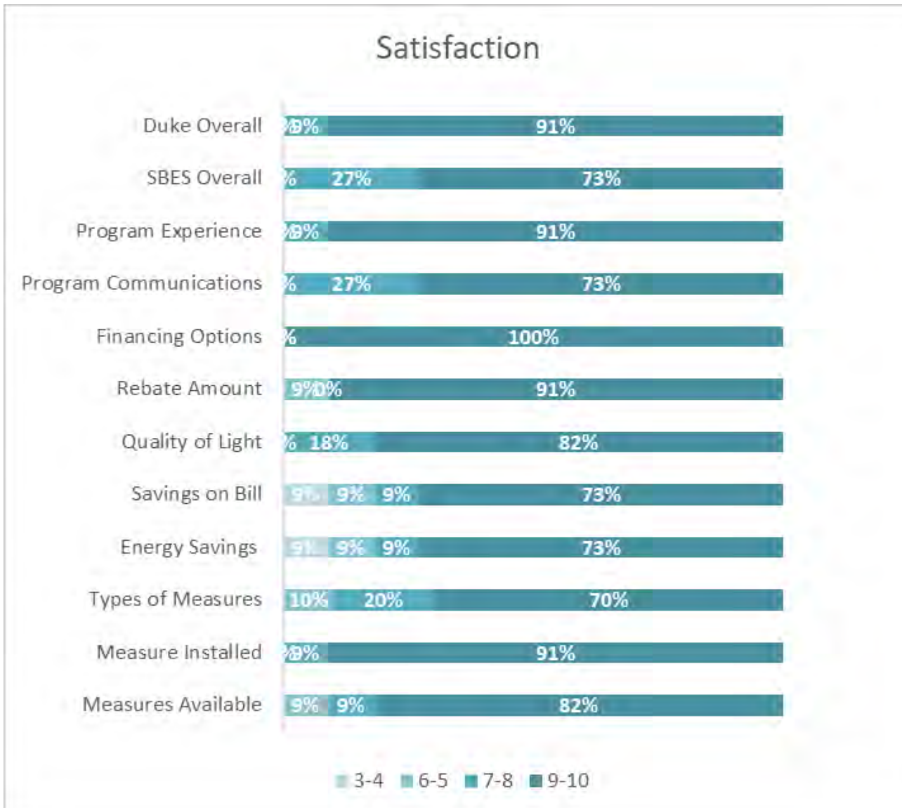
Participants are very satisfied with the program, with 64 percent rating their overall satisfaction with the program as a 10 on a 0-10 scale. This is an improvement over the latest research reported on during the 2017 DEK evaluation, when 40 percent offered an overall satisfaction rating 10, as shown below in Figure 5-8. All respondents rated their satisfaction in 2022 as an 8 – 10, while 74 percent offered similar ratings in 2017.

Figure 5-8. Satisfaction with the Program Overall in 2017 and 2022

2017 Evaluation, n=16; 2022 Evaluation n=11
Source: Guidehouse research

SBES participants were satisfied with their program experience, with 91 percent rating it at a 9 or 10, as shown in Figure 5-9 below. Similar high satisfaction is shown on other program elements and with Duke Energy overall.

Figure 5-9. Respondent Satisfaction with Program, n=11



Source: Guidehouse research

The exceptions to this high reported satisfaction are concerns about measures available, types of measures, savings on the bill and energy savings. We consider measures below in 5.2.7. Energy savings and savings on their bill received the lowest satisfaction ratings, with ratings of 3, 4 and 5. Some respondents commented:

> *"Did not save as much as described."*

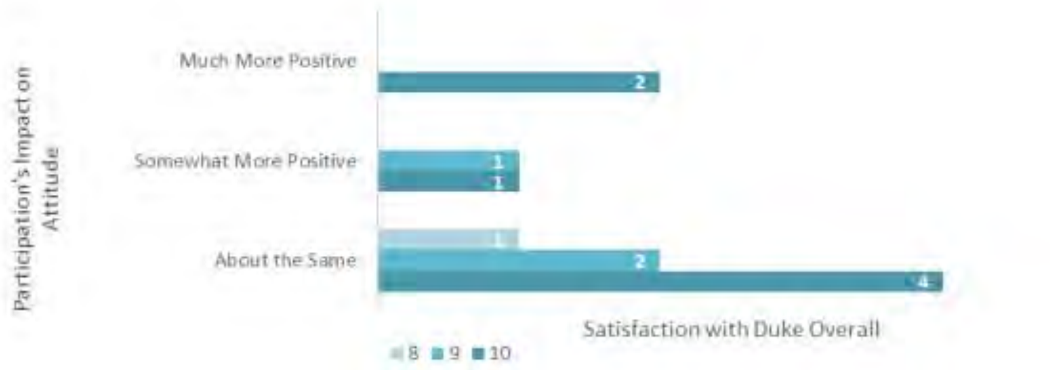
> *"Haven't really noticed a change yet [in our bill]."*

> *"Did not save as much [energy] as forecasted."*

Participant satisfaction with the program impacted their overall attitude toward Duke Energy.

Participation in the Program improved 37 percent of respondents' attitude toward Duke, as shown in Figure 5-10.

Figure 5-10. Program Participation Impact on Attitude Toward Duke Energy, n=11



Source: Guidehouse research

As shown above, all those reporting that they had a much more positive attitude toward Duke Energy following their participation rated that satisfaction at a 10 on a 0-10 scale.

Those respondents who reported a somewhat more positive attitude toward Duke Energy rated their satisfaction with Duke at a 9 or 10.

5.2.6 Program Experience and Ease of Participation

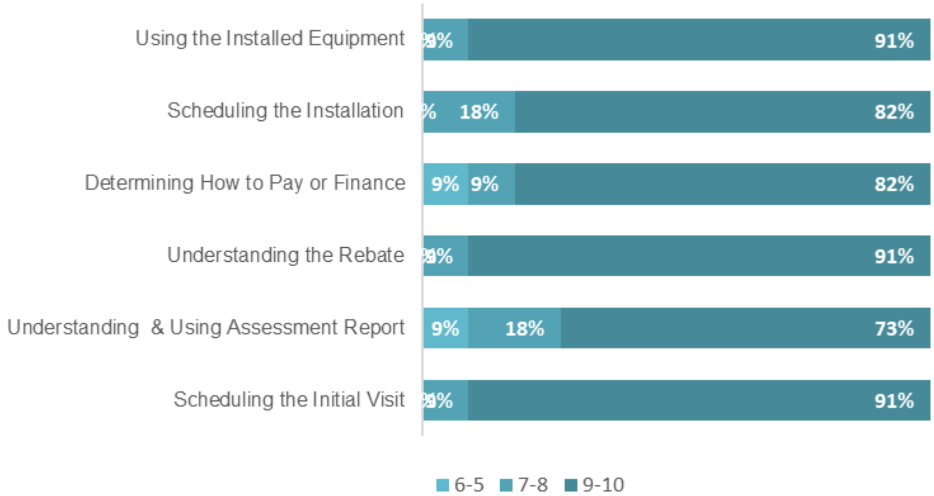
The majority (57 percent) of those who reported that their attitude toward Duke remained about the same rated their satisfaction with Duke at a 10, with another 28 percent rating it as a 9.

The vast majority of respondents (82 percent) reported no problems with their energy efficiency project. Those who experienced problems with their project reported two categories of issues: project installation issues and savings or cost issues.

- **Project installation issues** included the project taking too long, lack of coordination andcommunication among program staff, and installation failure.
  - Respondents rated the ease to resolve these issues as a 5.5 on average.
- **Savings and cost issues** included paying more than anticipated, seeing less energy savings and experiencing less savings on their bills.
  - Respondents rated the ease to resolve these issues as a 5.5 on average.

Participants overall rated the ease of using program features to be high, as shown below in Figure 5-11.

Figure 5-11. Ease of Program Features, n=11

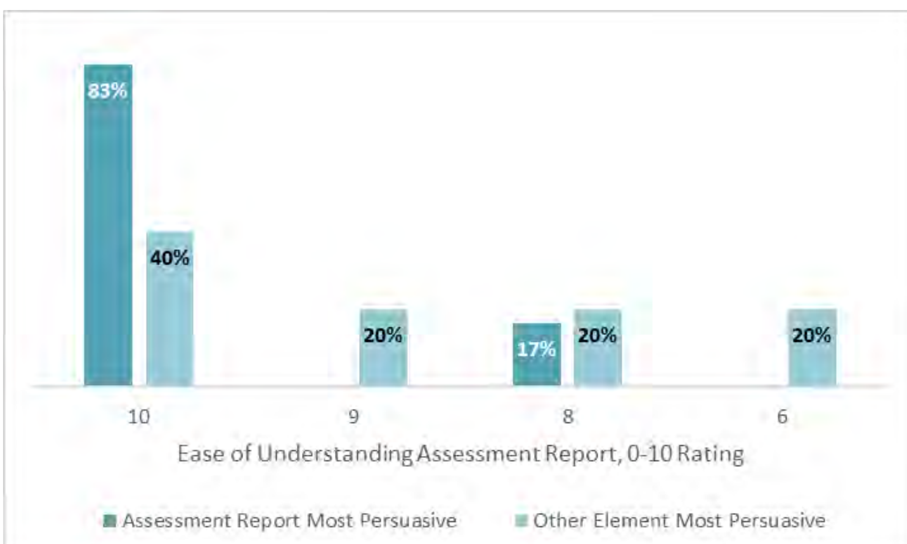


Source: Guidehouse research

The Assessment Report was the most persuasive element in driving participation for 55% or respondents, as reported above. All of those who found the Report most persuasive also found it easy to understand and use.

Respondents who said that another element persuaded them to participate reported greater difficulty understanding the Assessment Report, as shown below in Figure 5-12.

Figure 5-12. Ease of Using Assessment Report by Those Who Found It Most Persuasive



Source: Guidehouse research

One respondent, a business owner who installed a lighting project, reported less ease using the Assessment report and commented:

> *"Was a little confusing understanding equipment they would replace or install."*

5.2.7 Program Improvements and Requested New Measures

A minority of respondents offered suggestions on how to improve the program. Their suggestions focused on:

- Improved communications

"Better communication with contractors."

- Improved assessment accuracy

  "The building is large. Initial survey came back with many errors. Second surveyor was much better and corrected what the first missed."

- References to additional measures or programs

  "I would like to know if there are any more incentive options."

Respondents offered types of new measures that they would like to see offered through the program. As noted above, participant satisfaction slipped slightly regarding Types of Measures and Measures Available. Respondents asked that the following measure types be made available in the future:

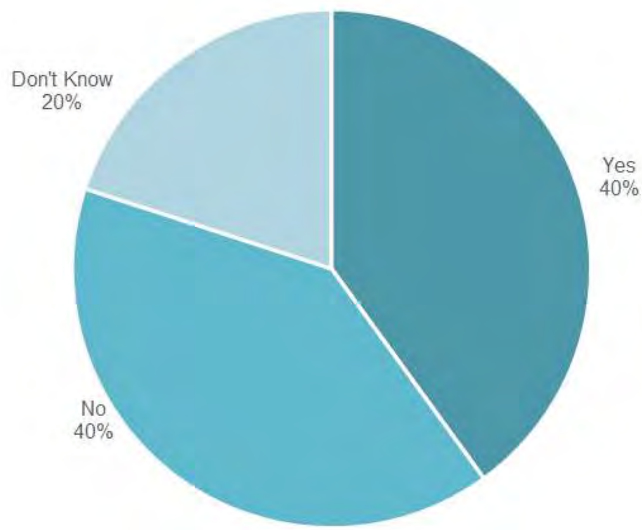
Exterior Lighting	HVAC
High Efficiency Motors	Refrigeration Equipment
Water Heaters	

The existence of some of these measure types through the program now may suggest, among other things, that there may be additional equipment within the measure type that customers want, or that the requested measures are for future projects not addressed by their Assessment.

5.2.8 Planned Future Projects

Participants are looking forward to future energy saving projects at their facilities, with 40 percent reporting that they have planned projects, as shown in Figure 5-13 below.

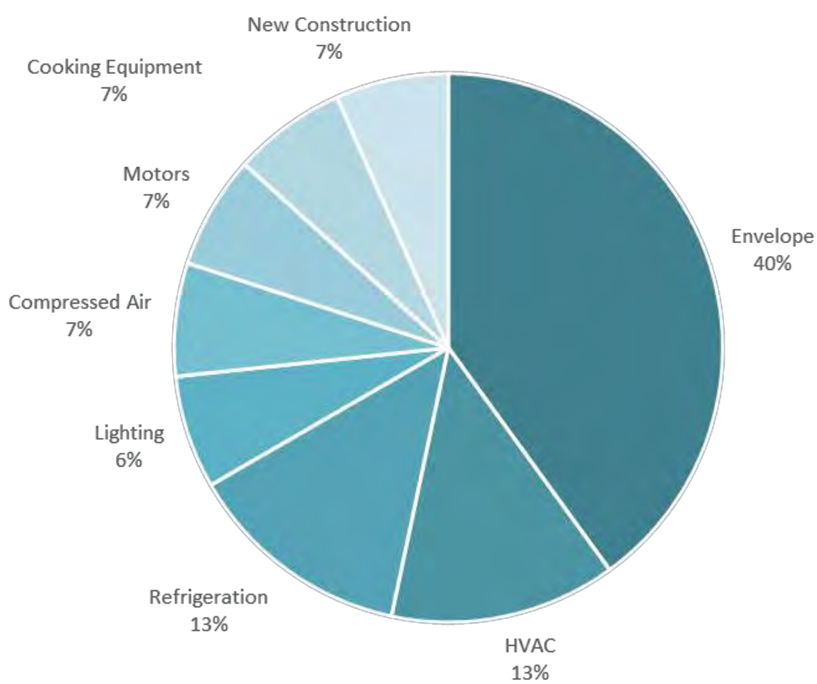
Figure 5-13. Respondents Reporting Future Energy Saving Projects



Source: Guidehouse research

Respondents with planned future projects offered a number of measure types that will be included, led by envelope measures, HVAC, and refrigeration, as shown below in Figure 5-14.

Figure 5-14. Measure Types Featured in Planned Projects



n=4, multiple responses accepted
Source: Guidehouse research

5.2.9 What the Program Does Well

With all respondents rating their overall satisfaction with the program at an 8, 9 or 10, they offered some praise for the Program:

- Makes energy efficient equipment available

  "Helps business owners upgrade their lighting with better more efficient lighting at acceptable costs"

- Good communications and process

  "Quality of communication from Duke. Quality of the contractor and their communication. Fast callbacks from both. Pleasant installers. Cooperative. Made it easy for us."

  "Provide an ROI [to help make a business decision]."

6. Conclusions and Recommendations

Guidehouse finds that Duke Energy's SBES program is being delivered and tracked effectively in the DEK jurisdiction. Customer satisfaction is high, and the program measure installations appear to be tracked appropriately. Guidehouse presents the following list of recommendations to help improve program delivery and impacts:

Impact

1. **Consider employing aspects of the Maryland/Mid-Atlantic Technical Reference Manual (MA TRM).** The reported ex-ante savings did not include energy and demand interactive or coincidence factors. Guidehouse recommends that the IC use the energy and demand interactive factors and coincidence factors provided in the Mid-Atlantic TRM while calculating savings. Using the MA TRM provides the opportunity to map the tracking data SIC description or measure location to the energy and demand interactive factors by building type and space type provided in the TRM.
2. **Completely capture of all required inputs.** The initial and final tracking data provided for evaluation did not capture all requested inputs to calculate savings for electronically commutated motor (ECM) measure and the Cooler Door Kits (LED Case Lighting). Some projects had missing inputs such as quantity of lamps installed or replaced, rated wattage of baseline and efficient lamps, efficiency of the cooler/freezer compressor (kW/ton), load reduction or operating hours of the evaporator fan motor. Guidehouse verified these inputs through the additional file reviews and TRM assumptions. For the next evaluation, the IC should capture all necessary inputs in the tracking data to enable Guidehouse to effectively verify inputs and calculate savings in a timely manner.
3. **Ensure tracking inputs produce required savings.** Guidehouse found a project (DEK00011832.2) had replaced an incandescent 60W bulb with a 60W T8 LED Lamps with 60W. The evaluation assigned zero verified savings for this measure compared to the reported values 2,337 kWh and 0.54 KW, which means the gross realization rate is zero. Another project (DEK00004998.1) reported energy savings for an occupancy sensor was 676 kWh but the verified savings was 73 kWh, based on inputs provided in the tracking data. The measure gross energy realization rate is 11 percent (overall energy realization rate for occupancy sensors was 102 percent due to application of HVAC interactive factors). Guidehouse recommends the IC ensure tracking savings inputs are applied consistently to produce the expected savings.
4. **Capture fuel type for participant buildings when applicable.** The tracking data did not capture HVAC fuel types for buildings participating in this program. When readily available Guidehouse recommends the IC capture the actual fuel type for participating buildings in the data tracking system. If the fuel type of any participating buildings is not readily available, Guidehouse recommends using an assumed fuel type of AC electric and non-electric gas heating based on the TRM.
5. **Confirm quantity of installed measures**. During the sample file review two projects had inconsistencies between the number of measures installed and the invoice that was used as the supporting document. The evaluation did not use the results from the documentation review to adjust savings since the sample size was too small to inform statistical adjustments at the population level. We recommend that the IC ensure consistency in tracking the number of efficient measures installed and invoiced to avoid potential risk of evaluation adjustment.

Process and NTG

6. **Satisfaction with the program is high**. The majority of respondents rated their satisfaction with the program overall as a 10 on a 0-10 scale, and 100 percent of respondents rated their overall satisfaction as an 8-10. Satisfaction has improved since the last evaluation period in 2017, when 74 percent rated their satisfaction as an 8-10.
7. **Structure Facility Assessment Reports for the layperson**. The Facility Assessment Reports were the most influential factor in driving program participation. When asked about challenges understanding or using elements of the program, some participants experienced the greatest challenge in using and understanding their facility assessment report. This was followed by determining how to finance their energy efficiency projects. The program should structure the Facility Assessment Reports to be easily understood by the non-engineer small business owners and decision makers.
8. **Phase in Non-Lighting measures.** When asked what additional equipment Duke should add to the program, respondents requested motors, water heaters, HVAC and additional refrigeration equipment. The Energy Independence and Security Act (EISA) rules will impact the savings Duke can achieve for lighting measures in the future. Guidehouse recommends phasing in more high impact non-lighting measures appropriate to the customer mix.
9. **Potentially expand consideration of Covid-19 impacts among DEK SBES-eligible customers**. Survey respondents did not forecast negative impacts to their business from Covid-19 disruptions to the economy. The respondents were all from industries less impacted by the pandemic than a typical small business mix, challenging our ability to determine how significant an impact Covid-19 is having on SBES-eligible customers. Analysis of SIC codes in tracking data suggest that participants overall may be more susceptable to economic impacts from Covid-19 than survey respondents. Examine self-report industries (SIC) participation compared to industry mix throughout jurisdiction to determine if additional research is recommended.
10. **Launch free ridership surveys shortly following project completion.** Survey response rates decline with time since the project completion. While it takes 1-2 years for spillover to develop, as time goes on program participants tend to forget details necessary to calculating accurate free ridership, such as program importance and prior plans. Guidehouse recommends launching free ridership surveys shortly after project completion and collect data for future analysis. Spillover surveys should continue to be fielded 1-2 years after project completion.

7. Summary Form

Small Business Energy Saver

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, HVAC, and refrigeration measures.

Lighting measures: LED lamps and fixtures, LED exit signs, occupancy sensors.

Refrigeration measures: LED case lighting, EC motor upgrades, anti-sweat heater controls,

Evaluation Methodology

The evaluation team used engineering analysis as the primary basis for estimating program impacts. Additionally, online surveys were conducted with participants to assess customer satisfaction and determine a net-to-gross ratio.

Impact Evaluation Details

Participants achieved an average of gross 44.66 MWh of energy savings per year for DEK. The program is accurately characterizing energy and demand impacts.

Date	November 10, 2022
Region(s)	Duke Energy Kentucky
Evaluation Period	DEK 8/01/2019 – 12/30/2021
Annual net kWh Savings	DEK 6,424,053 kWh
Per Participant net kWh Savings	45,886 kWh
Net-to-Gross Ratio	0.97
Previous Evaluation(s)	PY2015 (2017 evaluation)

8. 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.

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 8-1. Note that for this evaluation the EM&V team applied the coincidence factors for both summer and winter peak demand reductions by lamp type. For lighting controls, these values were taken from the NEEP Mid-Atlantic TRM, v10[6].

