COMMONWEALTH OF KENTUCKY

BEFORE THE PUBLIC SERVICE COMMISSION

In the Matter of:

THE APPLICATION OF DUKE ENERGY	)	
KENTUCKY, INC. TO AMEND ITS	)	Case No. 2021-00313
DEMAND SIDE MANAGEMENT	)	
PROGRAMS	)	

APPLICATION OF DUKE ENERGY KENTUCKY, INC. TO AMEND ITS DEMAND SIDE MANAGEMENT PROGRAMS

Comes now Duke Energy Kentucky, Inc. (Duke Energy Kentucky or the Company), pursuant to KRS 278.285, the Commission's April 11, 2013 Order in Case No. 2012-00495, and other applicable law, and does hereby request the Commission to approve an amendment to its Demand Side Management (DSM) programs.[1] In support of its Application, Duke Energy Kentucky respectfully states as follows:

<u>Introduction</u>

1. Pursuant to 807 KAR 5:001, Section 14(2), Duke Energy Kentucky is a Kentucky corporation, originally incorporated on March 20, 1901, is in good standing and, as a public utility as that term is defined in KRS 278.010(3), is subject to the Commission's jurisdiction. Duke Energy Kentucky is engaged in the business of furnishing natural gas and electric services to various municipalities and unincorporated areas in Boone, Bracken, Campbell, Gallatin, Grant, Kenton, and Pendleton Counties in the Commonwealth of

[1] *In the Matter of the Application of Duke Energy Kentucky, Inc. for the Annual Cost Recovery Filing for Demand Side Management,* Case No. 2012-00495, (Order) (April 11, 2013).

Kentucky. A copy of its articles of incorporation is on file with the Commission in Case No. 2013-00097.

2. Duke Energy Kentucky's business address is 139 East Fourth Street, Cincinnati, Ohio 45202. The Company's local office in Kentucky is Duke Energy Erlanger Ops Center, 1262 Cox Road, Erlanger, Kentucky 41018. Duke Energy Kentucky's email address is: KYfilings@duke-energy.com.

3. On November 15, 2012, Duke Energy Kentucky filed an application for the cost recovery of demand side management programs. The Company's application was docketed as Case No. 2012-00495. On April 11, 2013, this Commission approved that Application and Ordered Duke Energy Kentucky to file an application requesting program expansion(s) and to include: (1) an Appendix A, setting forth the Cost Effectiveness Test Results of all DSM programs with budget changes; (2) an Appendix B, setting forth the recovery of program costs, lost revenues, and shared savings that are used in determining the true-up of proposed DSM factors; and (3) a signed and dated proposed Rider DSMR, Demand Side Management rate, for both electric and natural gas customers, Appendix C, by August 15, annually.[2]

Current DSM Programs

4. Duke Energy Kentucky has a long history of successful DSM implementation and has been a leader in the industry with respect to energy efficiency (EE) and peak demand reduction (DR) programs, having offered such programs since the mid-90's. Its existing portfolio of DSM programs was approved by the Commission in Case

[2] *See* Order, para. 4.

No. 2020-00371,[3] by Order dated April 9, 2021. This current portfolio of programs are as follows:

- Program 1: Low Income Services Program
- Program 2: Residential Energy Assessments Program
- Program 3: Residential Smart $aver® Efficient Residences Program
- Program 4: Residential Smart $aver® Energy Efficient Products Program
- Program 5: Smart $aver® Prescriptive Program
- Program 6: Smart $aver® Custom Program
- Program 7: Power Manager® Program
- Program 8: PowerShare®
- Program 9: Low Income Neighborhood
- Program 10: My Home Energy Report
- Program 11: Non-Residential Small Business Energy Saver Program
- Program 12: Non-Residential Pay for Performance[4]
- Program 13: Peak Time Rebate Pilot Program[5]

5. Consistent with the Commission's previous Orders, the Company is proposing programmatic changes in this year's annual amendment filing, and budgetary management proposals to more effectively target funding between programs based upon customer interest mid-stream, which will then be reflected in the financial true-ups and forecasts to be included in the annual cost recovery filing for demand side management:

[3] *In the Matter of the Electronic Application of Annual Cost Recovery Filing for Demand Side Management by Duke Energy Kentucky, Inc.* Case No. 2020-00371.
[4] Marketed as Smart $aver® Performance
[5] Approved in Case No. 2019-00277

- This Application proposes to expand the scope and adjust program budgets to respond to market conditions and enhance the robustness of the following:
    - Residential Smart $aver®
    - Low Income Neighborhood
    - PowerShare®
    - Peak Time Rebate
    - Smart $aver® Prescriptive and Custom

6. The Residential Collaborative[6] and the Commercial and Industrial Collaborative[7] have received the Company's proposed changes and had the opportunity to provide comments.

Amendments to Existing Programs

7. Duke Energy Kentucky is seeking approval to expand the scope of the Multifamily portion of the Residential Smart $aver®.

The Multifamily Energy Efficiency Program is an extension of the Residential Smart $aver® program and allows Duke Energy Kentucky to use an alternative delivery channel which targets multifamily apartment complexes. The measures are directly installed in permanent fixtures by the program vendor, Franklin Energy. The target

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[6] The Residential Collaborative members receiving the information: Larry Cook, John Horne and Michael West (Office of the Kentucky Attorney General), Jock Pitts (People Working Cooperatively), Catrena Bowman-Thomas and Brandon Holmes (Northern Kentucky Community Action Commission), Laura Pleiman (Boone County), Peter Nienaber (Northern Kentucky Legal Aid), Kenya Stump (Kentucky Energy and Environment Cabinet), and Tim Duff and Trisha Haemmerle (Duke Energy).

[7] The Commercial & Industrial Collaborative members receiving the information: Larry Cook, John Horne and Michael West (Office of the Kentucky Attorney General), Jock Pitts (People Working Cooperatively), Kenya Stump (Kentucky Energy and Environment Cabinet), Chris Baker (Kenton County Schools), and Tim Duff and Trisha Haemmerle (Duke Energy).

audience for the program is property managers who have properties that are served on an individually metered residential rate schedule. To receive water measures, apartments must have electric water heating.

The program helps property managers upgrade lighting with energy efficient LEDs and saves energy by offering water measures such as bath and kitchen faucet aerators, water saving showerheads and pipe wrap. The quantity of lighting measures installed may vary by apartment size but there are no limits on LED installations in permanent fixtures. These measures assist with reducing maintenance costs while improving tenant satisfaction by lowering energy bills.

The modifications will increase the energy efficiency of the apartment, increase tenant satisfaction with the program and increase property manager satisfaction. The program is requesting to expand the property offerings to include additional Recessed and Track LED lighting and allow property managers the option for a 1.25 gallons per minute (gpm) efficient showerhead. Additionally, the property manager may purchase smart thermostats at a discounted price to be installed by the implementation provider.

Measures include but are not limited to the following:

- Recessed LED lighting
- Track LED lighting
- Smart thermostats
- 1.25 gpm Showerheads

While the eligibility of the program does not change for the LED lighting and 1.25 gpm showerhead, the smart thermostat will only be offered to properties with electric heat and replace a standard and/or programmable thermostat. The Company is not requesting a change in the current approved budget, however; the new measures enhance the cost effectiveness of the program. The new measures upon approval would be available July 1, 2022.

8. Duke Energy Kentucky is seeking approval to add additional measures to the Low Income Neighborhood program. The program is marketed as Neighborhood Energy Services (NES).

The NES takes a non-traditional approach to serve income-qualified areas of the Duke Energy Kentucky service territory through the direct installation of energy efficiency measures in customer homes. This customer-facing program allows for the direct engagement in a familiar setting to reduce energy consumption with the installation of energy efficient measures. In addition, Duke Energy Kentucky uses this opportunity to educate and work with customers to efficiently manage and lower their energy bills. Examples of direct installed measures include energy efficient light bulbs, water heater and pipe wrap, low flow shower heads/faucet aerators, window and door air sealing and a year supply of HVAC filter replacements.