Table 8-1. HVAC Interactive Effects and Coincidence Multipliers from the NEEP Mid-Atlantic TRM[7]

Building Type (Mid-Atlantic TRM)	Space Type	Summer CF	Winter CF	Summer IF Demand	Winter IF Energy	IF Energy
Other	Auto Repair Workshop	0.89	0.61	1.35	1	1.08
Other	Commercial work (High Bay)	0.91	0.82	1.35	1	1.08
Other	Conference Room	0.3	0.16	1.35	1	1.08
Other	Dining Area	0.53	0.51	1.35	1	1.08
Other	Hallways	0.86	0.73	1.35	1	1.08
Other	Kitchen/Break room & Food Prep	0.74	0.42	1.35	1	1.08
Other	Library	0.46	0.31	1.35	1	1.08
Other	Lobby (Main Entry)	0.82	0.71	1.35	1	1.08
Other	Lobby (Office Reception/Waiting)	0.87	0.49	1.35	1	1.08
Other	Mechanical Room	0.74	0.46	1.35	1	1.08
Other	Office (General)	0.67	0.43	1.35	1	1.08

[6]NEEP TRM (April 2020, v10), https://neep.org/sites/default/files/media-files/trmv10.pdf

[7] The TRM interactive factors are weighted by the heating system fuel type multipliers derived from the participant virtual verification survey.

Building Type (Mid-Atlantic TRM)	Space Type	Summer CF	Winter CF	Summer IF Demand	Winter IF Energy	IF Energy
Other	Office (Open Plan)	0.82	0.49	1.35	1	1.08
Other	Office (Private)	0.44	0.2	1.35	1	1.08
Other	Other	0.64	0.4	1.35	1	1.08
Other	Outside	0.11	0.58	1.35	1	1.08
Other	Patient, Break Room	0.61	0.41	1.35	1	1.08
Other	Restroom	0.42	0.3	1.35	1	1.08
Other	Retail Sales/ Showroom	0.97	0.78	1.35	1	1.08
Other	Storage (Conditioned)	0.84	0.82	1.35	1	1.08
Other	Storage (Other Conditioned)	0.81	0.44	1.35	1	1.08
Office	Hallways	0.64	0.71	1.36	1	1.1
Office	Lobby (Main Entry)	0.91	0.8	1.36	1	1.1
Office	Office (General)	0.7	0.48	1.36	1	1.1
Office	Storage	0.69	0.48	1.36	1	1.1
Retail	Lobby (Main Entry)	0.99	0.63	1.27	1	1.06
Retail	Office (General)	0.73	0.4	1.27	1	1.06
Retail	Retail Sales/ Showroom	0.98	0.64	1.27	1	1.06
School	Classroom	0.22	0.2	1.44	1	1.1
School	Computer Room/Storage	0.34	0.35	1.44	1	1.1
School	Hallways	0.78	0.75	1.44	1	1.1
School	Office (General)	0.67	0.46	1.44	1	1.1
School	Office (Open plan)	0.7	0.54	1.44	1	1.1
School	Office (Private)	0.57	0.26	1.44	1	1.1

Building Type (Mid-Atlantic TRM)	Space Type	Summer CF	Winter CF	Summer IF Demand	Winter IF Energy	IF Energy
Warehouse	Commercial Work (High Bay)	0.94	0.86	1.23	1	1.02
Warehouse	Commercial work (Precision)	0.69	0.44	1.23	1	1.02
Warehouse	Office (General)	0.74	0.36	1.23	1	1.02
Warehouse	Restroom	0.53	0.47	1.23	1	1.02
Warehouse	Vacant Storage (Conditioned)	0.69	0.44	1.23	1	1.02

Source: NEEP Mid-Atlantic TRM, V10

9. Process and NTG Survey Guide

Landing Page

Thank you for taking time to complete this short survey about your experiences with Duke Energy's Small Business Energy Saver Program.

Your responses will help Duke Energy **improve future program** offerings
All information will remain **confidential**, and be aggregated with other survey information for analysis and presentation
Survey should take approximately **15 minutes to complete**
You may **pause and return** later to complete the survey
You will receive a **$50 gift card** for completing the survey

This survey is being administered on behalf of Duke Energy by Guidehouse. Your responses are confidential.

Screening

S1. Our records show that your company participated in the Duke Energy Small Business Energy Saver Program in **<MONTH>** of **<YEAR>** and received a discount to install a **<MEASURE> at <ADDRESS>**. Do you recall this project?

1. Yes
2. Yes, but at different address or year **[Open Ended]**
3. No

S2. What is your title at **<FIRM>**?

1. Owner
2. President
3. Manager
4. Administrator
97. Other **[Open Ended]**

S3. What was your role at **<FIRM>** with respect to the decision to participate in the Duke **Small Business Energy Saver** program and install the **<MEASURE>** project? **[Rotate 1-7]**

1. I met with the Program representative, reviewed the facility assessment report and decided to fund the project
2. I met with the Program representative, reviewed the facility assessment report and recommended the project
3. I reviewed the facility assessment report and decided to fund the project
4. I approved funding for the project
5. I managed the project
6. I coordinated the project

7. I was responsible for accounts payable
97. Other **[Open Ended]**

[Ask if S3 = 1-3]

S4. Would you be able to answer questions related to your business' participation in this program?

1. Yes
2. No

[Ask if S3 = 4-7 or S4 = 2] [Following response to S5, thank respondent and end survey. Not eligible for incentive.]

S5. Please share the name and contact information for another person at **<FIRM>** who was responsible for deciding to participate in the **Small Business Energy Saver** Program **<MEASURE>** project.

1. Name
2. Contact Phone
3. Contact Email

Confirm Decision Maker

DM1. How did you fund the portion of this project that **<FIRM>** paid for?

1. Paid upon project completion in a lump sum
2. Paid over one year with free financing
3. Paid over two years with free financing
4. Arranged for additional financing with the program representative
5. Arranged for financing on my own
97. Other **[Detail]**
98. Don't Know

DM2. Who approved the **["expenditures" if DM1 = 1 or "financing" if DM1 = 2-5]** to install the **<MEASURE>** project?

1. I approved it
2. I recommended approval of it
3. Someone else approved it
97. Other **[Detail]**
98. Don't Know

Ask if DM1 ≠ 1

DM2b. Could you tell me who authorized the financing for this project, and how I could reach that person?

1. Name **[Detail]**
2. Position **[Detail]**
3. E-mail **[Detail]**
4. Phone **[Detail]**

Program Awareness

PA1 How did you learn about the Small Business Energy Saver program?

1. My Duke Account Representative
2. Visit at my facility from Program representative
3. Social Media ad from Duke
4. Email from Duke
5. Mailing from Duke
6. Participation in other Duke Energy programs
7. Duke Energy website
8. Vendor or contractor

97. Other **[Detail]**

PA2 What materials, experience, or conversation with Duke Energy or Willdan representatives persuaded you to complete this project? **[Rotate]**

1. Facility assessment report
2. Presentation or workshop
3. Program overview sheet
4. Duke website
5. Duke email
6. Fact sheets
7. Contractor sales pitch

97. Other **[Detail]**
98. Don't know
99. Refused

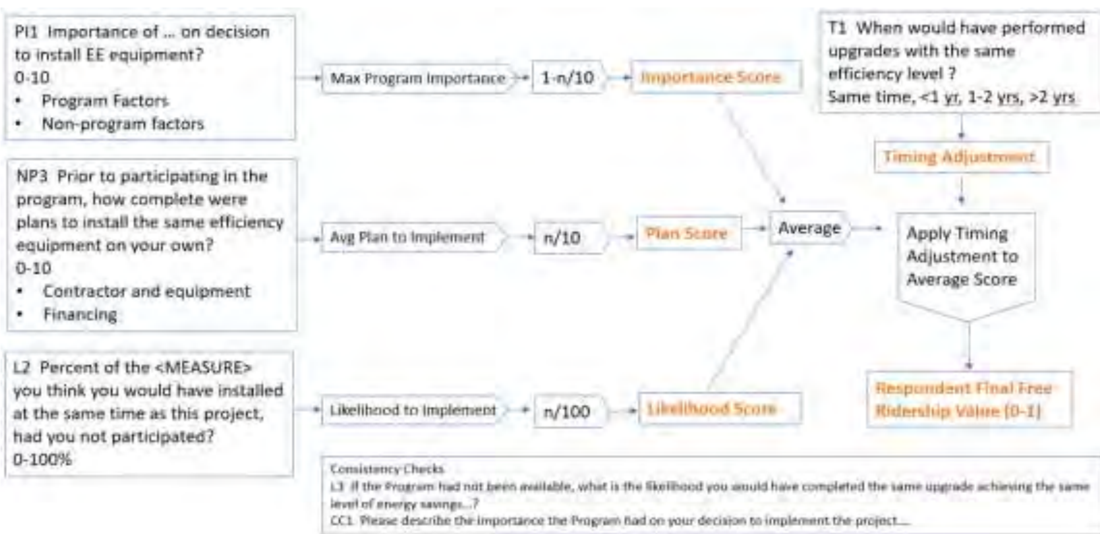
General Satisfaction

GS1. Now that you've completed your project, please tell us how satisfied you were with the program overall. Please rate your satisfaction with the Duke Energy Small Business Energy Saver Program in general. **[0-10 scale, with 0 meaning "Not at all Satisfied," 10 meaning "Extremely Satisfied", 98=Don't know, 99=Don't recall]**

NTG Free Ridership Battery

[Offer to <Year> = 2021 Sample]

Figure 9-1. Duke Energy SBES Free Ridership Algorithm



Source: Guidehouse research

Program Importance Score

Now we'd like to move away from satisfaction and ask you about how ***important*** the program activities were to implementing the energy efficiency improvements. As you answer these questions, please think about the **<MEASURE>** project that was installed.

PI1 Please rate the importance of several factors that may have contributed your decision to install the **<MEASURE>** project through the Duke Energy Small Business Energy Saver Program. **[0-10 scale, with 0 meaning "Not at all Important' and 10 meaning "Extremely Important"] [Rotate A-G]**

Program Factors

A. The **<VALUE>** rebate from Duke Energy for this project
B. The financing available from Duke for this project
C. The assessment report on your facility
D. Recommendations from the Willdan representative
E. Prior participation in a Duke Energy program
F. Information from Duke Energy about energy efficiency or related cost savings

Non-Program Factors

G. Your own analysis of the potential to save energy or money on your utility bill without the incentive.

Potential Program Factors

H. Recommendations from a friend or peer

[Ask PI1Ha if the score given to PI1H is the max (and only max) compared to scores given to PI1 A-F; Otherwise, Skip]

Ha. Did your peer mention the small business program from Duke Energy?

1. Yes
2. No
98. Don't know
99. Refused

[*NOTE: If PI1Ha=1, PI1H is a Program Factor*]

I. Other benefits from installing the energy-efficient equipment, such as comfort or ease of use?

[Ask PI1Ia if the score given to PI1I is the max (and only max) compared to scores given to PI1 A-F; Otherwise, Skip]

Ia. Did Duke Energy introduce you to the non-energy benefits of these improvements?

1. They were mentioned by Duke or its representative
2. No
98. Don't know
99. Refused

[*NOTE: If PI1Ia = 1 or 2, PI1I is a Program Factor*]

Program Components Score

PI2. Overall, how important was the program [including **<list program factors from PC1>6 >**on your decision to implement the **<MEASURE>** project, rather than a less efficient alternative? **[0-10 scale, with 0 defined as "Not at all Important" and 10 defined as "Extremely Important, 98=Don't know, 99=Don't recall]**

Counterfactual Plans

NP1. Prior to participating in the Duke Small Business Energy Saver program, had you considered installing energy efficient **<MEASURE>** at **<ADDRESS>**?

1. Yes
2. No

[Ask if NP1 = 1, Else Skip to CC1]

NP2. Please briefly describe your plans to install the efficient **<MEASURE>** project prior to participating in the Duke Small Business Energy Saver Program. **[OPEN END]**

NP3. Again, thinking back to before you participated in the Small Business Energy Saver program, please rate how far along your plans were to install energy efficient

<MEASURE> at your facility. [0-10 scale, where 0 means "No Established Plans" and 10 means "Complete Plans Established"]
A. Installation contractor and equipment of the same efficiency identified
B. Financing identified and secured to install the energy efficiency project

Counterfactual Likelihood

L1. What is the likelihood that you would have installed the same energy-efficient **<MEASURE>** (same quantity and same efficiency) without the program and its financial and technical assistance?

1. Definitely WOULD NOT have installed the same quantity of energy efficient **<MEASURE>**
2. MAY HAVE installed the same quantity of energy efficient **<MEASURE>**, even without the program
3. Definitely WOULD have installed the same quantity of energy efficient **<MEASURE>**

[Ask If L1 = 2, 3, Else Skip to L3]
L2. As best you can, please estimate the percent of the **<MEASURE>** you think you would have installed at the same time as this project, had the Duke program not been available. ____% **[Number]**

[Ask if NP3A or NP3B >0, Else Skip to T1]

L3. If the Duke Energy Small Business Energy Saver Program had not been available, and you went ahead with this project on your own without the rebate incentive, financing or technical assistance, what is the likelihood that you would have completed the same upgrade achieving the same level of energy savings? Again, we are not asking about your satisfaction with the **<MEASURE>** project, but about the likelihood that you would have completed an upgrade of the same level of energy savings without the Duke Energy Small Business Energy Saver Program. **[RECORD 0-10, 98=Don't Know, 99=Refused] [Define: where 0 means "Not at all Likely" and 10 means "Extremely Likely"]**

Timing Adjustment

T1. If the Duke Energy Small Business Energy Saver Program and incentives had not been available, when would do you think you have performed upgrades with the same efficiency level as completed through the program?

1. At the same time as the Duke incented project
2. Within 1 year
3. 1-2 years later
4. More than 2 years later
5. Would never have installed without the Program

Consistency Check

CC1. Please describe in your own words any importance that the Duke Energy Small Business Energy Saver Program had on your decision to implement the **<MEASURE>** project at your facility. **[OPEN ENDED]**

NTG Spillover Battery

[Offer both SO batteries to <Year> = 2020 Sample]

Inside Spillover

Please think about any energy efficient equipment you might have installed at the same facility without benefit of the Duke Energy Small Business Energy Savers program as you answer these next few questions.

SOI1. Did you install any additional energy-efficient equipment or make any operational improvements to save energy since participating in the Duke Energy Small Business Energy Saver Program?

1. Yes
2. No, we did not install anything additional **[SKIP to SOO1]**
98. Don't know **[SKIP to SOO1]**

SOI2. Did you receive rebates, incentives, financing or information for those projects from any other utility or government program?

1. Yes, from Duke Energy
2. Yes, from another utility or government
3. No
98. Don't know

[Ask If SOI2 = 3, Else Skip to SOO1]

SOI3. How important was your participation in the Duke Energy Small Business Energy Savings program on your decision to install additional energy efficient equipment without a rebate or incentive? **[0-10, where 0 means "Not at all Important" and 10 means "Extremely Important"**

SOI4. Please briefly describe how the Duke **Small Business Energy Saver** program influenced your decision to incorporate additional energy efficient equipment that did not receive an incentive or rebate. **[Open Ended]**

SOI5. Why didn't you apply for or receive a program incentive for the additional energy efficient equipment? **[Open Ended]**

SOI6. Please estimate the type(s), quantity, and cost of the energy efficient equipment you installed without benefit of a program rebate or incentive:

	Type of Energy Efficient Equipment (Describe as specifically as possible)	How many did you install?	What was the project cost?
Equipment Type 1			
Equipment Type 2			
Equipment Type 3			
Equipment Type 4			
Equipment Type 5			
Equipment Type 6			

SOI7. Please think only about the additional energy efficient equipment that did not receive a rebate or incentive. Would you estimate that the energy savings from these non-incented equipment is less, more or similar to the energy savings from the Duke Small Business Energy Savings program equipment?

1. Less than the SBES project
2. Similar to the SBES project
3. More than the SBES project
98. Don't know

SOI8. Did your experience with the Duke Small Business Energy Saver project in any way influence you to incorporate energy efficient equipment at other facilities that did not receive program rebates, but are also served by Duke Energy? Include only facilities served by Duke Energy, but that did not participate in any Duke Energy Efficiency programs.

1. Yes
2. No
98. Don't Know

[Ask if SOI8 = 1]

SOI9 Please estimate the number of other facilities that were influenced to install energy efficient equipment but did not participate in the program.

1. ______ Number
98. Don't Know

Outside Spillover

Please think about any energy efficient equipment you might have installed at *another facility* serviced by Duke Energy without benefit of the Duke Energy program as you answer these next few questions.

SOO1. Did you install any additional energy-efficient equipment or made any operational improvements to save energy since participating in the Duke Energy Small Business Energy Saver Program?

1. Yes
2. No, we did not install anything additional
98. Don't know

[Ask if SOO1 = 1, Else Skip to PE1]

SOO2. Did you receive rebates, incentives, financing or information for those projects from any other utility or government program?

1. Yes, from Duke Energy
2. Yes, from another utility or government
3. No
98. Don't know

[Ask If SOO2 = 3]

SOO3. How important was your participation in the Duke Energy Small Business Energy Savings program on your decision to install additional energy efficient equipment without a rebate or incentive? **[0-10, where 0 means "Not at all Important" and 10 means "Extremely Important"]**

[Ask If SOO3 > 6, Else Skip to PE1]

SOO4. Please briefly describe how the Duke program influenced your decision to incorporate additional energy efficient equipment that did not receive an incentive or rebate. **[Open Ended]**

SOO5. Why didn't you apply for or receive a program incentive for the additional energy efficient equipment? **[Open Ended]**

Ask if SO3 >6

SOO6. Please estimate the type(s), quantity and cost of the energy efficient equipment you installed without benefit of a program rebate or incentive:

	Type of Energy Efficient Equipment	How many did you install?	What was the project cost?

	(Describe as specifically as possible)		
Equipment Type 1			
Equipment Type 2			
Equipment Type 3			
Equipment Type 4			
Equipment Type 5			
Equipment Type 6			

SOO7. Please think only about the additional energy efficient equipment that did not receive a rebate or incentive. Would you estimate that the energy savings from these non-incented equipment is less, more or similar to the energy savings from the Duke Small Business Energy Savings (SBES) program equipment?

1. Less than the SBES project
2. Similar to the SBES project
3. More than the SBES project
98. Don't know

SOO8. Did your experience with the Duke Small Business Energy Saver project in any way influence you to incorporate energy efficient equipment at other facilities that did not receive program rebates, but are also served by Duke Energy? Include only facilities served by Duke Energy, but that did not participate in any Duke Energy Efficiency programs.

1. Yes
2. No
98. Don't Know

[Ask if SOO8 = 1]

SOO9. Please estimate the number of other facilities that were influenced to install energy efficient equipment but did not participate in the program.

1. ______ Number
98. Don't Know

Program Experience

PE1. Did you experience any negative issues, problems, delays or difficulties with your energy efficiency project? **[Rotate 2-14, Accept all selected]**

1. I did not experience any problems with this project
2. The process took too long
3. The process was too complex
4. The application materials were difficult to understand
5. The assessment report was difficult to understand

6. Lack of coordination and communication among program staff
7. Did not know who to contact with questions
8. The installation process was disruptive
9. The energy savings were lower than expected
10. The savings on my utility bill were lower than expected
11. The amount I needed to pay was higher than expected
12. I did not like the **<MEASURE>** installed
13. Equipment failure
14. Installation failure
97. Other **[Describe]**

[Ask If PE1 = 2-97]

PE2. Please rate how easy it was to resolve the issue(s) that you experienced. **[0-10, where 0 means "Very Difficult" and 10 means "Very Easy", 99 means "Not Resolved"]**

PE3. Please rate how easy the following program features were for you. **[0-10, where 0 means "Very Difficult" and 10 means "Very Easy", 99 means "Not Resolved"] [Rotate]**

A. Schedule initial visit
B. Understand and use the Facility Assessment Report
C. Understand the rebate amount for the project
D. Determine how to pay for or finance your portion of the project
E. Schedule project installation
F. Use equipment once installed

[Ask for Any PE3 <7]

PE3A. Please explain why you rated **[insert text]** as you did. **[Open Ended]**

Satisfaction

Now that you've completed your project, we'd like to ask how satisfied you were with aspects of the program.

S1. Please rate your satisfaction with the following. **[0-10 scale, with 0 meaning "Not at all Satisfied," 10 meaning "Extremely Satisfied" and 99 meaning "Not Applicable"] [Rotate A-I]**

A. **<MEASURE>** selection available through the program
B. **<MEASURE>** selection installed through the program
C. Available types of equipment (lighting, water saving, heating/cooling, refrigeration) options
D. Energy savings resulting from the new equipment
E. Savings on my bill resulting from the new equipment
F. Quality of light produced by the new light fixtures or bulbs
G. Rebate amount

H. Financing options through the program
I. Program communications
J. Overall program experience
K. Duke Energy overall

[Ask for Any PS1 <7]

S1A. Please explain why you rated **[insert text]** as you did. **[Open Ended]**

S2. Did your participation in the Small Business Energy Saver program change your attitude toward Duke Energy? Relative to before the program, is your attitude toward Duke Energy…

1. Much more positive
2. Somewhat more positive
3. About the same
4. Somewhat more negative
5. Much more negative
97. Other **[Detail]**

Covid-19 Impacts

Duke Energy would like to know more about how the COVID-19 pandemic has impacted your business.

C1. How has COVID-19 changed the way that you use energy? **[OPEN END]**

C2. We would like to learn how best to serve you during this unprecedented time. What would you like Duke Energy to know regarding how the COVID-19 pandemic might affect your business in the next 12-18 months? **[OPEN END]**

PROGRAM Improvement

PI1. What do you think could be improved about this program? **[OPEN END, 98=Don't Know, 99=Refused]**

PI2. What does the program do well? **[OPEN END, 98=Don't Know, 99=Refused]**

PI3. How could the program help you make more energy efficiency improvements at your facility? **[OPEN END, 98=Don't Know, 99=Refused]**

PI4. What additional equipment should Duke add to the program? **[OPEN END, 98=Don't Know, 99=Refused]**

PI5. How could the program reach other businesses like yours to participate in an energy efficiency project? **[OPEN END, 98=Don't Know, 99=Refused]**

Firmographics

We're almost done. I just have a few basic questions about your business.

F1. What industry is your business in?

Agriculture, Forestry and Fishing

1. Agricultural Production Crops

Construction

2. Construction

Manufacturing – Small Business

3. Manufacturing, Small Business

Other

25. Other **(Specify)**

Public Administration

26. Post Office
27. Postal Center Distribution
28. Public Emergency Services
29. Public Library
30. Public Offices Courts

Professional Services

31. Professional Services

Retail Trade

32. Auto Boat and Vehicle Dealer or Rental
33. Convenience and Gas Station
34. Convenience and Specialty Food
35. Grocery Store
36. Liquor Store
37. Restaurants Bars
38. Retail No Refrigeration
39. Retail with Refrigeration

Services

40. Amusement and Recreation Services
41. Automotive Repair and Service
42. Carwashes
43. Child Care
44. Cultural Facility Private
45. Cultural Facility Public
46. Data Center
47. Education K12 Private
48. Education K12 Public
49. Funeral Services

50. Garden Lawn Nursery
51. Health Clinic Hospital Private
52. Health Clinic Hospital Public
53. Health Services
54. Higher Education Private
55. Higher Education Public
56. Laundry and Dry Cleaning
57. Lodging
58. Multifamily Private
59. Multifamily Public
60. Nursing and Home Health
61. Personal Care
62. Personal Services
63. Pet Services
64. Recreation Private
65. Recreation Public
66. Religious Sanctuary Meeting
67. Religious School Office
68. Repair Services
69. Veterinary
70. Warehouse

Transportation

71. Transportation Private
72. Transportation Public

Wholesale Trade

73. Oil and Gas Extraction
74. Wholesale Trade

F2. What hours is your facility staffed? **[If Needed: the facility will likely be staffed before and after it is open for business.] [24-hour Number fields for StartTime and EndTime, 98=Don't Know, 99=Refused]Weekday open [TEXT BOX]**

A. On weekdays staffed from **[four digit StartTime]** to **[four digit EndTime]**
B. On weekends staffed from **[four digit StartTime]** to **[four digit EndTime]**

F3. How long has your business been at this location? **[Enter Years, 98=Don't Know, 99=Refused]**

F4. How many staff work at the facility in any given week? **[Enter Number, 998=Don't Know, 999=Refused]**

F5. Are you planning any future updates or renovations at your facility? **[DO NOT READ, 98=Don't Know, 99=Refused]**

1. Yes
2. No

3. Don't Know
99. Refused

[Ask If F5=1, Else Skip]

F5A. What systems that use or impact electricity are you planning to update? **[DO NOT READ, 98=Don't Know, 99=Refused]**

1. Lighting
2. HVAC
3. Insulation, Windows, Doors
4. Cooking equipment
5. Refrigeration equipment
6. Compressed Air
7. Motors
97. Other **[Record]**
98. Don't Know
99. Refused

F6. Does your business own or lease the facility? **[DO NOT READ, 98=Don't Know, 99=Refused]**

1. Own
2. Lease
97. Other **[Record]**
98. Don't know
99. Refused

Survey Closing

Thank you for your time in completing this survey!

$50 gift cards for completed surveys will be emailed in 4-8 weeks from fulfilment co name.

resource innovations
Reimagining tomorrow with Nexant today

Peak Time Credit Pilot Evaluation

Summer 2022 Incentive Test

Prepared for Duke Energy Kentucky

May 18, 2023

Prepared by Resource Innovations in partnership with Apex Analytics

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Contents

1 Executive Summary

In the summer of 2020, Duke Energy Kentucky (DEK or Company) launched the “Peak Time Credit” (PTC) Pilot, which offers customers the opportunity to lower their electric bill by reducing electric usage during Critical Peak Events (CPE). Designed for residential customers, the Pilot is an incentive-based demand response (DR) program based on a Peak Time Rebate (PTR) rate design. The Pilot was approved by the Kentucky Public Service Commission on April 27, 2020, under Case Number 2019-00277 and approved for a research extension for Summer 2022.

The pilot was designed to include up to eight summer CPEs (May to October), two winter CPEs (November to April), and two flexible CPEs (January – December). Summer events were from 3 PM to 7 PM, and winter events were from 6 AM to 10 AM. CPE notifications were generally provided to customers on the day prior to the event, but events could be called with as little as one hour notification. The Company agreed to implement at most one event per year with less than one day prior notice. Baseline usage estimates were determined from the usage history, and credits were paid for any net reduction in usage as compared to the baseline usage that occurred during the CPE. Participants enrolled in the first evaluation phase, conducted between August 2020 and October 2021, each received a $0.60 cents per kWh credit and are referred to as original participants in this report. To evaluate the impact of differing incentive levels in the second evaluation phase, new participants were enrolled before the Summer 2022 season and are referred to as incentive test participants. Approximately half of the new participants received $0.60 per kWh credit while the remainder of new participants received $1.20 per kWh credit. If no reduction occurred, the participant did not receive a credit, but was not penalized. Findings from the Summer 2022 season of the Pilot are documented in this evaluation report.[1]

1.1 Overall Findings

The primary research objective for the incentive test phase of the Pilot was to determine if customers receiving the $1.20 incentive produced larger load reduction impacts than the customers receiving the $0.60 incentive.

As part of the evaluation plan approved, the following additional research questions were investigated in order to provide context to the findings and facilitate a deeper understanding of impact performance drivers and customer experience:

- Were customers effectively educated and motivated to use the program?
- Did event notifications reach the customer such that they could effectively respond to the event?
- What were the most common actions participants took to reduce usage during summer events?

[1] Summer 2022 load impacts from the Original Participant group are provided in Appendix A.

- What were the most common reasons participants gave for not reducing usage during summer events?
- What were the participants most frequently identified program improvement recommendations?
- How satisfied were participants with the Pilot, and did it vary by incentive level?

The following subsections provide an additional level of detailed key findings to the research questions presented above.

1.1.1 Load Impacts

In Summer 2022, a new subset of participants was tested to determine the impact of different incentive levels on average hourly load impacts per participant. Incentive test customers received either $0.60 per kWh or $1.20 per kWh. Original participants enrolled in 2020 receive $0.60 per kWh and are included in the table below for reference. In Summer 2022, seven events were called between 3 PM – 7 PM for incentive test customers and three events were called between 3 PM – 7 PM for original Pilot participants. Table 1-1 displays average hourly load impacts per customer, by incentive segment. Incentive test customers provided an overall average hourly load impact per customer in Summer 2022 of 0.23 kW or 10.7% while participants receiving $0.60 per kWh provided a reduction of 0.22 kW (9.9%) and participants receiving $1.20 per kWh provided a 0.25 kW reduction (11.6%). The difference in load reductions was not statistically significant. For original Pilot participants, average hourly load impacts per customer during the Summer 2022 season were 0.15 kW or 6.0%.

Table 1-1: Summary of Average Hourly Load Impacts - Summer 2022[2]

Segment	Load w/o DR* (kW)	Load w/ DR (kW)	Impact (kW)	Impact (%)
$0.60/kWh	2.21	1.99	0.22	9.9%
$1.20/kWh	2.12	1.87	0.25	11.6%
All Incentive Test Participants	2.16	1.93	0.23	10.7%
Original Participants	2.53	2.38	0.15	6.0%

*DR represents Demand Response (i.e., a PTC critical peak event).

[2] The primary focus of the evaluation was estimating impacts for the incentive test customers. Impacts from the original participants group were included to provide point of comparison. Note, the event dates for the Incentive Test and Original Participant treatment groups were different. See Section 3.3 for a comparison of impacts across the same set of days.

Key findings pertaining to load impacts from the Pilot include:

- Statistically significant load impacts were detected across both incentive levels for customers in Single-family and Multi-family homes.
- At the population level, participants receiving the $1.20 per kWh incentive had slightly larger load impacts (0.25 kW) than participants receiving $0.60 per kWh (0.22 kW), however the difference in impacts were not statistically significant.
- At the population level, participants receiving the $1.20 per kWh incentive had slightly lower reference loads than that of participants receiving $0.60 per kWh though the difference was not statistically significant.
- Single-family participants receiving $1.20 per kWh consistently provided larger load impacts (0.29 kW) than single-family participants receiving $0.60 per kWh (0.24 kW), though the difference was not statistically significant. Multi-family participants receiving $1.20 per kWh provided smaller load impacts (0.15 kW) than multi-family participants receiving $0.60 per kWh (0.18 kW) at the segment level, however the difference was not statistically significant.
- As Summer 2022 was the incentive test participants first event season, impacts were larger than that of original participants (i.e., 2022 was the third summer of participation for the original group) on the three common event days in Summer 2022. This is consistent with what was observed in the original pilot population in prior seasons, with their first event season (Summer 2020) producing load impacts 2.7 times larger than that of Summer 2021.
- Original participants' load impacts were comparable in Summer 2022 to Summer 2021 at the population level.

1.1.2 Process Evaluation

Key findings and recommendations pertaining to the process evaluation include:

Participation Awareness and Motivation

- Most respondents were aware of their participation in the Pilot with 99.6% of participants recalling their participation.
- The most important reason provided by participants for joining the Pilot was to save money on their electricity bill, with an average rating of 9.3 out of 10 on average.

Peak Time Credit Awareness and Notification Satisfaction

- In the post-event survey, the majority (82.4%) of respondents recalled the event and a majority became aware through email notifications from Duke Energy (73.2%).
- Respondents generally agreed that Duke Energy notified them in a timely manner (9.2 out of 10), provided them with helpful information (8.9 out of 10), and gave

them confidence of which hours they can earn credits on Peak Days (9.5 out of 10).

Response to Peak Time Credit Event

- In the post-event survey, 80.6% of the respondents reported being home during the event and 82.4% of respondents took action or changed their behavior due to the event.
    - Customers in the $0.60 per kWh group were home more frequently (84.9%) during the event than customers in the $1.20 per kWh group (76.7%), a statistically significant difference.
- The most commonly reported actions taken by participants were turning off lights in unoccupied rooms, increasing temperature on their thermostat, and shifting large appliance use. There were no statistically significant differences between the two incentive groups in terms of actions taken.
- Participants generally find responding to an event to be relatively easy, giving an average rating of 8.5 out of 10. There was no statistically significant difference in this rating between the two incentive groups.
- Commonly reported challenges to event response included not being able to think of any additional actions to take (25.3%), not having any barriers to shifting usage (14.8%), and already using very little energy (14.0%). There were no statistically significant differences between the incentive groups in terms of challenges to reduce usage.

Satisfaction with Peak Time Credit and Incentive Test

- Participants were generally satisfied with Pilot implementation overall (7.7 out of 10), but customers receiving $1.20 per kWh bill credit were statistically significantly more satisfied (8.1 out of 10) compared to $0.60 per kWh bill credits (7.3 out of 10).
- Customers would generally recommend the Pilot to others (8.4 out of 10) and would continue participating in future seasons (88.8%).
    - The $1.20 per kWh group was statistically significantly more likely to recommend the Pilot to others (8.6 out of 10) than the $0.60 per kWh group (8.1 out of 10).
    - The $0.60 per kWh group was statistically significantly more likely to respond “No” or “Don’t know” when asked if they would continue participating in the Pilot in the future (12.7%) than the $1.20 per kWh group (9.3%).
- The Net Promoter Score[3] (NPS) for the full set of incentive test customers is 46.7. The NPS for the $0.60 per kWh group is 38.4 while the NPS for the $1.20 per

[3] Net Promoter Score is a popular metric used to estimate how likely a customer is to promote a program. It is calculated by subtracting the percentage of customers who rate their likelihood to recommend the program from 1 to 6 (detractors) from the percentage of customers who rate their likelihood to recommend the program 9 or 10 (promoters).

kWh group is 53.7. The difference in scores between the two groups is statistically significant – however, the positive magnitude of the scores indicate that there is a large proportion of customers in both groups that would recommend the Pilot to others.

- Participants receiving $0.60 per kWh bill credits are statistically significantly less satisfied (6.1 out of 10) with the credits earned than customers receiving $1.20 per kWh bill credits (7.2 out of 10).
- Out of the customers receiving the $0.60 per kWh bill credit and who planned on discontinuing their participation in later seasons (12.7% of the overall $0.60 per kWh group), over two-thirds (8.6% of the overall $0.60 per kWh group) said they would stay in the Pilot if the credit increased.
- Out of the customers receiving the $1.20 per kWh bill credit and who planned on continuing their participation in later seasons (90.4% of the overall $1.20 per kWh group), over one-third (30.3% of the overall $1.20 per kWh group) said they would stay in the Pilot if the credit decreased.

Recommendations from Participants

- Respondents were given the opportunity to provide free-form response recommendations to improve the Peak Time Credit Pilot. In total, 28.8% of respondents provided suggestions. The bullets below provide a summary of the suggestions offered by participants.
    - Out of the 124 suggestions provided by participants, 24% were to increase the credit. This represents 6.9% of all survey respondents. While the bill credit is the primary motivation for enrollment (9.3 out of 10), customers are the least satisfied with the credit (6.7 out of 10) and would work harder to reduce usage if the credit were higher (9.0 out of 10). It is worth noting that a quarter of participants stated that they cannot think of any other actions to reduce their usage.
        - Of the suggestions provided, 26.7% of respondents in the $1.20 per kWh group suggested increasing the bill credits, compared to 21.1% of the $0.60 per kWh group.
    - Several participants (8.9% of 124 suggestions provided) suggested communicating the credits earned swiftly and clearly following an event, even if no credit was earned. This represents 2.6% of all survey respondents.
        - Of the suggestions provided, 8.0% of respondents in the $1.20 per kWh group suggested communicating the credits earned swiftly and clearly following an event, compared to 9.9% of the $0.60 per kWh group.
    - A common recommendation (19.9% of 124 suggestions provided) was to provide in-depth information on energy savings methods and give examples of how they may translate to bill credits. This represents 5.7% of all survey respondents.

    - Of the suggestions provided, 20% of respondents in the $1.20 per kWh group suggested providing information on energy savings methods, compared to 19.7% of the $0.60 per kWh group.
- Several customers (11.6% of 124 suggestions provided) suggested creating a Peak Time Credit website or app that tracks participants' usage, provides Pilot information and event notifications, and tracks and contextualizes Peak Day performance. This represents 3.3% of all survey respondents.
    - Of the suggestions provided, 10.7% of respondents in the $1.20 per kWh group suggested creating a Peak Time Credit website or app, compared to 12.7% of the $0.60 per kWh group.

2 Introduction

In the summer of 2020, Duke Energy Kentucky launched the "Peak Time Credit" Pilot, which offers customers the opportunity to lower their electric bill by reducing electric usage during Critical Peak Events (CPE). Designed for residential customers, the Pilot is an incentive-based demand response (DR) program based on a Peak Time Rebate (PTR) rate design. The first phase of the Pilot's evaluation documented impacts and findings from the first three event seasons, August 2020 through August 2021. This report documents the second phase evaluation covering the Summer 2022 season, which aimed to examine the influence of incentive levels on customer participation and load impacts. This report contains background information on the Pilot including the Pilot design and the evaluation methodology in addition to load impacts and process evaluation findings.

The load impact evaluation section presents event-period load reductions for each event day by customer segment. The process evaluation section presents results from a post-event survey for Summer 2022. Findings from the Pilot evaluation can inform future decisions regarding the current pilot or future peak time rebate program.

2.1 Summary of Pilot

The Pilot was approved by the Kentucky Public Service Commission on April 27, 2020, under Case Number 2019-00277. The Pilot was approved for a research extension for the Summer of 2022 to evaluate the impact of differing customer incentive levels. Customers in the eligible population were randomly assigned to receive either the $0.60 or the $1.20 offer and were unaware of the other incentive level. Approximately 1,350 participants were enrolled in 2022 for incentive testing, with about half under each incentive level. This resulted in each incentive group consisting of over 650 participants, which was sufficient to obtain statistically significant load impacts for the duration of the Pilot.

In Summer 2022, seven events were called between 3 PM – 7 PM for incentive test customers. CPE notifications were generally provided to customers on the day prior to the event, but events could be called with as little as one hour notification. Baseline usage estimates were determined from the usage history, and for any net reduction in usage as compared to the baseline usage that occurred during the CPE, each participant received a $0.60 per kWh or $1.20 per kWh credit. If no reduction occurred, the participant did not receive a credit, but was not penalized. Customers who earned credits received email or text messages regarding earned credit amounts within five business days following each CPE during the term of the pilot.

2.2 Participant Summary

Duke Energy started recruitment for incentive test customers in May 2022. Participants were recruited randomly from a list of eligible customers, which included those that were not enrolled on another demand response program and did not have a past due bill on their account. All program outreach was conducted through email marketing to reduce cost and ensure customers that enrolled would respond to email event notifications once the program began. The recruitment emails included general information about the program offering and a link to a webpage with further details and an enrollment form. In total 1,346 customers enrolled, with 679 enrolling at the $0.60 per kWh level and 667 at the $1.20 per kWh level. Both incentive groups had similar acquisition rates.

Table 2-1: Recruitment Summary

Incentive Level	Recruitment Emails Sent	Customers Enrolled	Acquisition Rate
$0.60/kWh	31,598	679	2.2%
$1.20/kWh	31,630	667	2.1%

Table 2-2 displays customer participation in DEK's PTC Pilot by dwelling and primary heating fuel type as of the Summer 2022 event season. Approximately the same number of customers were enrolled in each of the two incentive groups. A significant portion of newly enrolled customers had unknown heating types. 70.8% of $0.60 per kWh incentive Pilot participants live in single-family residences, while more than 71.1% of $1.20 per kWh incentive customers live in single-family residences.[4] In both incentive groups, roughly 49% of participants have gas heating.

Table 2-2: Counts by Customer Segment – Summer 2022 Incentive Test

Segment	$0.60/kWh Incentive Participant Count	$0.60/kWh Incentive Percent	$1.20/kWh Incentive Participant Count	$1.20/kWh Incentive Percent
Residential Single-Family Combined	**481**	**70.8%**	**474**	**71.1%**
Residential Single-Family (Electric Heat)	111	16.4%	117	17.5%
Residential Single-Family (Gas Heat)	283	41.7%	282	42.3%
Residential Single-Family (Unknown Heat)	87	12.8%	75	11.2%
Residential Multi-Family Combined	**198**	**29.2%**	**193**	**28.9%**
Residential Multi-Family (Electric Heat)	91	13.4%	87	13.0%
Residential Multi-family (Gas Heat)	56	8.3%	49	7.4%
Residential Multi-Family (Unknown Heat)	51	7.5%	57	8.6%
Total	**679**	**100.0%**	**667**	**100.0%**

[4] Customer counts and results are presented at the customer segment level including the electric versus gas heating distinction across all seasons to allow for comparison across these groups between seasons. Customers with electric versus gas heating may have different building characteristics that could lead to differences in impacts during the summer seasons as well.

Figure 2-1 illustrates average hourly energy use during event-like days in Summer 2022. Average summer demand is separated by incentive level and dwelling type, showing single and multi-family customers separately. Single-family customers have much higher loads than multi-family customers at all times of the day in both incentive groups. Generally, multi-family customers' loads are flatter throughout the day. Both customer segments experience afternoon peaks during the summer season. Customers receiving a $1.20 per kWh incentive had very similar loads on event-like days when compared to participants receiving a $0.60 per kWh incentive. This indicates there were no major differences in energy consumption patterns between the customers who accepted the $0.60 offer and the $1.20 offer.