The primary goal of the Program is to empower income-qualified residential customers to better manage their energy usage, thereby reducing their energy consumption and the resulting costs and emissions associated with the generation of electricity. The NES program is also intended to reduce the participant's household energy costs.

The NES program provides eligible customers, at no charge, an energy assessment to identify energy efficiency opportunities in the customer's home, a one-on-one educational session on energy efficiency techniques and measures and includes a comprehensive package of energy conservation measures identified through the energy assessment which will either be installed or provided to the customer. The Company's proposed modification is as follows:

- In addition to the current 16 measures[8] offered to customers, the Company is requesting to revise the available measures to include insulation, air sealing, duct sealing, and smart thermostats to address customers high energy use.

Eligibility of the revised additional measures (NES 2.0) will be made available to NES participating customers that the Company deems a high-energy user and the customer's home will be audited to see if these measures can be effectively and safely installed.

9. PowerShare® is Duke Energy Kentucky's Peak Load Management Program (Rider PLM, Peak Load Management Program KY.P.S.C. Electric No. 2, Sheet No. 77) for non-residential customers. The program is voluntary and offers customers the opportunity to reduce their electric costs by managing their electric usage during the Company's peak load periods. Customers and the Company will enter into a service agreement under Rider PLM, specifying the terms and conditions under which the customer agrees to reduce usage.

Duke Energy Kentucky is seeking approval to discontinue its Limited Summer option of the PowerShare® program effective May 31, 2022. The current PowerShare® program offerings include the Annual, Summer Period, and Limited Summer options. The Limited Summer option limits customers' exposure to a maximum ten emergency events only during the months of June-September. PJM discontinued its Limited DR (Limited

[8] The program currently offers the following measures: LEDs, Water Heater Insulation Wrap, Water Heater Pipe Insulation, Water Heater Temperature Check and Adjustment, Faucet Aerators, Low Flow Showerheads, Refrigerator Thermometers, Switch Plate Wall Thermometer, Cover for Wall/Window Air Conditioner Unit-Installed, Cover for Wall/Window Air Conditioner Unit-Left behind and not installed, HVAC Filters (1-year supply for each HVAC system), Weather-Stripping, Door Sweep, Poly Tape , Caulking Foam Insulation

Summer) resource following the 2017-2018 delivery year placing greater value on Capacity Performance resources with greater availability – unlimited number of events with year-round or expanded summer availability. Duke Energy Kentucky continued to offer Limited DR/Limited Summer to customers through the 2021-2022 delivery year to provide customers unable to meet the requirements of the Capacity Performance resources an option to remain on the program. Duke Energy Kentucky seeks to discontinue this program option because these resources have not been eligible for registration since the 2017-2018 delivery year and no longer hold any value with PJM. Customers have been informed that the Limited Summer option would be eliminated and have been encouraged to move to one of the other remaining options for the 2022-2023 delivery year – Annual or Summer Period.

The Company is not requesting a change in the current approved budget.

10. The Peak Time Rebate (PTR) pilot program offers participating customers the opportunity to lower their electric bill by reducing their electric usage during Company-designated peak load periods known as Critical Peak Events (CPE). The Company has branded the program to customers under the name of Peak Time Credits and describes CPEs to participants as peak day events. The program was launched on July 27, 2020. As noted in previous filings, the launch of the program did not occur in May 2020 as planned. This resulted in the need to reschedule EM&V tasks. The approved cost of the EM&V analysis has not changed for the pilot program. The revised EM&V schedule and Statement of Work (SOW) is attached as Appendix D. The revised EM&V plan is consistent with the original EM&V plan as it was approved. All EM&V efforts are scheduled for completion by the end of April 2022.

- This Application submits the revised EM&V schedule for the Peak Time Rebate pilot program. There are no changes to the pilot design and no change in the EM&V total estimated cost.

11. Smart $aver® Prescriptive & Custom program management have collaborated to share program funding from Smart $aver® Custom to Prescriptive to ensure spend levels do not exceed the total of the two programs. Moving forward, the program will be consolidated as Non-Residential Smart $aver®.