Figure 2-1: Summer Average Hourly Demand on Event-Like Days

2.3 Event Summary

Table 2-3 provides a summary of the Summer 2022 event season. Over the course of the Summer 2022 season, seven events were called between 3 PM – 7 PM for Incentive Test customers. Original Pilot participants only experienced three of the seven Summer 2022 events. The DEK PTC Pilot events were called on hot days. Daily minimum temperatures ranged from 59°F to 75°F, while daily maximum temperatures ranged from 87°F – 94°F. The Summer 2022 event season averaged about 669 $0.60 per kWh incentive customers, 665 $1.20 per kWh incentive customers, and 698 original Pilot customers.

Table 2-3: Summer 2022 Season Event Summary (3 PM – 7 PM Events)

Event Date	$0.60/kWh Participants	$1.20/kWh Participants	Original Participants	Min Temp (°F)	Max Temp (°F)
6/14/2022	676	668	703	75.0	94.0
6/15/2022	676	668	703	75.0	91.0
6/21/2022	676	668	-	59.0	92.0
7/6/2022	665	668	-	73.0	94.0
7/20/2022	666	663	-	73.0	91.0
7/28/2022	662	660	-	71.0	87.0
8/3/2022	662	658	689	68.0	90.0
Average	**669**	**665**	**698**	**70.6**	**91.3**

3 Load Impact Evaluation

One of the primary objectives of the PTC Pilot evaluation is to estimate the load reduction during the event days for PTC participants. For the Summer 2022 season, a new objective was to compare the load impacts across the $0.60 per kWh and $1.20 per kWh incentive level customers. This section summarizes the methodology used to estimate load impacts and the resulting load impacts for the Pilot and for each incentive level, dwelling type, and primary heating fuel type. The Summer 2022 load impacts of original pilot participants were also evaluated and detailed in the Appendix.

This section utilizes two terms that may require clarification. Demand Response (DR) denotes a program like the Peak Time Credit Pilot, which incentivizes customers to reduce their load during specified event periods. When this report displays load with and without DR in figures and tables, it represents customer load during CPE hours for customers enrolled or not enrolled in the Pilot, respectively. Figures including hourly load shapes illustrate kW demand on an hourly basis, which is equivalent to kWh.

3.1 Methodology

The primary challenge in estimating load impacts for opt-in programs, where there is no randomized controlled trial, is estimating how much electricity participants would have consumed in the absence of the treatment. The estimated usage in the absence of the treatment is referred to as the reference load or counterfactual. To estimate load impacts, Resource Innovations compared participant load to a matched control group during each hour during the events and selected proxy days. The matched control group was selected from a pool of customers not enrolled in the PTC Pilot. Resource Innovations matched participants with nonparticipant customers – the control group – based on similar usage during proxy days and customer class (dwelling and primary heating fuel type). The impact estimates represent the difference in loads for the participant and control group customers during the event period minus any difference in load between the two groups during the same hour on proxy days– this approach is referred to as a difference-in-differences analysis.

3.1.1 Control Group and Proxy Day Selection

Resource Innovations developed matched control groups via propensity score matching. A matched control group is the primary source for reference loads which are used to estimate impacts. The method used to assemble the matched control group is designed to ensure that the control group's load on event days is an accurate proxy for Pilot customer load, had an event not taken place. First, a pool of potential control customers was established. There were approximately 20,000 potential control customers chosen for the incentive test Pilot population of around 1,300 customers. The potential control customers were selected to have similar monthly usage, geographic locations, household size, and customer segments as the treatment customers.

Then, the actual control group was selected using a propensity score matching model to find customers in the control group pool who had load shapes most similar to Pilot customers.

A probit model was used to estimate a propensity score for each treatment customer and potential control candidate. Observed characteristics such as customer class and load profiles are explanatory variables that are used to predict whether or not a particular customer enrolled in the treatment or not. The probit model outputs propensity scores for each customer indicating how likely they are to be in the treatment group given the observable characteristics used in the model. Treatment customers are matched to a customer in the control group with the most similar propensity score. This process helps eliminate the difference between the treatment and match-controlled group on the matching variables.

To select the probit model which picked the best match for each treatment customer, we evaluated several model specifications. For each model, the customer load shapes for both the treatment and the control customers on proxy days were checked against each other to find the closest match. This was done separately for the four customer classes: single-family space heat, single-family non-space heat, multi-family space heat, and multi-family non-space heat. During this process, we tested fifteen model specifications using different observable variables, including usage during typical event hours, average total daily usage, morning usage, and usage during pre-event hours. During the matching process, the treatment customer is matched to the control customer who has the most similar propensity score. If the difference between a treatment customer's and a control customer's propensity score is higher than a set caliper, the treatment customer will not be matched. The model producing the best matched control group for each customer segment was selected, which resulted in a mixture of specifications that were used to determine the best-matched pairs and included the usage during events hours, average total daily usage, pre-event usage, and morning usage.

Figure 3-1 and Figure 3-2 show the Summer 2022 results of the matched control group for all $0.60 per kWh and $1.20 per kWh treated customers, respectively. The load profiles compare control and treatment groups' use during the average proxy day.

Figure 3-1: Average Hourly Demand (kW) for All $0.60 per kWh Incentive Treatment and Control Customers on Proxy Days

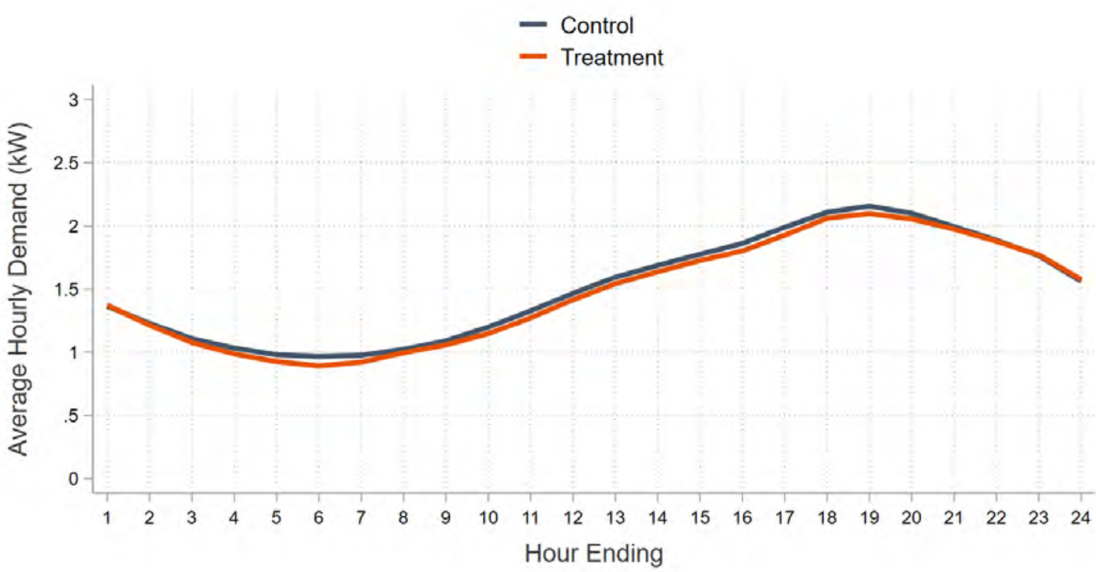
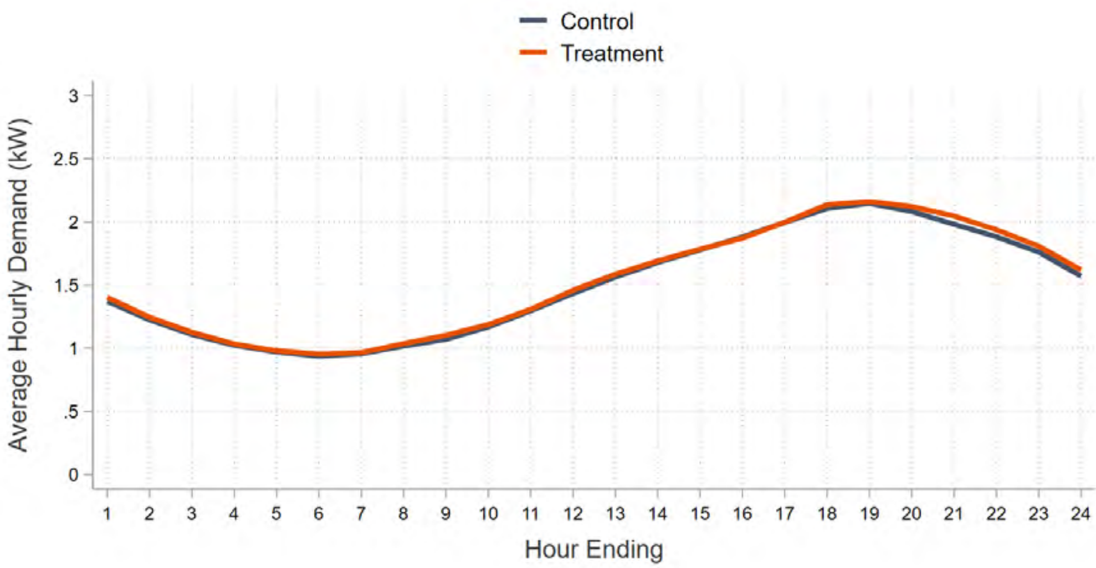


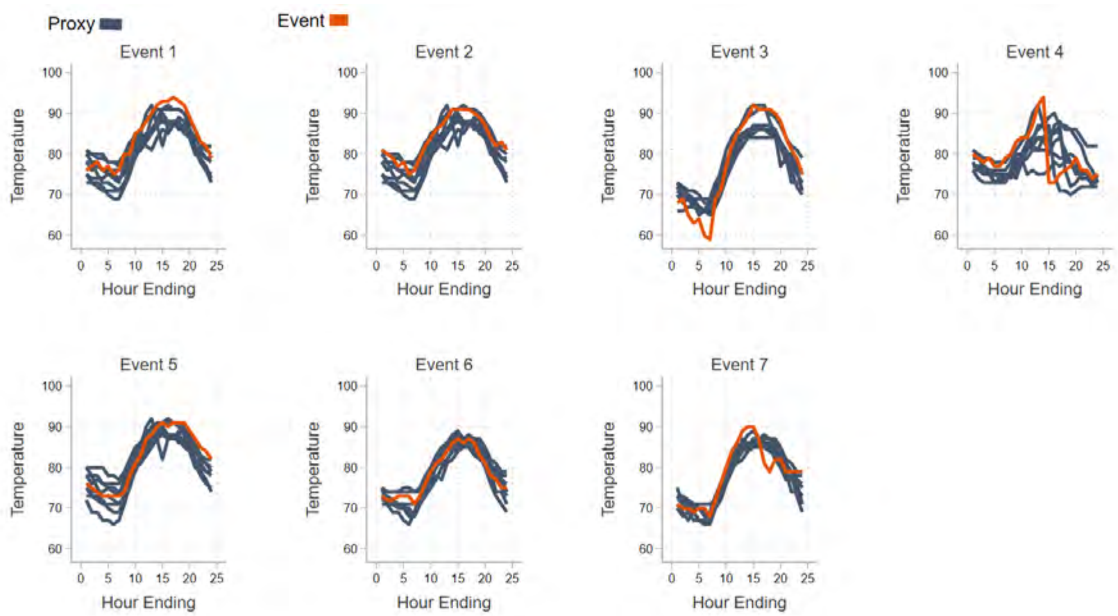
Figure 3-2: Average Hourly Demand (kW) for All $1.20 per kWh Incentive Treatment and Control Customers on Proxy Days



Proxy days were selected to ensure treatment and control customers' usage on event days were compared to similar non-event days. Each of the event days were matched with eight additional proxy days, based on the hourly temperature profile from 12 AM – 8 PM. This process ensured that we compare like-to-like days, so that the load impacts are not biased by large differences in temperature between event days and non-event days.

Figure 3-3 displays hourly temperature for all seven Summer 2022 event days and each of their respective proxy days. Event temperature is displayed in orange while the proxy days' temperatures are in blue.

Figure 3-3: Average Hourly Temperature (°F) on Event and Proxy Days



3.1.2 Load Impact Estimation

The load impacts were estimated using a difference-in-differences (DiD) analysis. This method estimates impacts by subtracting treatment customers' loads from control customers' loads in each hour after the treatments are in place. Then, the difference in loads between treatment and control customers for the same period on proxy days is subtracted from the first difference. Subtracting any difference between treatment and control customers prior to the treatment going into effect adjusts for any pre-existing differences between the two groups that might occur due to random chance.

The DiD calculation can be done arithmetically using simple averages or it can be done using a regression analysis. Customer fixed-effects regression analysis allows each customer's mean usage to be modeled separately, which reduces the standard error of the impact estimates by taking into account the fact that it is a single customer with multiple observations, without changing their magnitude. Additionally, standard statistical software allows for the calculation of standard errors, confidence intervals, and significance tests for load impact estimates that correctly account for the correlation in customer loads over time. Implementing a DiD through simple arithmetic would yield the same point estimate, but the confidence intervals would be wider than ones estimated by a fixed-effects regression. The regression model was run separately for each hour of the day, each incentive level, and each of the six customer classes. This model specification is shown in Equation 3-1 below:

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Equation 3-1: Difference-in-Difference Model with Fixed Effects

$$kW_{i,t} = a + \delta \text{treat}_i + \gamma \text{post}_t + \beta(\text{treat} \times \text{post})_{i,t} + v_i + u_t + \varepsilon_{i,t\ for\ i \in \{1,\ldots,ni\}\ and\ t \in \{1,\ldots,nt}$$

In the above equation, the variable $kW_{i,t}$ equals electricity usage during the time period of interest, which is measured at an hourly level in this analysis. The index *i* refers to customers and the index *t* refers to the time period of interest. The variable *treat* denotes whether customers are enrolled in the PTC Pilot, while the variable *post* denotes whether it is an event or proxy day. The *treatpost* term is the interaction of treat and post and its coefficient β is a difference-in-differences estimator of the treatment effect that makes use of the pretreatment data. The primary parameter of interest is β, which provides the estimated load impacts of the new rate during each event hour. The parameter u_t is the time fixed-effects, controlling for differences in usage between days, common to all customers. The v_i term is the customer fixed-effects variable that controls for unobserved factors that are time-invariant and unique to each customer. Parameter a is the model constant. $\varepsilon_{i,t}$ is the error term for each individual customer and time period.

We estimated the model using both event days and proxy days. Any differences in loads between the treatment and the control groups for the event period hours on proxy days are subtracted from differences on PTC event hours to adjust for any differences between the treatment and the control groups due to random chance.

3.2 Event Impacts

The estimated load impact averaged across all incentive test pilot participants for the Summer 2022 season was 0.23 kW or 10.7%. Across both incentive levels, single-family customers had an average load impact of 0.26 kW (10.7%) while multi-family customers had an average load impact of 0.16 kW (10.9%) during the event hours of 3 PM to 7 PM. The average impact across all participants receiving $0.60 per kWh was 0.22 kW or 9.9% while the average impact across all participants receiving $1.20 per kWh was 0.25 or 11.6%.

3.2.1 Summer 2022 Season – Incentive Test

Table 3-1 displays average hourly load impacts per customer during the event hours of 3 PM – 7 PM by segment for participants that received a $0.60 per kWh incentive in Summer 2022. As discussed in Section 2, single-family and multi-family customers have very different load profiles. As a result, the load impacts from these two groups are also very different. Some participants had an unknown heat type, resulting in six customer segments within the incentive test population. Average hourly impacts per customer for $0.60 per kWh incentive participants were 0.22 kW or 9.9% overall, while single-family participant impacts were 0.24 kW (9.5%), and multi-family participants were 0.18 (11.5%).

Table 3-1: Average Hourly Load Impact (kW) $0.60 per kWh Incentive (Summer 2022)

$0.60/kWh Incentive Customer Segment	Load w/o DR (kW)	Load w/ DR (kW)	Impact (kW)	Impact (%)
Residential Single Family Combined	**2.48**	**2.25**	**0.24**	**9.5%**
Residential Single Family (Electric Heat)	2.09	1.93	0.17	8.0%
Residential Single Family (Gas Heat)	2.71	2.42	0.29	10.6%
Residential Single Family (Unknown Heat)	2.23	2.08	0.15	6.6%
Residential Multi-family Combined	**1.54**	**1.36**	**0.18**	**11.5%**
Residential Multi-family (Electric Heat)	1.39	1.22	0.17	12.5%
Residential Multi-family (Gas Heat)	1.71	1.49	0.22	12.7%
Residential Multi-family (Unknown Heat)	1.62	1.48	0.14	8.4%
All Events Participants	**2.21**	**1.99**	**0.22**	**9.9%**

Table 3-2 presents the average hourly load impacts per customer during the event hours of 3 PM – 7 PM by segment for the $1.20 per kWh participants in Summer 2022. Average hourly load impacts per customer during Summer 2022 for all participants in the $1.20 per kWh incentive group were 0.25 kW or 11.6%, while single-family impacts were 0.29 kW (11.9%), and multi-family impacts were 0.15 kW (10.3%).

Table 3-2: Average Hourly Load Impact (kW) $1.20 per kWh Incentive (Summer 2022)

$1.20/kWh Incentive Customer Segment	Load w/o DR (kW)	Load w/ DR (kW)	Impact (kW)	Impact (%)
Residential Single Family Combined	**2.40**	**2.12**	**0.29**	**11.9%**
Residential Single Family (Electric Heat)	2.08	1.80	0.27	13.2%
Residential Single Family (Gas Heat)	2.64	2.31	0.33	12.4%
Residential Single Family (Unknown Heat)	2.02	1.88	0.14	7.2%
Residential Multi-family Combined	**1.41**	**1.27**	**0.15**	**10.3%**
Residential Multi-family (Electric Heat)	1.26	1.11	0.15	12.1%
Residential Multi-family (Gas Heat)	1.77	1.61	0.17	9.3%
Residential Multi-family (Unknown Heat)	1.32	1.21	0.12	8.8%
All Events Participants	**2.12**	**1.87**	**0.25**	**11.6%**

Table 3-3 compares the average hourly load impacts by segment across the two incentive levels in Summer 2022. Overall, $1.20 per kWh incentive participants achieved slightly higher load impacts than $0.60 per kWh participants at 0.25 kWh (11.6%) and 0.22 kWh (9.9%), respectively. Single-family participants in the $1.20 per kWh incentive group outperformed single-family participants in the $0.60 per kWh incentive group at 0.29 (11.9%) and 0.24 (9.5%), while multi-family participants in the $1.20 per kWh incentive group achieved slightly smaller load impacts than that of the $0.60 per kWh incentive group at 0.15 (10.3%) and 0.18 (11.5%). Overall, the combined incentive test population achieved load impacts of 0.23 kW or 10.7%, with the largest impacts seen in the single-family gas heat segment at 0.31 kW (11.5%) and the smallest impacts in multi-family unknown heat segment at 0.13 kW (8.6%).

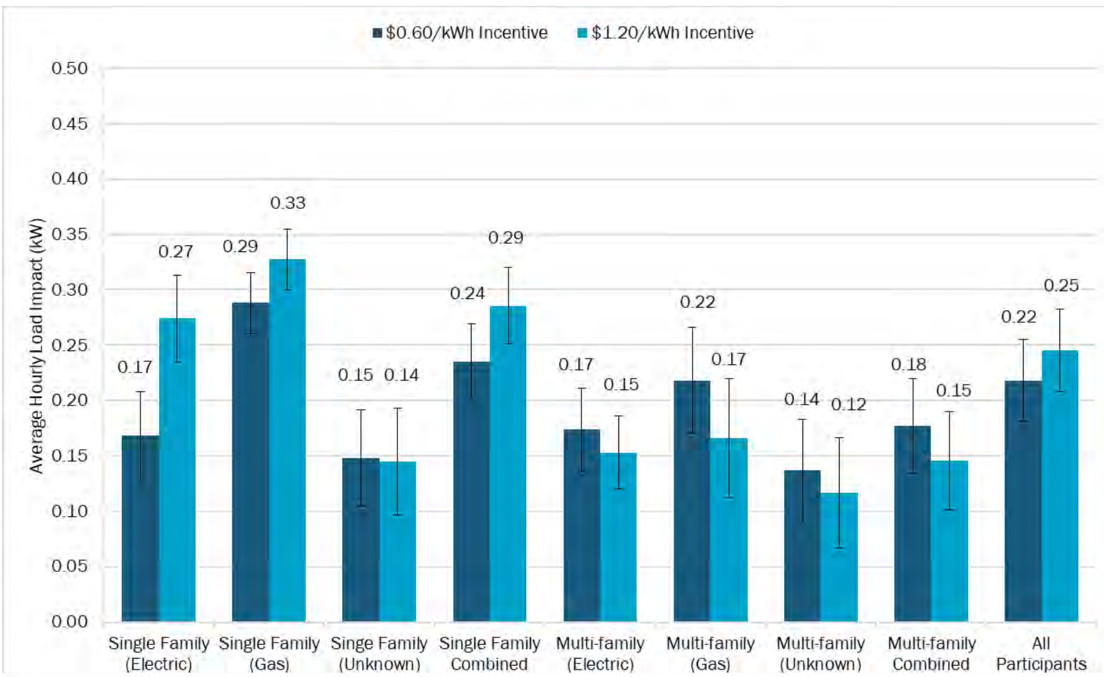
Table 3-3: Average Hourly Load Impact (kW) Comparison Across Incentives (Summer 2022)

Customer Segment	$0.60/kWh Incentive		$1.20/kWh Incentive		All Incentive Test	
	Impact (kW)	Impact (%)	Impact (kW)	Impact (%)	Impact (kW)	Impact (%)
Residential Single Family Combined	**0.24**	**9.5%**	**0.29**	**11.9%**	**0.26**	**10.7%**
Residential Single Family (Electric Heat)	0.17*	8.0%*	0.27*	13.2%*	0.22	10.7%
Residential Single Family (Gas Heat)	0.29	10.6%	0.33	12.4%	0.31	11.5%
Residential Single Family (Unknown Heat)	0.15	6.6%	0.14	7.2%	0.15	6.9%
Residential Multi-family Combined	**0.18**	**11.5%**	**0.15**	**10.3%**	**0.16**	**10.9%**
Residential Multi-family (Electric Heat)	0.17	12.5%	0.15	12.1%	0.16	12.3%
Residential Multi-family (Gas Heat)	0.22	12.7%	0.17	9.3%	0.19	11.1%
Residential Multi-family (Unknown Heat)	0.14	8.4%	0.12	8.8%	0.13	8.6%
All Events Participants	**0.22**	**9.9%**	**0.25**	**11.6%**	**0.23**	**10.7%**

* Indicates a statistically significant difference between the $0.60 and $1.20 group load impacts.

Figure 3-4 displays the magnitude and statistical significance of each of the six customer classes, as well as that of all participants, all single-family, and all multi-family groups separated by incentive level. The 90% confidence interval is displayed for each group of customers as an error bar over their impact. If the error bar crosses zero, the impact is not statistically significant from zero at the 90% level of confidence. All customer classes display statistical significance. In the single-family electric segment, the higher incentive level produced larger load impacts. Comparing between the two incentive groups, this is the only segment that displays a statistically significant difference between observed load impacts. However, in the multi-family segment, the lower incentive level produced larger load impacts, although the difference between the two incentive levels is not statistically significant. See Figure 3-8 for additional details at the individual event day level to further explore drivers for this observed outcome.

Figure 3-4: Average Hourly Load Impact (kW) by Customer Class (Summer 2022)



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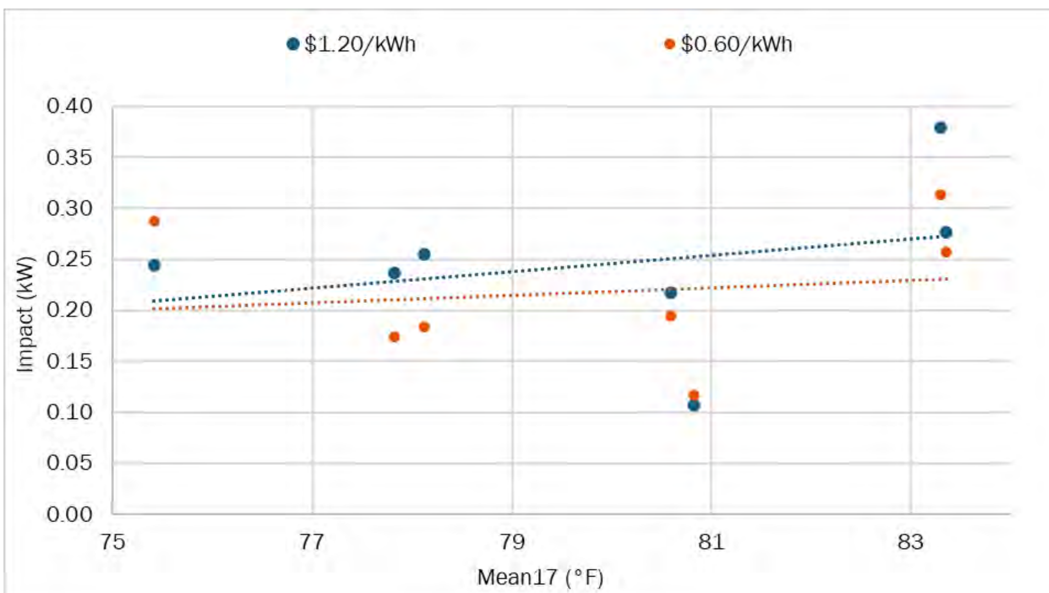
To examine how event day temperature may impact load impacts, Figure 3-5 compares the kW impacts from each of the seven event days with the weather variable *mean17*, which represents the average hourly temperature between midnight and 5 PM. This variable captures the heat buildup overnight and is strongly correlated with weather-sensitive premise-level consumption data. Therefore, it is helpful in predicting premise-level energy usage, particularly for customers with air conditioning. This figure shows that Summer 2022 events were generally called on warm days but also included some hotter days. The figure displays a weak but noticeable relationship between *mean17* temperature buildup on event days and load impacts. The incentive levels are separated out on the Figure to further examine the impact of incentive level on event response. The $1.20 per kWh incentive level shows a slightly stronger positive correlation between *mean17* and average hourly load impact. The July 6th event had unusual weather, yielding relatively low load impacts. This event is reflected in the two dots just below 81°F and just above 0.10 kW. While July 6th had a moderately high *mean17,* the temperature dropped by over 20°F just prior to the event. Impacts for each of the events conducted in Summer 2022 are covered in greater detail in the following section.

Figure 3-5: Comparison of kW Impact and Average Hourly Temperature (°F) between Midnight and 5 PM (Mean17)



Load Impacts by Event Day

Figure 3-6 and Figure 3-7 show the average hourly load impact for single-family and multi-family customers for each event. The events are broken into two figures with the first reflecting the $0.60 per kWh incentive level and the second reflecting the $1.20 per kWh incentive level. Error bars represent the 90% confidence interval. When the black bars cross zero on the y-axis, the results are not statistically different from zero with 90% confidence, and therefore are insignificant. For $0.60 per kWh incentive customers, the largest impacts are observed on the first event day (6/14/2022) in both the single-family and multi-family segments at 0.32 kW and 0.29 kW, respectively. The second-largest event impacts are observed on the third event (6/21/2022) in both single- and multi-family segments at 0.30 kW and 0.26 kW. The smallest event impacts were observed on the fourth event (7/6/2022) in both segments at 0.12 kW and 0.10. The multi-family segment impacts are not statistically significant on 7/6/2022 and load shape and temperature suggest there may have been a storm on that event date, while single-family impacts were statistically significant on all event days.

Figure 3-6: Average Hourly Load Impact per Customer - $0.60 per kWh

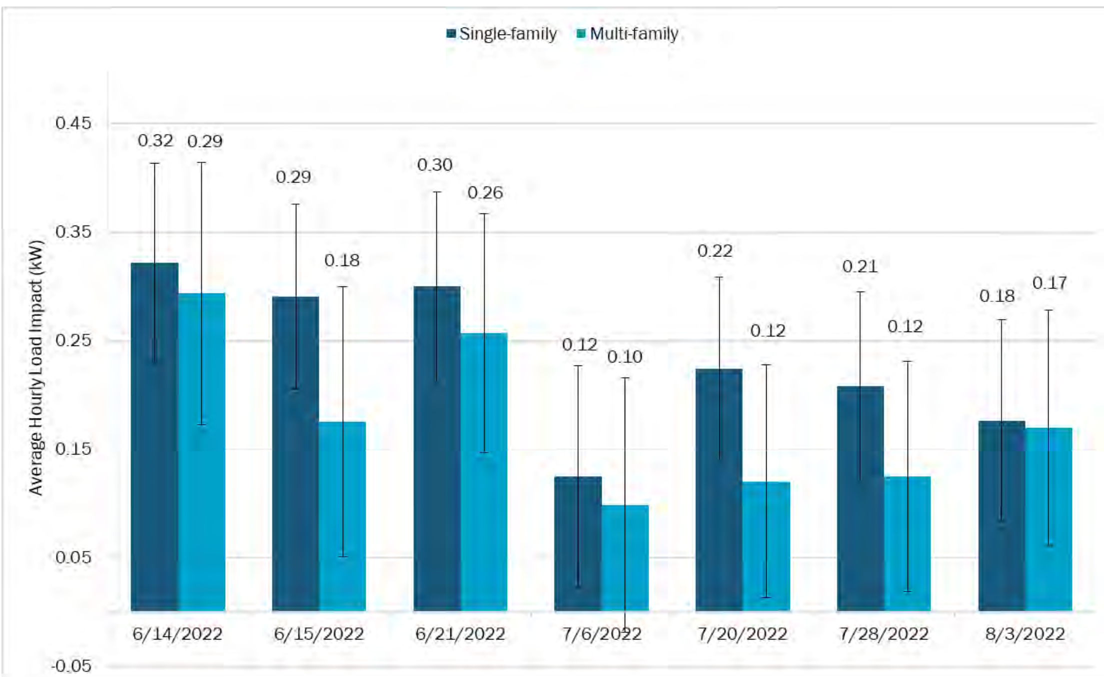
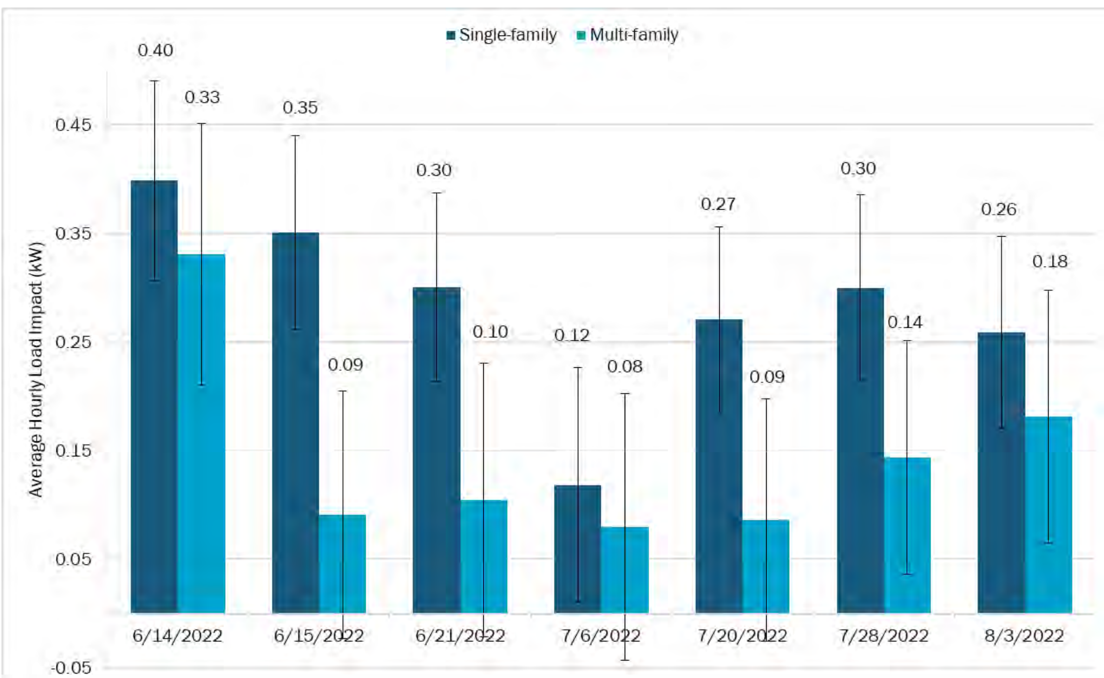


Figure 3-7 displays the average hourly load impact for single-family and multi-family customers for each event for the $1.20 per kWh incentive level customers. The higher incentive group follows a similar pattern to that of the $0.60 per kWh incentive customers, with the largest impacts are observed on the first event day (6/14/2022) in both the single-family and multi-family segments at 0.40 kW and 0.33 kW. The second-largest single-family event impacts are observed on the second event (6/15/2022) at 0.35 kW. The third greatest event impacts for single-family customers were observed on the third and sixth events (6/21/2022 and 7/28/2022) at 0.30 kW, while the second largest event impacts for multi-family customers were observed on the last event date (8/3/2022) at 0.18 kW. The smallest event impacts for both segments were observed on the fourth event (7/6/2022) in both segments at 0.12 kW and 0.08. The multi-family segment impacts are not statistically significant on the second, third, fourth, and fifth events while single-family impacts were statistically significant on each of the seven event days.

Figure 3-7: Average Hourly Load Impact per Customer - $1.20 per kWh



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To further investigate the reversal of trend in the load impacts among the multi-family segments, Figure 3-8 displays the average hourly load impact for the multi-family combined segment by event date and incentive level. The June 15th and 21st events appear to be the main drivers of the relatively smaller load impacts among multi-family $1.20 per kWh incentive participants. The impacts for these event dates are not statistically significant for the $1.20 per kWh incentive group when evaluated alone. During three of the event days, the $1.20 per kWh incentive multi-family combined segment had statistically significant load impacts that were higher than the $0.60 per kWh incentive multi-family combined segment, while on four event days, the $1.20 kWh incentive multi-family combined segment had lower impacts that were not statistically significant. The difference in average hourly load impacts between the two incentive groups are not statistically significant on any event day. Overall, the multi-family segments have smaller sample sizes than their single-family counterparts which could be driving noise in the data.

Figure 3-8: Average Hourly Load Impact (kW) Multi-family Segment by Event and Incentive

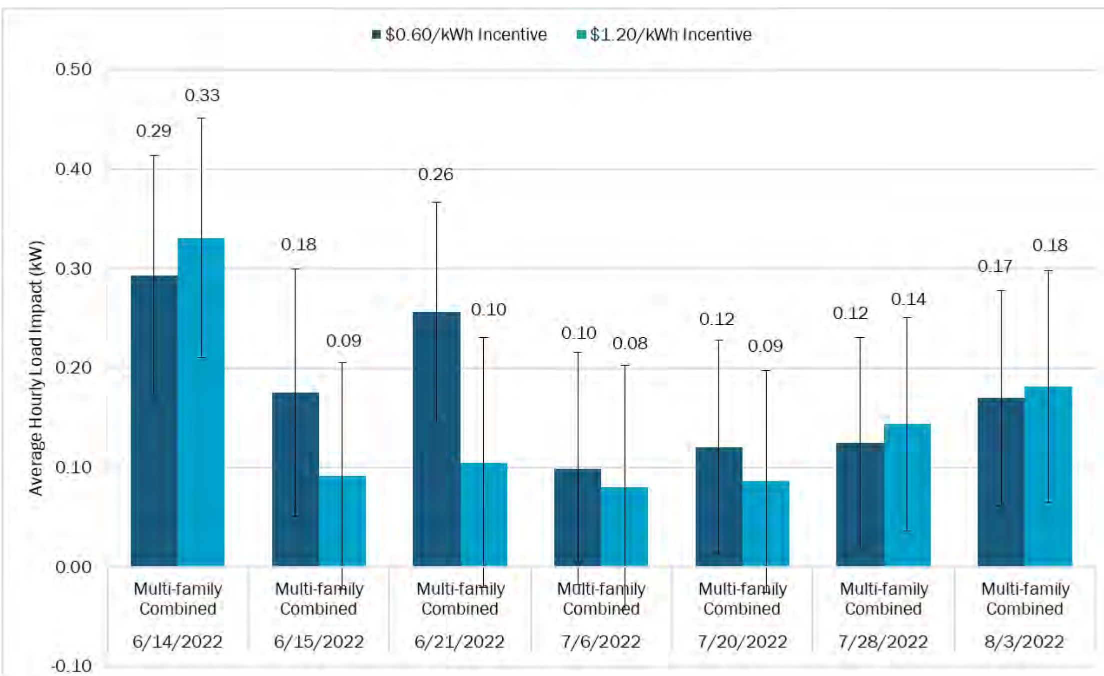

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Figure 3-9 displays the average hourly load impact for the single-family combined segment by event date and incentive level. Customers receiving $1.20 per kWh had higher load impacts than customers receiving $0.60 per kWh on all event days except for the July 7th event, although the difference in single-family load impacts by event day between incentive levels is never statistically significant.

Figure 3-9: Average Hourly Load Impact (kW) Single-family Segment by Event and Incentive

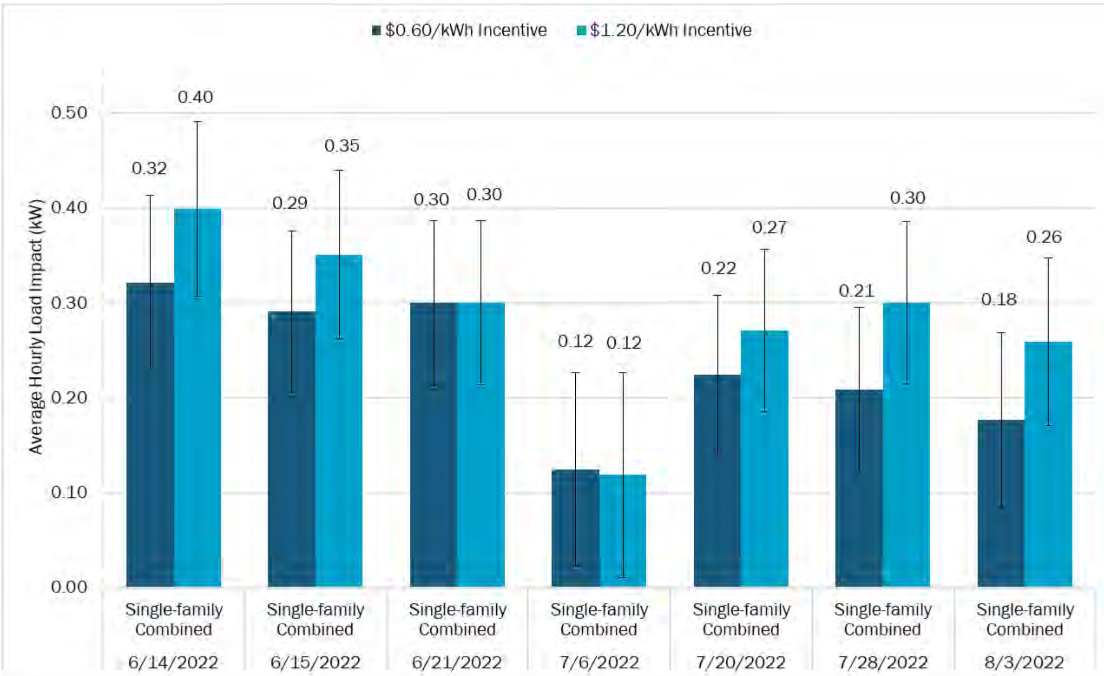

Table 3-4 and Table 3-5 display summaries of all seven Summer 2022 PTC Pilot events. Table 3-4 presents the results for the $0.60 per kWh incentive level customers while Table 3-5 presents results for the $1.20 per kWh incentive level customers. Each event's average event period temperature, control load, treatment load, average hourly load impact per customer, percentage impact, and 5th and 95th percentiles are displayed. Across all participants receiving $0.60 per kWh, all daily event impacts were statistically significant at the 90% confidence level. The largest impacts in magnitude and percentage were seen on June 14th, the hottest event day with an event period temperature of 94 °F, at 0.31 kW or 12.7%. The average event day had an event period temperature of 86.8 °F and impacts of 0.22 kW or 9.9%. Variation in magnitude and percentage impact is highly dependent on reference load and temperature.

Table 3-4: Average Hourly Load Impact by Event Day (Summer 2022) - $0.60 per kWh

Event Date	Event Temp.	Load w/o DR (kW)	Load w/ DR (kW)	Impact (kW)	Impact (%)	5th Percentile	95th Percentile
6/14/2022	93.0	2.46	2.14	0.31	12.7%	0.21	0.41
6/15/2022	90.3	2.47	2.21	0.26	10.4%	0.16	0.36
6/21/2022	90.8	2.17	1.88	0.29	13.3%	0.19	0.38
7/6/2022	75.3	1.60	1.48	0.12	7.3%	0.01	0.22
7/20/2022	90.8	2.41	2.21	0.19	8.1%	0.10	0.29
7/28/2022	85.5	2.09	1.91	0.18	8.8%	0.09	0.28
8/3/2022	82.3	2.26	2.09	0.17	7.7%	0.08	0.27
Avg. Event	**86.8**	**2.21**	**1.99**	**0.22**	**9.9%**	**0.18**	**0.26**

Across all participants receiving $1.20 per kWh, all daily event impacts except for July 6 were statistically significant at the 90% confidence level. Like the $0.60/kW incentive group, the largest impacts in magnitude and percentage were seen on June 14th, the hottest event day, at 0.38 kW or 15.8%. The average event day had an event period temperature of 86.8 °F and impacts of 0.25 kW or 11.6%. Notably, participants receiving a $1.20 per kWh incentive had larger load impacts in magnitude than those receiving $0.60 per kWh on all event days except June 21st, despite having a lower reference load on all event days.