12. Pursuant to KRS 278.285(1)(b) and the Commission's Order, Appendix A includes the Cost Effectiveness Test Results for Low Income Neighborhood.

13. Pursuant to KRS 278.285(1)(c) and the Commission's Order, Appendix B includes the calculations to recover program costs, lost revenues, and shared shavings, that are used in determining the true-up of proposed DSM factor(s).

14. A signed and dated proposed Rider DSMR, Sheet No. 78 Demand Side Management Rider for electric customers is attached hereto as Appendix C.

15. Pursuant to KRS 278.285(1)(c) and the Commission's Order, the Company is filing program evaluations within this application. The following evaluations are included in appendices E – H: Appendix E: Evaluation, Measurement, and Verification Schedule; Appendix F: Power Manager Evaluation; Appendix G: Residential Energy Assessments Evaluation; Appendix H: Save Energy and Water Kits Evaluation.

16. Finally, Duke Energy Kentucky respectfully requests that the Commission's Order in this proceeding approve any tariff modifications to be effective so to align with the Company's first billing cycle in the month following the Commission's Order. The Company is unable to implement tariff changes immediately upon approval and

outside of a billing cycle under its current billing system. The Company needs at least five business days from the issuance of an Order to implement rate changes and appropriately test the calculations.

WHEREFORE, Duke Energy Kentucky respectfully requests that the Commission grant the relief requested herein.

Respectfully submitted,

/s/Rocco D'Ascenzo

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CERTIFICATE OF SERVICE

This is to certify that the foregoing electronic filing is a true and accurate copy of the document in paper medium; that the electronic filing was transmitted to the Commission on August 16, 2021; that there are currently no parties that the Commission has excused from participation by electronic means in this proceeding; and that submitting the original filing to the Commission in paper medium is no longer required as it has been granted a permanent deviation.[9]

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[9] *In the Matter of Electronic Emergency Docket Related to the Novel Coronavirus COVID-19,* Order, Case No. 2020-00085 (Ky. P.S.C. July 22, 2021).

Cost Effectiveness Test Results (A)

	2021-22 Program Modifications			
Program Name	**UCT**	**TRC**	**RIM**	**PCT**
Residential Programs				
Low Income Neighborhood	0.43	0.54	0.32	2.52

(A) Cost effectiveness scores of the modified programs listed, as filed in 2021 amendment filing.
Most recent scores for existing programs can be found In the Company's annual true up filing, Case No. 2020-00371, Appendix A.

Kentucky DSM Rider

Comparison of Revenue Requirement to Rider Recovery

Residential Programs	(1) Projected Program Costs 7/2019 to 6/2020 (A)	(2) Projected Lost Revenues 7/2019 to 6/2020 (A)	(3) Projected Shared Savings 7/2019 to 6/2020 (A)	(4) Program Expenditures 7/2019 to 6/2020 (B)	(5) Program Expenditures (C) Gas	(6) Electric	(7) Lost Revenues 7/2019 to 6/2020 (B)	(8) Shared Savings 7/2019 to 6/2020 (B)	(9) 2019 Reconciliation Gas (D)	(10) Electric (E)	(11) Rider Collection (F) Gas	(12) Electric	(13) (Over)/Under Collection Gas (G)	(14) Electric (H)
Low Income Neighborhood	$ 371,468	$ 7,935	$ (15,844)	$ 158,232	$ -	$ 158,232	$ 3,394	$ (7,678)						
Low Income Services	$ 810,628	$ 11,128	$ (30,069)	$ 477,566	$ 275,989	$ 201,577	$ 4,095	$ (28,151)						
My Home Energy Report	$ 165,696	$ 161,739	$ 13,511	$ 82,028	$ -	$ 82,028	$ 34,406	$ 707						
Residential Energy Assessments	$ 326,678	$ 15,180	$ 7,262	$ 152,247	$ -	$ 152,247	$ 12,090	$ 6,203						
Residential Smart $aver®	$ 1,949,221	$ 260,300	$ 252,080	$ 2,064,345	$ -	$ 2,064,345	$ 178,042	$ 195,043						
Power Manager®	$ 564,560	$ -	$ 131,418	$ 607,753	$ -	$ 607,753	$ -	$ 117,092						
Peak Time Rebate Program	$ 207,736	$ -	$ -	$ 36,811	$ -	$ 36,811	$ -	$ -						
Revenues collected											$ (509,633)	$ (3,272,047)		
Total	$ 4,395,987	$ 456,282	$ 358,358	$ 3,578,982	$ 275,989	$ 3,302,993	$ 232,028	$ 283,216	$ 1,746,882	$ (7,212,847)	$ (509,633)	$ (3,272,047)	$ 2,532,504	$ (122,563)