Table 3-5: Average Hourly Load Impact by Event Day (Summer 2022) - $1.20 per kWh[5]

Event Date	Event Temp.	Load w/o DR (kW)	Load w/ DR (kW)	Impact (kW)	Impact (%)	5th Percentile	95th Percentile
6/14/2022	93.0	2.40	2.02	0.38	15.8%	0.28	0.48
6/15/2022	90.3	2.39	2.11	0.28	11.6%	0.18	0.37
6/21/2022	90.8	2.06	1.82	0.24	11.9%	0.15	0.34
7/6/2022	75.3	1.48	1.37	0.11	7.3%	0.00	0.22
7/20/2022	90.8	2.32	2.11	0.22	9.4%	0.12	0.31
7/28/2022	85.5	2.01	1.75	0.26	12.7%	0.16	0.35
8/3/2022	82.3	2.17	1.93	0.24	10.9%	0.14	0.33
Avg. Event	**86.8**	**2.12**	**1.87**	**0.25**	**11.6%**	**0.21**	**0.28**

[5] Cells shaded in blue denote results that were not statistically significant at the 90% confidence level.

Figure 3-10, Figure 3-11, and Figure 3-12 show the average per-customer load with demand response, load without demand response (reference load), load impact, and hourly temperature for the average event day for all PTC incentive test participants, the $0.60 incentive participants, and the $1.20 incentive participants, respectively. Very little, if any, "snapback" occurred after the completion of each event. Snapback is defined as customer energy usage being higher after an event than what would be expected if an event had not taken place. For example, snap-back sometimes occurs if customers turned off their ACs or set their thermostats higher during the event and consequently the temperature inside the house increased. At the end of the event, the AC will sometimes need to run more than usual in order to bring the inside temperature back to within the customers' preferred range; assuming the thermostat is returned to its pre-event setting shortly after the event concludes. This can result in increased load in the hours following an event compared to what would typically be expected on a similar non-event day.

Figure 3-10 shows the average load profile for all PTC incentive test participants ($0.60 per kWh and $1.20 per kWh combined) across all Summer 2022 event days. The average load without DR during all event hours was 2.16 kW. The average load with DR during event hours was around 1.93 kW. This resulted in an average load reduction of 0.23 kW per customer, or a 10.7% reduction relative to the reference load. Average event temperature was 86.82° F.

Figure 3-10: Average Hourly Load Impacts per Customer on Average Event Day (Summer 2022)

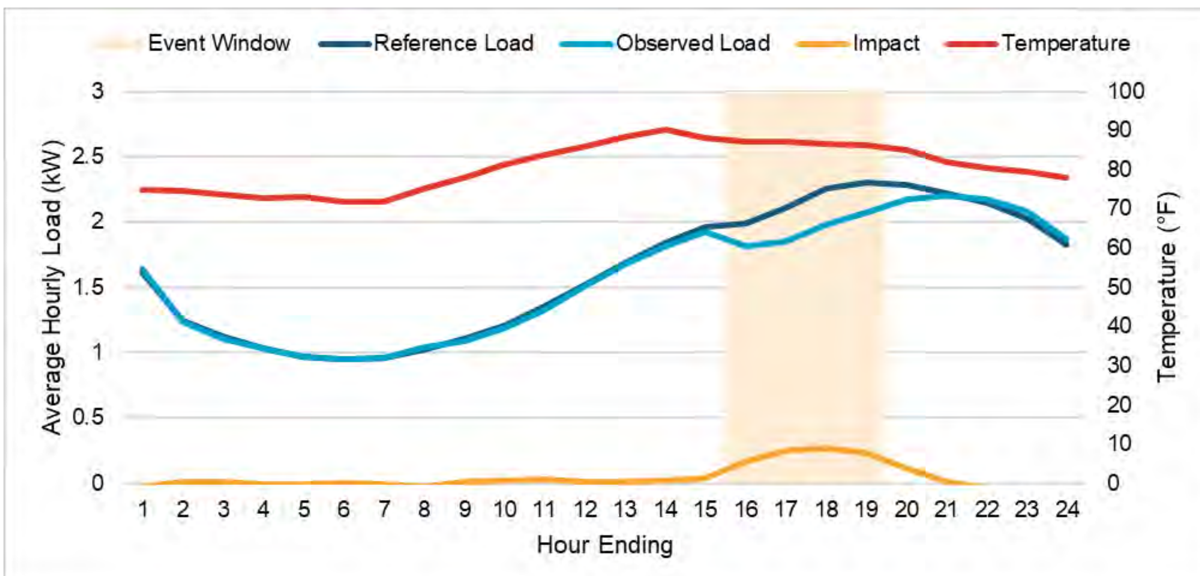

Figure 3-11 shows the average load profile for the $0.60 per kWh incentive level participants and Figure 3-12 shows the average load profile for the $1.20 per kWh incentive level participants across all Summer 2022 events. Average load without DR during all event hours for the $0.60 per kWh incentive participants was 2.21 kW, and 2.12 kW for the $1.20 per kWh participants, indicating the $0.60 and $1.20 participants were similar to each other. The average load with DR during event hours for the $0.60 per kWh participants was 1.99 kW, and 1.87 kW for the $1.20 per kWh participants. Average load reductions of 0.22 kW (9.9%) for the $0.60 per kWh participants and 0.25 kW (11.6%) for the $1.20 per kWh incentive participants were observed.

Figure 3-11: Average Hourly Load Impacts per Customer on Average Event Day (Summer 2022) - $0.60 per kWh Incentive

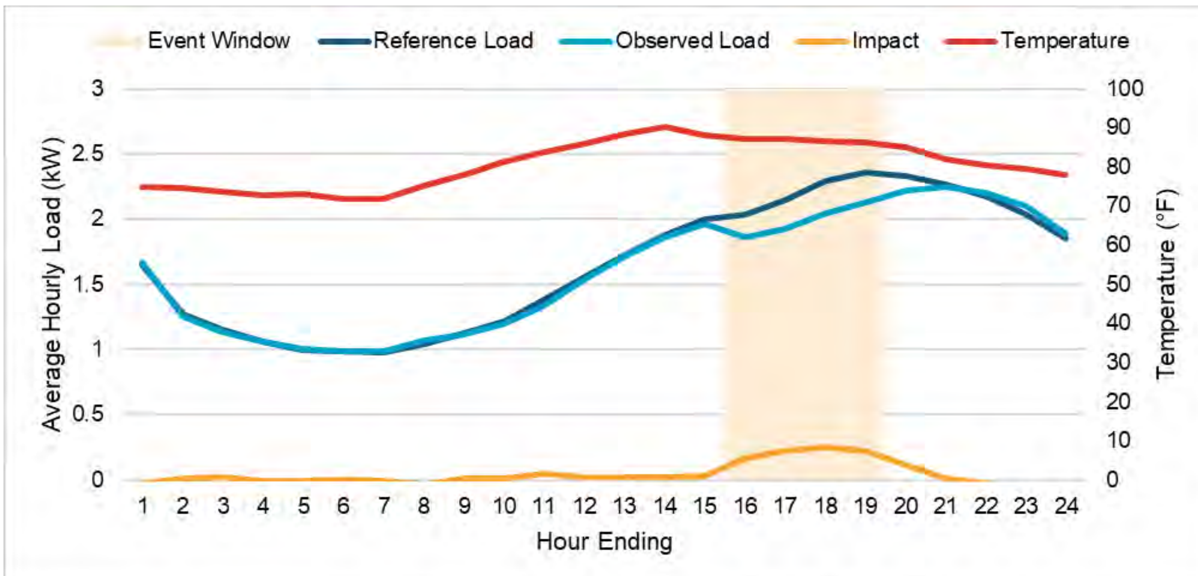

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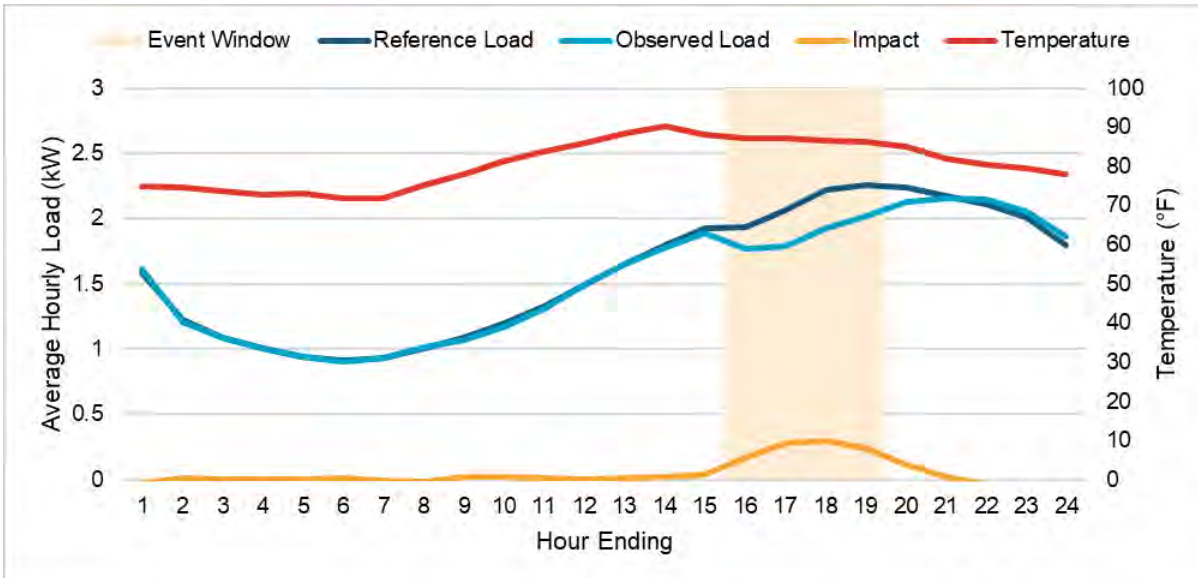
Figure 3-12: Average Hourly Load Impacts per Customer on Average Event Day (Summer 2022) - $1.20 per kWh Incentive



3.3 Load Impacts Comparison with Original Participants

Original group participants produced significant responses to events throughout the past four event seasons Summer 2022, Summer 2021, Winter 2021, and Summer 2020. In Summer 2022, a new subset of participants was tested to determine the impact of different incentive levels on load impacts. Incentive test customers received either $0.60 per kWh or $1.20 per kWh. In Summer 2022, seven events were called between 3 PM – 7 PM for incentive test customers and three events were called between 3 PM – 7 PM for original Pilot participants. Summer 2021 had sixteen events called between 3 PM – 7 PM. Winter 2021 had two events called between 6 AM – 10 AM and Summer 2020 experienced two events called between 3 PM – 7 PM. Table 3-6 displays average hourly load impacts per customer, by event season. On the three event days that overlapped with the Original Participants the Incentive Test customers provided an overall average hourly load impact per customer in Summer 2022 of 0.27 kW or 11.5% while participants receiving $0.60 per kWh provided a reduction of 0.25 kW (10.3%) and participants receiving $1.20 per kWh provided a 0.30 kW reduction (12.8%).

For original Pilot participants, average hourly load impacts per customer during the Summer 2022 season were 0.15 kW or 6.0%. Average hourly impacts per customer during the Summer 2021 events were 0.14 kW or 6.1% while Summer 2020 impacts were much larger at 0.38 kW or 15.4%. Average hourly impacts per customer across the two Winter 2021 events were 0.12 kW or 5.6%. Original participants began their participation in the Pilot during the COVID-19 pandemic, which may have contributed to the large load impacts estimated during the Summer 2020 season. While original participants load impacts are smaller than in the first season, they have remained similar in the last three event seasons.

Incentive test participants also produced relatively large load impacts in their first event season, Summer 2022. Note that original participants were only called for a subset of Summer 2022 events. Differences in temperature and reference load also impact average hourly load impacts displayed below, through time.

Table 3-6: Summary of Average Hourly Load Impacts by Season[6]

Season	Load w/o DR* (kW)	Load w/ DR (kW)	Impact (kW)	Impact (%)
Summer 2022 $0.60/kWh Participants	2.40	2.15	0.25	10.3%
Summer 2022 $1.20/kWh Participants	2.32	2.02	0.30	12.8%
Summer 2022 All Incentive Test Participants	2.36	2.08	0.27	11.5%
Summer 2022 Original Participants	2.53	2.38	0.15	6.0%
Summer 2021 Original Participants	2.37	2.22	0.14	6.1%
Winter 2021 Original Participants	2.04	1.93	0.12	5.6%
Summer 2020 Original Participants	2.49	2.11	0.38	15.4%

*DR represents Demand Response, or a PTC event.

[6] Impacts from the Summer 2022 are limited to the three common event days to allow for a direct comparison between Incentive Test Participants and Original Participants. Impacts from 2021 and 2020 reflect all events from each season.

3.4 Load Impact Conclusions

Key findings pertaining to load impacts from the Pilot include:

- Statistically significant load impacts were detected across both incentive levels for customers in Single-family and Multi-family homes.
- At the population level, participants receiving the $1.20 per kWh incentive had slightly larger load impacts (0.25 kW) than participants receiving $0.60 per kWh (0.22 kW), however the difference in impacts were not statistically significant.
- At the population level, participants receiving the $1.20 per kWh incentive had slightly lower reference loads than that of participants receiving $0.60 per kWh though the difference was not statistically significant.
- Single-family participants receiving $1.20 per kWh consistently provided larger load impacts (0.29 kW) than single-family participants receiving $0.60 per kWh (0.24 kW), though the difference was not statistically significant. Multi-family participants receiving $1.20 per kWh provided smaller load impacts (0.15 kW) than multi-family participants receiving $0.60 per kWh (0.18 kW) at the segment level, however the difference was not statistically significant.
- As Summer 2022 was incentive test participants first event season, impacts were larger than that of original participants on the three common event days in Summer 2022, their fourth event season. This is consistent with what was observed in the original pilot population in prior seasons, with their first event season (Summer 2020) producing load impacts 2.7 times larger than that of Summer 2021.
- Original participants' load impacts were comparable in Summer 2022 to Summer 2021 at the population level.

4 Process Evaluation

Leveraging insights from the impact evaluation, Resource Innovations' process evaluation goals were to develop insights into the pilot's strengths and weaknesses, to identify opportunities for improving pilot operations, and to identify any other additional measures or other strategies that Duke Energy can adopt that are likely to increase the effectiveness of Peak Time Credit if it is continued. More specifically, the survey data collection strategy was designed towards answering the following research questions which are consistent with those required in this study:

- Does the Pilot's bill credit motivate behavior change? Does it vary by incentive level?
- Did event notifications reach the customer such that they could effectively respond to the event?
- What were the most common actions participants are taking to reduce usage during events? Does it vary by incentive level?
- What were the most common reasons or barriers participants are giving for not reducing usage during events? Does it vary by incentive level?
- What enhancements should be made to the Pilot from participants perspective? Do the enhancements suggested vary by incentive level?
- How satisfied were participants with the Pilot? Does it vary by incentive level?

Resource Innovations addressed these research questions by collecting data from participants through a post-event survey. The results from these post-event surveys are presented in the following subsections.

4.1 Post-Event Survey

Resource Innovations fielded a post-event survey for PTC Pilot participants about their experience following a Peak Day event. This survey aimed to obtain feedback from participants to estimate awareness of the event and to collect information on actions customers took to reduce load and their motivations for those actions. The post-event survey also collected information on participants' assessment and opinions on Duke Energy's role in empowering and motivating participants to reduce load, in addition to educating participants on how the Pilot works. The post-event survey also assessed satisfaction with the bill credit offering, with the event notification process, and of the pilot overall. In conjunction with the survey results, the Resource Innovations team's process evaluation focused on the comparison of the post-event survey responses of participants who received a $0.60 per kWh bill credit and participants who received a $1.20 per kWh bill credit.

The post-event survey was conducted following the Peak Day event that occurred in the afternoon on August 3rd, 2022. PTC incentive test participants were sent emails to complete the survey on the web and received follow-up phone calls providing them with the opportunity to complete the survey over the phone. The survey completion rates are shown in Table 4-1. In total, 221 out of the 662 customers in the $0.60 per kWh incentive group responded to the survey yielding a response rate of 33.4%. Out of the participants in this group who completed the survey, 155 responded on the web and 66 responded over the phone. For the $1.20 per kWh incentive group, 261 out of the 660 customers responded to the survey yielding a response rate of 39.5%. These response rates are relatively high for a Pilot participant survey, suggesting that Peak Time Credit participants are engaged and willing to provide feedback to Duke Energy. Out of the participants in this group who completed the survey, 191 responded on the web and 70 responded over the phone. The survey was open from August 10th, 2022, to August 21st, 2022.

Table 4-11: Survey Completion Rates by Method

Group	Event Date	Event Start Time	Event Finish Time	Survey Start	Survey Close	Phone Responses	Web Responses	Number of Responses	Valid Response Rate
$0.60/kWh	8/3/2022	3:00 PM	7:00 PM	8/10/2022	8/21/2022	66	155	221	33.4%
$1.20/kWh						70	191	261	39.5%

Survey questions covered the following main topics:

- Participation Awareness and Motivation
- Peak Time Credit Event Awareness and Notification Satisfaction
- Responding to Peak Time Credit Events
- Satisfaction with the Peak Time Credit Pilot and Incentive Test

Participation Awareness and Motivation

Peak Time Credit participants were first asked if they recalled their participation in the Pilot. For the 2022 survey, 99.6% of the full set of respondents were aware of their participation in the Pilot. Furthermore, all the $0.60 per kWh incentive respondents recalled their participation while 99.2% of $1.20 per kWh incentive customers recalled their participation.

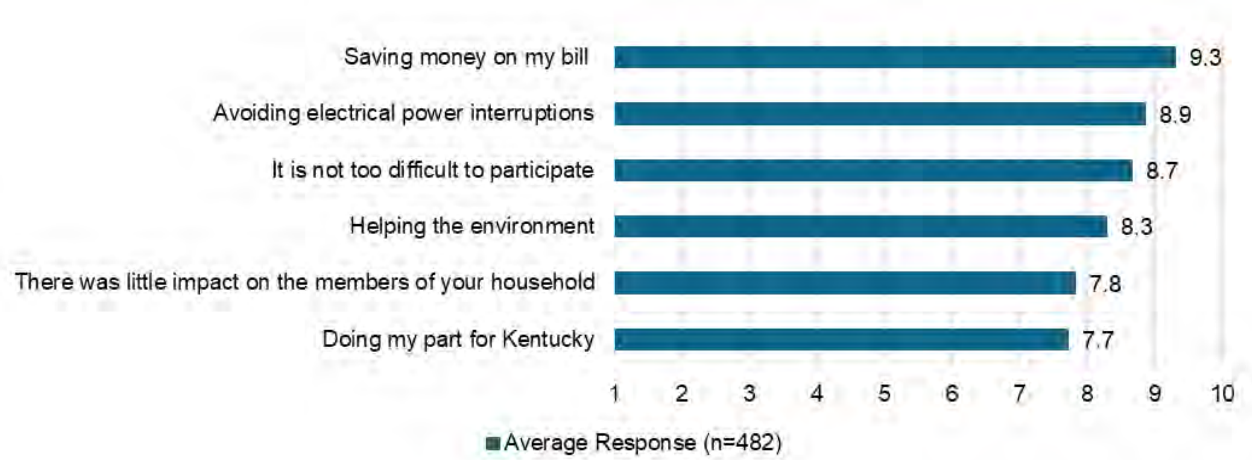
This question was followed by asking participants if they had recalled a Peak Day event happening in the past month. Overall, 82.4% of respondents recalled that an event occurred with 84.2% of the $0.60 per kWh incentive respondents recalling the event and 80.8% of the $1.20 per kWh incentive respondents recalling the event. These results are shown in Table 4-2. The difference in percentage of respondents that recalled the event between the $0.60 per kWh group and the $1.20 per kWh group is not statistically significant at a 90% confidence level.

Table 4-2: Participants Who Recalled a Peak Day Event

Group	Yes	No	Don't Know	Refused
$0.60 per kWh (n=221)	84.2%	4.5%	11.3%	0.0%
$1.20 per kWh (n=261)	80.8%	5.8%	13.0%	0.4%
Total (n=482)	**82.4%**	**5.2%**	**12.2%**	**0.2%**

Participants were asked to rate how important potential benefits were to their decision to participate in the Pilot. The potential benefits were rated on a scale from 1 to 10 with 10 being "extremely important" and 1 being "not at all important". As shown in Figure 4-1, the most motivating potential benefit is the financial incentive which had an average rating of 9.3. The second most influential benefit is the avoidance of electrical power interruptions which had an average rating of 8.9. There were no statistically significant differences in ratings between the two incentive groups.

Figure 4-1: Participant Motivation Ratings



Peak Time Credit Awareness and Notification Satisfaction

The next group of questions was related to the notification methods that Duke Energy used to alert Pilot participants about the event. Participants who recalled a Peak event occurring were asked what method Duke Energy used to notify them of the event. Recalled notification methods are recorded in Table 4-3 where the majority of all participants (73.2%) said that they recalled an email from Duke Energy to alert them of the Peak Day event. Furthermore, a sizeable proportion of participants were notified by text (13.1%) or noticed that it was a hot day (12.5%). All other notification methods were recalled by less than 1% of the participants. The differences between the $0.60 per kWh and $1.20 per kWh groups were not statistically significant at a 90% confidence level.

Table 4-3: Peak Event Notification Method (n=397)

Group	I got an email from Duke	I got a text from Duke	It was a hot day	Some other way	I saw it on Duke Energy's website	Heard about it from someone I know	I got a phone call from Duke
$0.60/kWh	69.7%	12.9%	15.8%	1.2%	0.0%	0.0%	0.4%
$1.20/kWh	76.6%	13.3%	9.4%	0.0%	0.4%	0.4%	0.0%
Total	**73.2%**	**13.1%**	**12.5%**	**0.6%**	**0.2%**	**0.2%**	**0.2%**

The survey also presented the respondents who were notified by text or email with various statements about the notification method. As shown in Table 4-4, the participants overwhelmingly agreed with statements saying that Duke Energy notified them in a timely manner, provided them with helpful information, and gave them confidence of which hours they can earn credits on Peak Days. The average ratings of customers in the $1.20 per kWh incentive group were consistently higher than those in the $0.60 per kWh incentive group but were not statistically significant except for one question. Participants in the $1.20 per kWh group gave statistically significantly higher ratings (with 90% confidence) for the timeliness of the peak day notification than those in the $0.60 per kWh group.

Table 4-4: Participant Agreement with Statements Concerning the Notification Method

How much do you agree with the following…	Average Rating		
	$0.60/kWh (n = 183)	$1.20/kWh (n = 206)	Total (n = 389)
The timeliness of the peak day notification	9.0	9.3	9.2
Duke Energy has given me helpful information on how to respond to Peak Days	8.8	9.0	8.9
I feel confident that I know which hours of the day I can earn credits during Peak Days	9.4	9.6	9.5

* Blue shaded cells are responses which are statistically different between the $0.60 per kWh and $1.20 per kWh incentive groups at the 90% level

Participants who recalled being notified by an email, text, or phone call were asked if Duke Energy notified them through their preferred communication channel. As shown in Table 4-5, 87.9% of participants were notified by their preferred communication channel. Those who were not notified by their preferred channel generally would have rather been notified by text or email. The differences between the $0.60 per kWh and $1.20 per kWh group were not statistically significant.

Table 4-5: Were you notified through your preferred communication channel?

Group	Yes	No; prefer email	No; prefer text	No; prefer phone call	Don't know
$0.60/kWh (n=183)	86.9%	5.5%	7.1%	0.0%	0.5%
$1.20/kWh (n=206)	88.8%	4.4%	5.8%	0.0%	1.0%
Total (n=389)	**87.9%**	**4.9%**	**6.4%**	**0.0%**	**0.8%**

Response to Peak Time Credit Event

The next section in the survey asked participants about how they responded to the August 3rd, 2022, event. These questions were only asked to participants who had recalled that there was an event in the past month (82.4% of respondents), as they would have not had the opportunity to respond to the event if they did not know it happened. The first question asked participants if they were home during the Peak Day event. The responses are recorded in Table 4-6, which shows that most of the participants reported that they were home during the event. Furthermore, customers in the $0.60 per kWh incentive group were home more frequently than those in the $1.20 per kWh group. The portion of respondents that were home during the event is statistically significant at the 90% confidence level between participants receiving $0.60 per kWh and those receiving $1.20 per kWh.

Table 4-6: Was the Participant Home During the Peak Time Credit Event?

Group	Yes	No
$0.60/kWh (n=186)	84.9%	15.8%
$1.20/kWh (n=211)	76.7%	23.3%
Total (n=397)	**80.6%**	**19.4%**

* Blue shaded cells are responses which are statistically different between the $0.60 per kWh and $1.20 per kWh incentive groups at the 90% level

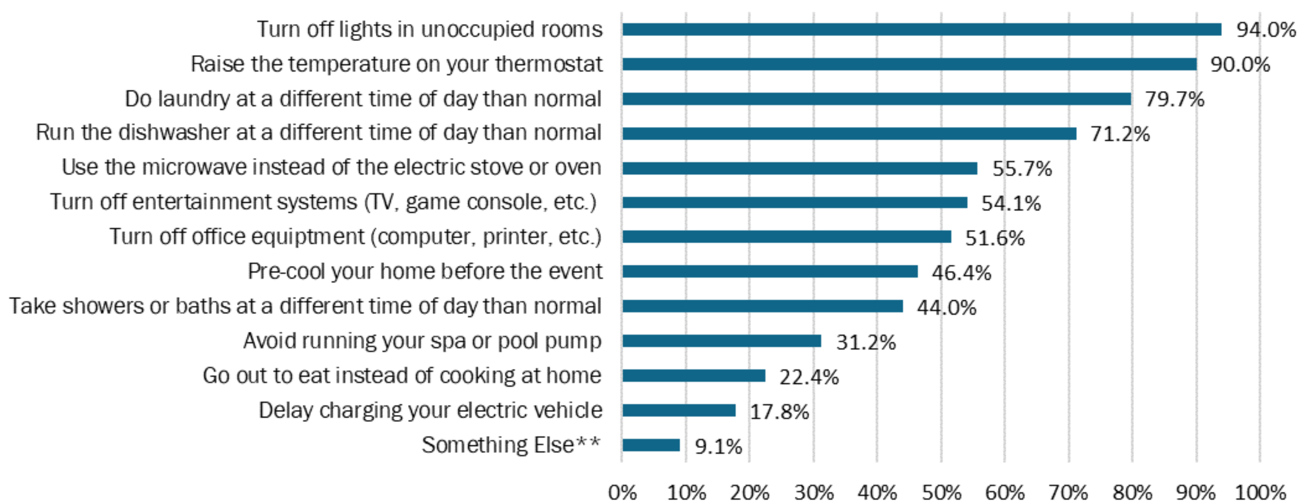
The same participants were later asked if they took action to lower their electricity usage during the Peak Time Credit event. The responses and accompanying bill credit incentives are presented in Table 4-7. Most of the participants responded that they did take action to reduce electricity usage during the peak times. Slightly more $1.20 per kWh incentive participants reported taking action but the difference between the groups is not statistically significant at the 90% confidence level.

Table 4-7: Did the Participant Take Action to Reduce Electric Usage During the Peak Time Credit Event?

Group	Yes	No
$0.60/kWh (n=186)	84.3%	15.7%
$1.20/kWh (n=211)	85.2%	14.8%
Total (n=397)	**84.8%**	**15.2%**

Participants who responded that they took action during the Peak Day event were presented with various actions that they may have taken to reduce electric usage during Peak Day events and asked to identify which actions they took. Figure 4-2 presents their responses. The most cited action was turning off lights in unoccupied rooms with 94% of participants responding that they took this action. The second most cited action was raising the temperature on their thermostat, with about 90% of participants saying they took this action. Participants were also able to provide their own response about what actions they took that were not originally listed in the survey, the most common free response was from customers saying they unplugged other appliances. For the non-free responses, there were no statistically significant differences between the two incentive groups in terms of recalled actions taken.

Figure 4-2: Recalled Actions Taken by Participants to Reduce Electric Usage During the Peak Day Event (n=335)



** Asterisks represent statistical significance difference between the $0.60 per kWh and $1.20 per kWh incentive groups at the 90% level

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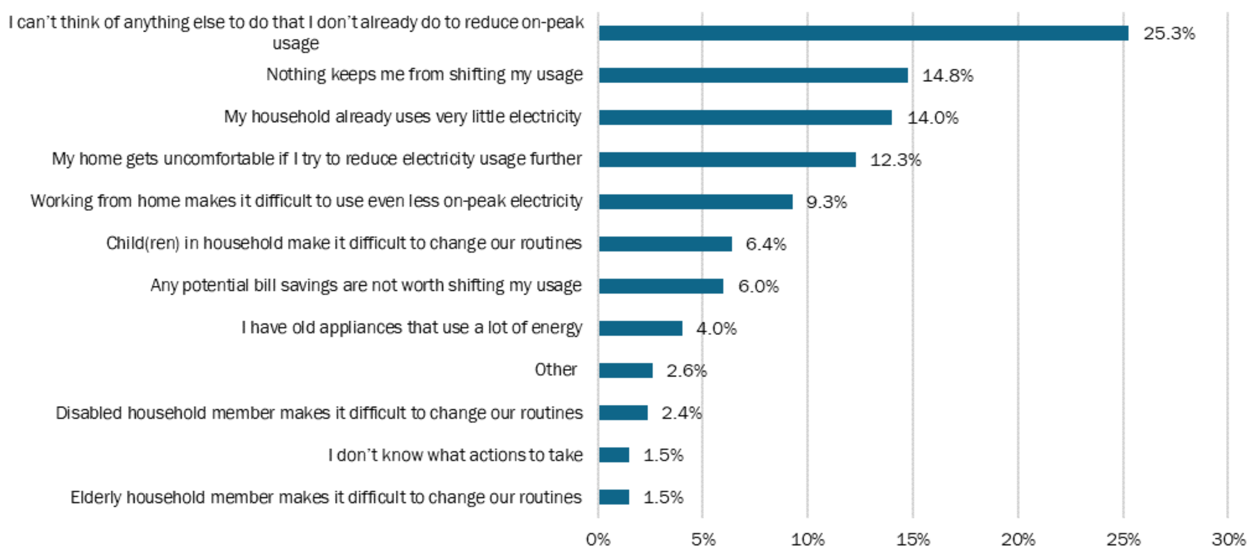
The final question in the event response section asked all participants what challenges they faced when they were reducing usage during any of the Peak Day events over the summer. Participants reported that it is generally easy for them to take action during Peak Day events with the average customers rating the ease of response being 8.5 out of 10. There was not a statistically significant difference (with 90% confidence) in the responses between the $0.60 per kWh and $1.20 per kWh groups. As shown in Figure 4-3 most customers said that they did not have many challenges in reducing their electricity during peak times with a plurality of participants reporting that they couldn't think of any other actions to reduce usage (25.3%), nothing stopped them from shifting usage (14.8%), or their household already uses very little electricity during peak hour (14.0%). The most commonly reported challenges were that participants at home would get uncomfortable if they reduced usage further (12.3%) and working from home limits the amount a customer can reduce their usage (9.3%). About 3% of participants stated "Other" which includes being away from guests, pet's comfort, and poor insulation.

Figure 4-3: Which of the Following Made it Difficult to Reduce Electricity Usage During Peak Day Events? (n=482)



Satisfaction with Peak Time Credit and Incentive Test

The next section in the survey presented various questions to Pilot participants and asked them how much they agreed with the statements on a scale from 1 to 10, with 1 meaning "Do not agree at all" and 10 meaning "Completely agree". Responses and the customers' associated incentive group are recorded in Table 4-8, participants generally agreed that the Pilot was easy to understand, the number of Peak Days is reasonable and the Peak Days work with their household schedule. Participants in the $1.20 per kWh group reported that they were more likely to recommend the Pilot than participants from the $0.60 incentive group at 8.6 and 8.1 out of 10, respectively. The Net Promoter Score[7] for the $0.60 per kWh group is 38.4 while the Net Promoter Score for the $1.20 per kWh group is 53.7. The Net Promoter group for the full set of customers is 46.7. The difference between groups was statistically significant at a 90% level of confidence. Similarly, customers in the $0.60 per kWh group agreed significantly more than the $1.20 per kWh group that they would make additional efforts to reduce Peak Day usage if the bill credit was greater at 9.3 and 8.7 out of 10, respectively.

Table 4-8: Participant Agreement with Provided Statements by Incentive Group

Statement	Average Response		
	$0.60/kWh (n=221)	$1.20/kWh (n=261)	Total (n=482)
The number of Peak Days is reasonable	8.7	8.9	8.8
The Peak Time Credit Pilot is easy to understand	9.2	9.2	9.2
The Peak Days work with my household's schedule	8.2	8.4	8.3
I would recommend the Peak Time Credit Pilot to friends or family	8.1	8.6	8.4
I would make additional effort to reduce my usage during Peak Days if the bill credit was greater	9.3	8.7	9.0

* Blue shaded cells are responses which are statistically different between the $0.60 per kWh and $1.20 per kWh incentive groups at the 90% level

[7] Net Promoter Score is a popular metric used to estimate how likely a customer is to promote a program. It is calculated by subtracting the percentage of customers who rate their likelihood to recommend the program from 1 to 6 (detractors) from the percentage of customers who rate their likelihood to recommend the program 9 or 10 (promoters).

The next question asked the participants to rate their satisfaction with the Pilot, the information provided by Duke Energy, and the bill credits that they have earned from the Pilot. As shown in Table 4-9, the full set of customers were generally very satisfied with the Pilot, giving the Pilot an average rating of 7.7 out of 10. The participants earning $1.20 per kWh were generally more satisfied with the Pilot, giving it an average score of 8.1 while the participants earning $0.60 per kWh gave an average score of 7.3. Note the difference between groups is significantly different with 90% confidence. Participants were generally very satisfied with the information provided by Duke Energy, giving an average score of 8.9. Customers were generally satisfied by the bill credits they earned through the Pilot, giving an average rating of 6.7. There was a significantly higher satisfaction rating among customers earning $1.20 per kWh than those earning $0.60 per kWh.

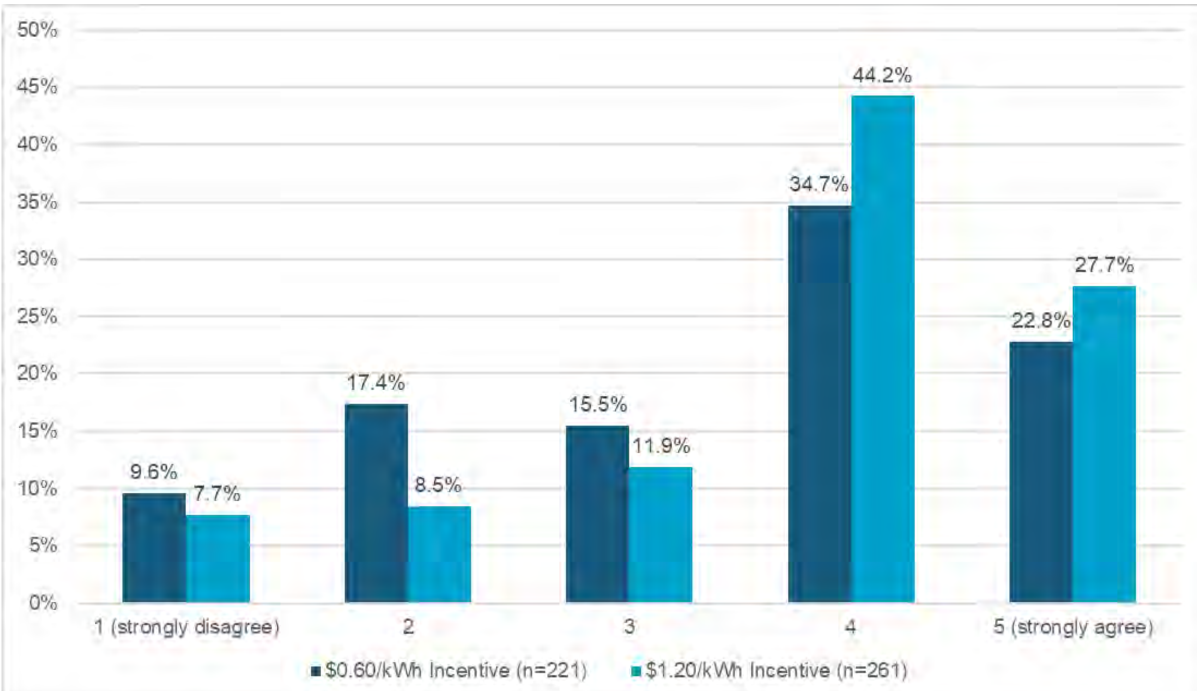
Table 4-9: Participant Average Satisfaction (n=192)

Statement	Average Response		
	$0.60/kWh (n=221)	$1.20/kWh (n=261)	Total (n=482)
The Peak Time Credit Pilot	7.3	8.1	7.7
Duke Energy's provided information on how the PTC works	8.7	9.0	8.9
The bill credits you have earned through the Peak Time Credit Pilot	6.1	7.2	6.7

* Blue shaded cells are responses which are statistically different between the $0.60 per kWh and $1.20 per kWh incentive groups at the 90% level

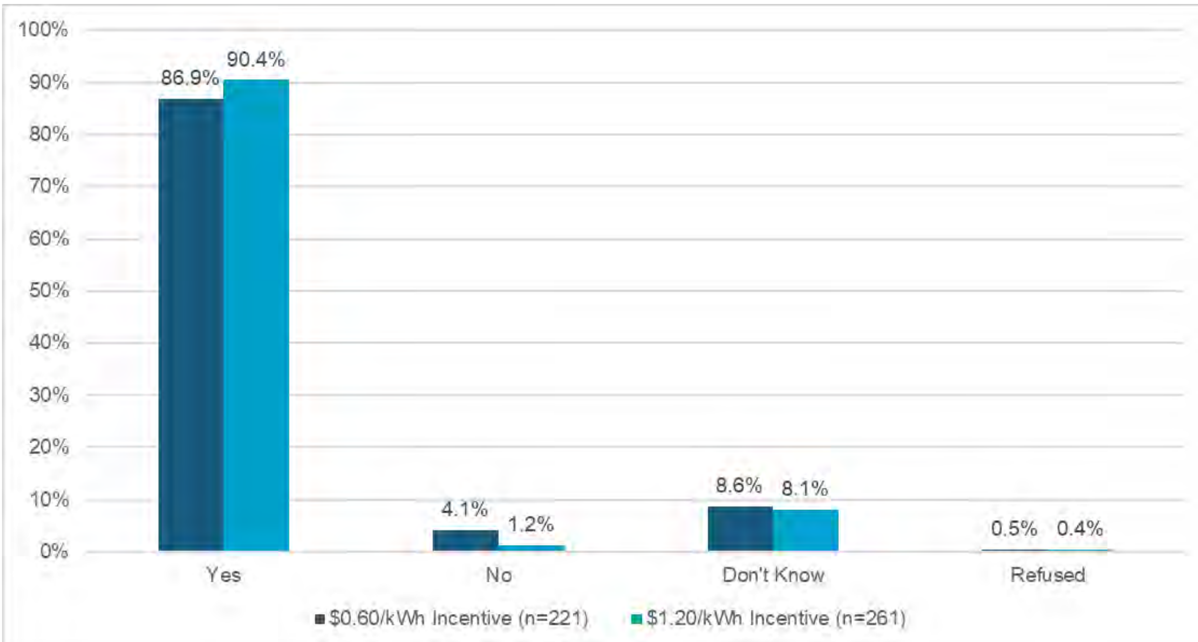
The same participants were later asked if receiving the current credit amount on Peak Days is enough to motivate them to reduce energy usage on a scale of 1 (strongly disagree) to 5 (strongly agree). These results are depicted in Figure 4-4. On average, participants receiving $0.60 per kWh ranked the credit earned at 3.4 while participants receiving $1.20 per kWh ranked the credit 3.8. Customers earning $0.60 per kWh find the bill credit statistically significantly less sufficient (with 90% confidence) than customers earning $1.20 per kWh, with average ratings of 3.5 and 3.8 out of 5, respectively.

Figure 4-4: Receiving the current incentive credit during the Peak Days is enough to motive the participant to reduce their usage



Participants were asked if they would continue to participate in this Pilot if it were to resume in future seasons. As shown in Figure 4-5, most participants said yes, however customers receiving the $0.60 per kWh incentive responded “No” and “Don’t know” more frequently, a statistically significant difference. The 28 customers in the $0.60 per kWh incentive group who answered “No” and “Don’t know” were then asked if they would participate in the Pilot if the bill credit was increased to $1.20 per kWh. The majority of such customers answered “Yes” (67.9%), with the second most frequent answer being “Don’t Know” (25.0%), and “No” being the most uncommon response (7.1%). Similarly, the 236 participants earning $1.20 per kWh who said they would participate if the Pilot was offered in future seasons were asked if they would participate in the future if the bill credit were reduced to $0.60 per kWh. Their responses were roughly evenly split between “Yes”, “No”, and “Don’t Know”, with respective frequencies of 33.5%, 32.3% and 34.3%.