(A) Amounts identified in report filed in Case No. 2018-00370
(B) Actual program expenditures, lost revenues (for this period and from prior period DSM measure installations), and shared savings for the period July 1, 2019 through June 30, 2020.
(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, 2019 and June 30, 2020.
(G) Column (5) + Column (9) - Column(11).
(H) Column (6) + Column (7) + Column (8) + Column (10) - Column(12).

Commercial Programs	(1) Projected Program Costs 7/2019 to 6/2020 (A)	(2) Projected Lost Revenues 7/2019 to 6/2020 (A)	(3) Projected Shared Savings 7/2019 to 6/2020 (A)	(4) Program Expenditures 7/2019 to 6/2020 (B)	(5) Lost Revenues 7/2019 to 6/2020 (B)	(6) Shared Savings 7/2019 to 6/2020 (B)	(7) 2019 Reconciliation (C)	(8) Rider Collection (D)	(9) (Over)/Under Collection (E)
Small Business Energy Saver	$ 874,529	$ 36,499	$ 116,303	$ 460,326	$ 94,779	$ 69,968			
Smart $aver® Custom	$ 675,415	$ 36,816	$ 155,383	$ 397,763	$ 190,461	$ 125,576			
Smart $aver® Prescriptive	$ 1,676,125	$ 60,956	$ 520,952	$ 1,141,244	$ 154,998	$ 452,467			
Power Manager® for Business(F)	$ -	$ -	$ -	$ 1,283	$ 80	$ 545			
Total	$ 3,226,069	$ 134,271	$ 792,638	$ 2,000,615	$ 440,319	$ 648,555	$ 340,779	$ 8,702,093	$ (5,271,825)
PowerShare®	$ 908,290	$ -	$ 153,191	$ 650,303	$ -	$ 139,905	$ 304,370	$ 1,514,890	$ (420,313)

(A) Amounts identified in report filed in Case No. 2018-00370
(B) Actual program expenditures, lost revenues (for this period and from prior period DSM measure installations), and shared savings for the period July 1, 2019 through June 30, 2020.
(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, 2019 and June 30, 2020.
(E) Column (4) + Column (5) + Column (6) + Column (7) - Column (8)
(F) Costs associated with customers still on the program during the fiscal year.

Kentucky DSM Rider

2021-2022 Projected Program Costs, Lost Revenues, and Shared Savings

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(D)	$ 535,375	$ 16,582	$ (18,687)	$ 533,270	100.0%	0.0%	$ 535,375	$ 533,270	$ -
Low Income Services	$ 674,774	$ 13,372	$ (23,004)	$ 665,141	57.7%	42.3%	$ 389,359	$ 379,726	$ 285,415
My Home Energy Report	$ 92,858	$ 59,707	$ 4,925	$ 157,491	100.0%	0.0%	$ 92,858	$ 157,491	$ -
Residential Energy Assessments	$ 259,935	$ 20,469	$ 6,026	$ 286,429	100.0%	0.0%	$ 259,935	$ 286,429	$ -
Residential Smart $aver®(D)	$ 1,009,464	$ 138,531	$ 39,241	$ 1,187,236	100.0%	0.0%	$ 1,009,464	$ 1,187,236	$ -
Power Manager®	$ 702,947	$ -	$ 113,199	$ 816,146	100.0%	0.0%	$ 702,947	$ 816,146	$ -
Peak Time Rebate Program	$ 197,549	$ -	$ -	$ 197,549	100.0%	0.0%	$ 197,549	$ 197,549	$ -
Total Costs, Net Lost Revenues, Shared Savings	$ 3,472,902	$ 248,660	$ 121,701	$ 3,843,262			$ 3,187,487	$ 3,557,847	$ 285,415

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
Small Business Energy Saver	$ 827,238	$ 40,699	$ 105,787	$ 973,725	100.0%	0.0%	$ 827,238	$ 973,725	NA
Smart $aver® Custom	$ 938,180	$ 78,053	$ 233,546	$ 1,249,779	100.0%	0.0%	$ 938,180	$ 1,249,779	NA
Smart $aver® Prescriptive (C)	$ 504,975	$ 43,088	$ 145,368	$ 693,431	100.0%	0.0%	$ 504,975	$ 693,431	NA
PowerShare®	$ 857,738	$ -	$ 107,428	$ 965,166	100.0%	0.0%	$ 857,738	$ 965,166	NA
Total Costs, Net Lost Revenues, Shared Savings	$ 3,128,132	$ 161,841	$ 592,128	$ 3,882,101			$ 3,128,132	$ 3,882,101	NA
Total Program	$ 6,601,034	$ 410,501	$ 713,829	$ 7,725,363					

(A) Costs, Lost Revenues (for this period and from prior period DSM measure installations), and Shared Savings for Year 9 of portfolio.
(B) Allocation of program expenditures to gas and electric in accordance with the Commission's Order in Case No. 2014-00388.
(C) Smart $aver® Prescriptive consists of the following technologies: Energy Efficient Food Service Projects, HVAC, Lighting, IT, Pumps and Motors, and Process Equipment.
(D) 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 2020 to June 2021

	Program Costs (A)
Electric Rider DSM	
Residential Rate RS	$ 3,557,847
Distribution Level Rates Part A DS, DP, DT, GS-FL, EH & SP	$ 2,916,935
Transmission Level Rates & Distribution Level Rates Part B	$ 965,166
Gas Rider DSM	
Residential Rate RS	$ 285,415

(A) See Appendix B, page 2 of 7

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

Year	2021
Projected Annual Electric Sales kWH	
Rate RS	1,487,109,845
Rates DS, DP, DT, GS-FL, EH, & SP	2,237,356,418
Rates DS, DP, DT, GS-FL, EH, SP, & TT	2,475,033,418
Projected Annual Gas Sales CCF	
Rate RS	62,283,830

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

July 2019 to June 2020

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	$ (124,291)	$ 3,557,847	$ 3,433,556	1,487,109,845	kWh	$ 0.002309	$/kWh
Distribution Level Rates Part A DS, DP, DT, GS-FL, EH & SP	$ (5,346,158)	$ 2,916,935	$ (2,429,222)	2,237,356,418	kWh	$ (0.001086)	$/kWh
Transmission Level Rates & Distribution Level Rates Part B TT	$ (426,239)	$ 965,166	$ 538,927	2,475,033,418	kWh	$ 0.000218	$/kWh
Distribution Level Rates Total DS, DP, DT, GS-FL, EH & SP						$ (0.000868)	$/kWh
Gas Rider DSM							
Residential Rate RS	$ 2,568,212	$ 285,415	$ 2,853,627	62,283,830	CCF	$ 0.045817	$/CCF
Total Rider Recovery			$ 4,396,888				

(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: 1.014100
(B) Appendix B, page 2.
(C) Appendix B, page 4.