Figure 4-5: Participants would continue to participate if the Pilot were to continue in future winter and summer seasons



To close the survey, all customers were able to provide free-response recommendations for the Peak Time Credit Pilot. Participants in both the low and high incentive groups provided suggestions at around the same rate, 30.5% and 27.4% respectively. The Resource Innovations team summarized the responses into general topics, and results are presented in Table 4-10. A plurality of the recommendations related to bill credits as 36.3% (i.e., 11.0% of survey respondents) of the responses fall within the category, with the most frequent suggestion being to increase the bill credits. A further 21% of the responses (i.e., 7.5% of survey respondents) were about education, with the most frequent education suggestion being to offer more information on energy saving methods. The remaining suggestions fell into the categories of Track performance, Expansion of Pilot, Event notifications and Other/Expressed Frustration, each of which represents around 10% or less of the responses.

Table 4-10: Participants Recommendations for the Peak Time Credit Pilot

Category	Subcategory	Percent of $0.60/kWh Responses (n=61)	Percent of $1.20/kWh Responses (n=63)	Percent of Responses (n=124)	Percent of All Respondents (n=482)
Bill Credits	Increase them	21.1%	26.7%	24.0%	7.3%
	Communicate them	9.9%	8.0%	8.9%	2.7%
	Calculation/application of credits	5.6%	1.3%	3.4%	1.0%
Education	Energy saving methods	19.7%	20.0%	19.9%	6.0%
	How the program works	4.2%	5.3%	4.8%	1.5%
Track Performance		12.7%	10.7%	11.6%	3.5%
Expansion of Program		9.9%	12.0%	11.0%	3.3%
Other/Express Frustration		11.3%	6.7%	8.9%	2.5%
Event Notifications		5.6%	9.3%	7.5%	2.3%
Total		100.0%	100.0%	100.0%	-

4.2 Process Evaluation Conclusions and Recommendations

Key findings and recommendations pertaining to the process evaluation include:

Participation Awareness and Motivation

- Most respondents were aware of their participation in the Pilot with 99.6% of participants recalling their participation.
- The most important reason provided by participants for joining the Pilot was to save money on their electricity bill, with an average rating of 9.3 out of 10 on average.

Peak Time Credit Awareness and Notification Satisfaction

- In the post-event survey, the majority (82.4%) of respondents recalled the event and a majority became aware through email notifications from Duke Energy (73.2%).
- Respondents generally agreed that Duke Energy notified them in a timely manner (9.2 out of 10), provided them with helpful information (8.9 out of 10), and gave them confidence of which hours they can earn credits on Peak Days (9.5 out of 10).

Response to Peak Time Credit Event

- In the post-event survey, 80.6% of the respondents reported being home during the event and 82.4% of respondents took action or changed their behavior due to the event.
  - Customers in the $0.60 per kWh group were home more frequently (84.9%) during the event than customers in the $1.20 per kWh group (76.7%), with statistical significance.
- The most commonly reported actions taken by participants were turning off lights in unoccupied rooms, increasing temperature on their thermostat, and shifting large appliance use. There were no statistically significant differences between the two incentive groups in terms of actions taken.
- Participants generally find responding to an event to be relatively easy, giving an average rating of 8.5 out of 10. There was no statistically significant difference in this rating between the two incentive groups.
- Commonly reported challenges to event response included not being able to think of any additional actions to take (25.3%), not having any barriers to shifting usage (14.8%), and already using very little energy (14.0%). There were no statistically significant differences between the incentive groups in terms of challenges to reduce usage.

Satisfaction with Peak Time Credit and Incentive Test

- Participants were generally satisfied with Pilot implementation overall (7.7 out of 10), but customers receiving $1.20 per kWh bill credit were statistically significantly more satisfied (8.1 out of 10) compared to $0.60 per kWh bill credits (7.3 out of 10).

- Customers would generally recommend the Pilot to others (8.4 out of 10) and would continue participating in future seasons (88.8%).
  - The $1.20 per kWh group was statistically significantly more likely to recommend the Pilot to others (8.6 out of 10) than the $0.60 per kWh group (8.1 out of 10).
  - The $0.60 per kWh group was statistically significantly more likely to respond “No” or “Don’t know” when asked if they would continue participating in the Pilot in the future (12.7%) than the $1.20 per kWh group (9.3%).
- The Net Promoter Score (NPS) for the full set of incentive test customers is 46.7. The NPS for the $0.60 per kWh group is 38.4 while the NPS for the $1.20 per kWh group is 53.7. The difference in scores between the two groups is statistically significant – however, the positive magnitude of the scores indicate that there is a large proportion of customers in both groups that would recommend the Pilot to others.
- The Net Promoter Score (NPS) for the full set of incentive test customers is 46.7. The NPS for the $0.60 per kWh group is 38.4 while the NPS for the $1.20 per kWh group is 53.7. The difference in scores between the two groups is statistically significant – however, the positive magnitude of the scores indicate that there is a large proportion of customers in both groups that would recommend the Pilot to others.
- Participants receiving $0.60 per kWh bill credits are statistically significantly less satisfied (6.1 out of 10) with the credits earned than customers receiving $1.20 per kWh bill credits (7.2 out of 10).
- Out of the customers receiving the $0.60 per kWh bill credit and who planned on discontinuing their participation in later seasons (12.7% of the overall $0.60 per kWh group), over two-thirds (8.6% of the overall $0.60 per kWh group) said they would stay in the Pilot if the credit increased.
- Out of the customers receiving the $1.20 per kWh bill credit and who planned on continuing their participation in later seasons (90.4% of the overall $1.20 per kWh group), over one-third (30.3% of the overall $1.20 per kWh group) said they would stay in the Pilot if the credit decreased.

Recommendations from Participants

- Respondents were given the opportunity to provide free-form response recommendations to improve the Peak Time Credit Pilot. In total, 28.8% of respondents provided suggestions. The bullets below provide a summary of the suggestions offered by participants.
  - Out of the 124 suggestions provided by participants, 24% were to increase the credit. This represents 6.9% of all survey respondents. While the bill credit is the primary motivation for enrollment (9.3 out of 10), customers are the least satisfied with the credit (6.7 out of 10) and would work harder to reduce usage if the credit were higher (9.0 out of 10). It is worth noting that a quarter of participants stated that they cannot think of any other actions to reduce their usage.
    - Of the suggestions provided, 26.7% of respondents in the $1.20 per kWh group suggested increasing the bill credits, compared to 21.1% of the $0.60 per kWh group.
  - Several participants (8.9% of 124 suggestions provided) suggested communicating the credits earned swiftly and clearly following an event, even if no credit was earned. This represents 2.6% of all survey respondents.
    - Of the suggestions provided, 8.0% of respondents in the $1.20 per kWh group suggested communicating the credits earned swiftly and clearly following an event, compared to 9.9% of the $0.60 per kWh group.
  - A common recommendation (19.9% of 124 suggestions provided) was to provide in-depth information on energy savings methods and give examples of how they may translate to bill credits. This represents 5.7% of all survey respondents.
    - Of the suggestions provided, 20% of respondents in the $1.20 per kWh group suggested providing information on energy savings methods, compared to 19.7% of the $0.60 per kWh group.
  - Several customers (11.6% of 124 suggestions provided) suggested creating a Peak Time Credit website or app that tracks participants' usage, provides Pilot information and event notifications, and tracks and contextualizes Peak Day performance. This represents 3.3% of all survey respondents.
    - Of the suggestions provided, 10.7% of respondents in the $1.20 per kWh group suggested creating a Peak Time Credit website or app, compared to 12.7% of the $0.60 per kWh group.

Appendix A Summer 2022 Load Impacts: Original Participants

To: Bruce Sailers, Jean Williams, Duke Energy Kentucky
From: Eric Bell, Apex Analytics, George Jiang, Anna-Elise Smith, Resource Innovations
RE: Summer 2022 Original Participants Load Impacts

Original Pilot participants, enrolled in Summer 2020, experienced three events between 3 PM – 7 PM during the Summer 2022 season. Approximately 700 original participants experienced events during the Summer 2022 season. Methodology used to estimate load impacts for the original participants aligns with Section 3.

Table A-1 displays average hourly load impacts per customer during the event hours of 3 PM – 7 PM by segment for original participants during the Summer 2022 season. The estimated load impact averaged across all original Pilot participants for the Summer 2022 season was 0.15 kW or 6.0%. Single-family customers had an average load impact of 0.17 kW (5.9%) while multi-family customers had an average load impact of 0.10 kW (6.6%) during the event hours of 3 PM to 7 PM.

Table A-1: Average Hourly Load Impact (kW), Summer 2022 – Original Participants

Original Customer Segment	Load w/o DR (kW)	Load w/ DR (kW)	Impact (kW)	Impact (%)
Residential Single Family Combined	**2.93**	**2.76**	**0.17**	**5.9%**
Residential Single Family (Electric Heat)	2.87	2.67	0.20	6.9%
Residential Single Family (Gas Heat)	2.95	2.79	0.17	5.6%
Residential Multi-family Combined	**1.53**	**1.43**	**0.10**	**6.6%**
Residential Multi-family (Electric Heat)	1.49	1.34	0.15	10.0%
Residential Multi-family (Gas Heat)*	1.57	1.51	0.05	3.3%
All Events Participants	**2.53**	**2.38**	**0.15**	**6.0%**

*Blue highlighted cells are not statistically significant at the 90% level.

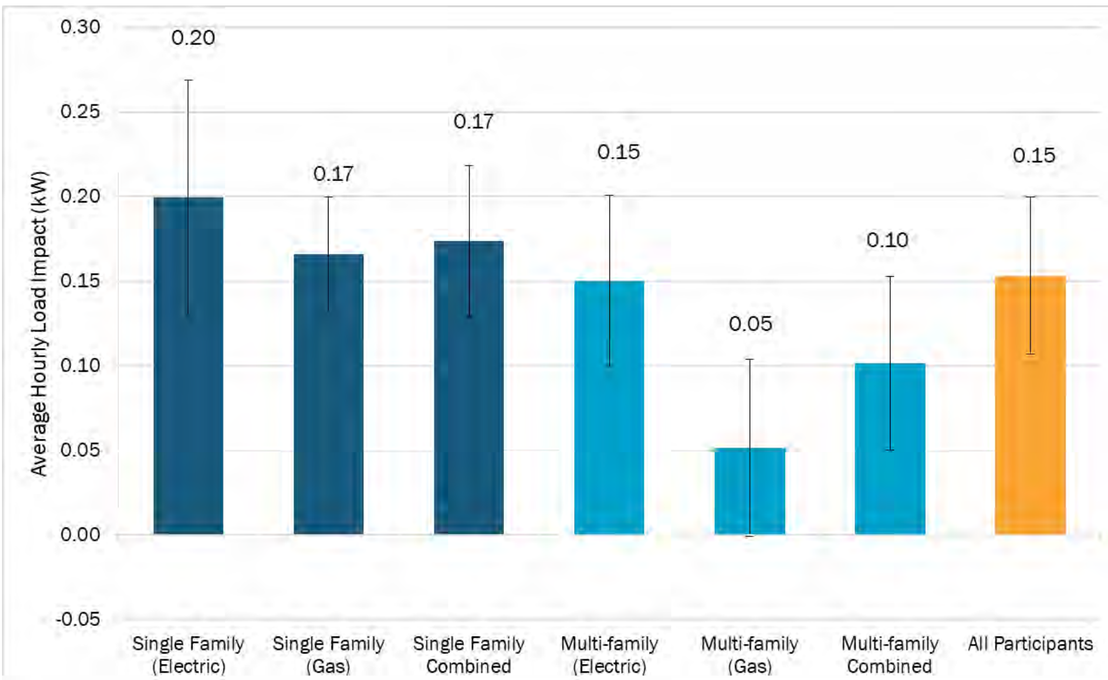
In Summer 2022, three events were called between 3 PM – 7 PM for original Pilot participants. Summer 2021 had sixteen events called between 3 PM – 7 PM. Winter 2021 had two events called between 6 AM – 10 AM and Summer 2020 experienced two events called between 3 PM – 7 PM. Table A-2 displays average hourly load impacts per customer, by event season. Original Pilot participants' average hourly load impacts per customer during the Summer 2022 season were 0.15 kW or 6.0%. Average hourly impacts per customer during the Summer 2021 events were 0.14 kW or 6.1% while Summer 2020 impacts were much larger at 0.38 kW or 15.4%. Average hourly impacts per customer across the two Winter 2021 events were 0.12 kW or 5.6%. Notably, the Summer 2020 event season coincided with the COVID-19 pandemic, leaving many folks at home. This may have impacted the load impacts observed. Next, each season experienced different event temperature, which is highly correlated with reference load and the magnitude of load impacts observed.

Table A-2: Average Hourly Load Impact (kW) Comparison Across Seasons - Original Participants

Season	Load w/o DR (kW)	Load w/ DR (kW)	Impact (kW)	Impact (%)
Summer 2022	2.53	2.38	0.15	6.0%
Summer 2021	2.37	2.22	0.14	6.1%
Winter 2021	2.04	1.93	0.12	5.6%
Summer 2020	2.49	2.11	0.38	15.4%

Figure A-1 displays the magnitude and statistical significance of each of the four customer classes, as well as that of all participants, all single-family, and all multi-family groups for original participants. The 90% confidence interval is displayed for each group of customers as an error bar over their impact. If the error bar crosses zero, the impact is not statistically significant from zero at the 90% level of confidence. All customer classes display statistical significance except the multi-family gas segment. In both the single-family and multi-family segments, customers with electric heating had larger load impacts, although the differences in impacts are not statistically significant. Single-family segments provided larger load impacts than multi-family segments.

Figure A-1: Average Hourly Load Impact (kW) by Customer Class (Summer 2022) - Original Participants



A.1 Load Impacts by Event Day

Figure A-2 shows the average hourly load impact for single-family and multi-family customers during each of the three events. Error bars represent the 90% confidence interval. When the black bars cross zero on the y-axis, the results are not statistically different from zero with 90% confidence, and therefore are insignificant. The largest impacts are observed on the third event day (8/3/2022) in both the single-family and multi-family segments at 0.24 kW and 0.11 kW, respectively. The second-largest event impacts are observed on the first and hottest event (6/14/2022) in both single- and multi-family segments at 0.16 kW and 0.10 kW. The smallest event impacts were observed on the second event (6/15/2022) in both segments at 0.12 kW and 0.09, although the impacts for the multi-family segment are not statistically significant.

Figure A-2: Average Hourly Load Impact per Customer - Original Participants

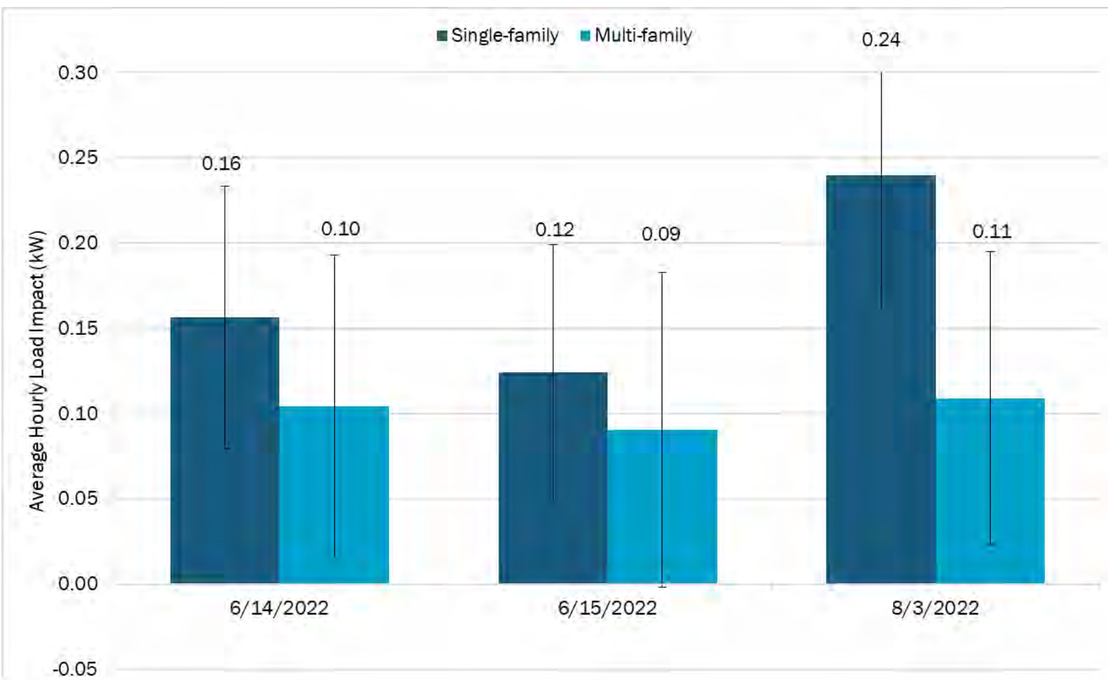


Table A-3 displays summaries of the three Summer 2022 PTC Pilot events for original participants. Each event's average event period temperature, control load, treatment load, average hourly load impact per customer, percentage impact, and 5th and 95th percentiles are displayed.

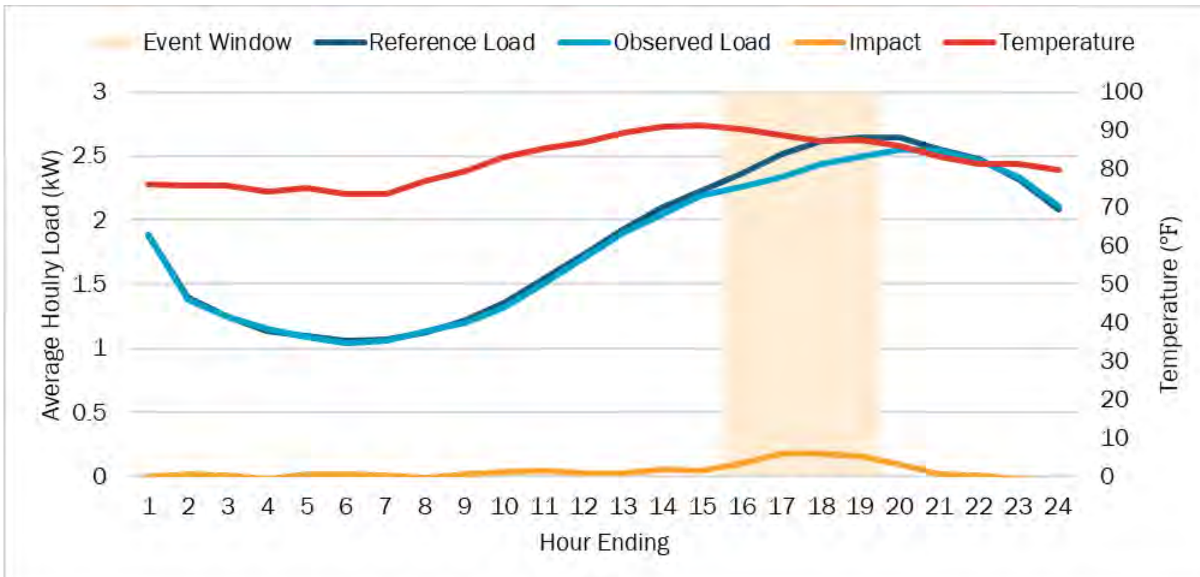
Aggregated to all original participants, all daily event impacts are statistically significant at the 90% confidence level. The average hourly load impacts per customer across all original participants in Summer 2022 was 0.15 kW or a 6.0% reduction to reference load. Interestingly, the load impacts have a negative relationship to event period temperature in the original participant segment.

Table A-3: Average Hourly Load Impact by Event Day (Summer 2022) - Original Participants

Event Date	Event Temp.	Load w/o DR (kW)	Load w/ DR (kW)	Impact (kW)	Impact (%)	5th Percentile	95th Percentile
6/14/2022	93.00	2.56	2.41	0.14	5.5%	0.06	0.22
6/15/2022	90.25	2.59	2.48	0.11	4.4%	0.03	0.19
8/3/2022	82.25	2.45	2.25	0.20	8.3%	0.12	0.28
Avg. Event	**88.50**	**2.53**	**2.38**	**0.15**	**6.0%**	**0.11**	**0.20**

Figure A-3 shows the average per-customer load with demand response, load without demand response (reference load), load impact, and hourly temperature for the event day with highest load impacts and the average event day, respectively, for all original PTC participants. The average load without DR during all event hours was 2.53 kW. The average load with DR during event hours was 2.38kW resulting in an average load reduction of 0.15 kW per customer, or a 6.0% reduction relative to the reference load.

Figure A-3: Average Hourly Load Impacts per Customer on Average Event Day (Summer 2022) - Original Participants



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