Allocation Factors based on July 2019-June 2020

Summary of Load Impacts July 2019 Through June 2020 (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	138,758	0.0092%	-	0.0000%	100%	0%
Low Income Services	122,143	0.0081%	6,549	0.0111%	42%	58%
My Home Energy Report	1,596,695	0.1061%	-	0.0000%	100%	0%
Residential Energy Assessments	285,139	0.0190%	-	0.0000%	100%	0%
Residential Smart $aver®	6,640,873	0.4414%	-	0.0000%	100%	0%
Power Manager®	-	0.0000%	-		100%	0%
Total Residential	8,783,608	0.5838%	6,549	0.0111%		
Total Residential (Rate RS) Sales For July 2019 Through June 2020	1,504,643,154	100%	58,919,207	100%		

(1) Load Impacts Net of Free Riders at Meter

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

Allocation Factors Projected

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	224,406	0.0151%	-	0.0000%	100%	0%
Low Income Services	255,140	0.0172%	7,833	0.0126%	58%	42%
My Home Energy Report	1,338,472	0.0900%	-	0.0000%	100%	0%
Residential Energy Assessments	384,320	0.0258%	-	0.0000%	100%	0%
Residential Smart $aver®	2,038,692	0.1371%	-	0.0000%	100%	0%
Power Manager®	-	0.0000%	-	0.0000%	100%	0%
Total Residential	4,241,029	0.2852%	7,833	0.0126%		
Total Residential (Rate RS) Sales Projected	1,487,109,845	100%	62,283,830	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. 75 of this Tariff.

The DSMR to be applied to residential customer bills is $0.~~002175~~ 002309 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 ($0.000868) per kilowatt-hour. ~~(R)~~

The DSMR to be applied for transmission service customer bills is $0.000218 per kilowatt-hour. ~~(R)~~

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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 $0.002309 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 ($0.000868) per kilowatt-hour.

The DSMR to be applied for transmission service customer bills is $0.000218 per kilowatt-hour.

Evaluation Plan

APPENDIX D

Peak Time Rebate Pilot Evaluation Plan- Update

Submitted to Duke Energy Kentucky

Principal Authors:
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June 29, 2021

1 Background and Evaluation Summary

This document presents Nexant's updated plan to evaluate the Duke Energy Kentucky (DEK) Peak Time Rebate (PTR) pilot. Several updates to the scope of work and timeline have been incorporated since the initial proposal was submitted to Duke Energy in 2018. The content that follows includes details on the impact and process evaluations. The associated tasks and timeline includes activities leading up to the implementation of the pilot such as consultation during the design of the pilot and presentation of the evaluation, measurement, and verification (EM&V) plan to the Collaborative prior to pilot approval. These tasks have already been completed, but are included in this document in order to provide a comprehensive view of the entire body of work associated with this evaluation.

As a vendor with 11 years of experience evaluating PTR programs, Nexant brings considerable knowledge and expertise to the design and evaluation of the DEK PTR pilot. Our prior analyses have demonstrated our ability to properly design pilots, provide precise estimates of load impacts, assess the effectiveness of marketing and outreach efforts, and verify customer baselines. Nexant brings lessons learned from the Southern California Edison (SCE), Commonwealth Edison (ComEd), and Oklahoma Gas & Electric (OG&E) PTR pilots and programs to the pilot design and evaluation at Duke Energy. Nexant has also investigated the accuracy of hundreds of different baseline methods for several clients, including San Diego Gas & Electric (SDG&E), OG&E, and ComEd, comparing the relative bias and payment errors associated with various baselines under different assumptions about average load reductions. This extensive experience in evaluating PTR programs provides very useful insights regarding how to improve DEKs program over time.

Nexant's evaluation rests on a few key assumptions:

- Nexant understands that Duke Energy is operating a residential PTR pilot in Kentucky for up to 1,000 participating customers[1] on an opt-in basis.
- PTR events can be dispatched year-round.
- AMI has been deployed in the DEK territory, and data from summer 2018 onwards will be available from a large, representative sample of customers.

[1] The final participation target was determined by Nexant through a power analysis.

2 Impact Evaluation

The primary challenge in estimating load impacts for demand response programs such as PTR is estimating how much electricity participants would have consumed during a PTR event in the absence of the incentive payment. The estimated usage in the absence of the incentive is referred to as the reference load. PTR payments for each customer are based on an estimated reference load called a baseline. Although these estimates are necessary to determine incentive payments, prior studies (many of them conducted by Nexant) have shown them to be inaccurate at the individual customer level and often biased for the average customer. As such, they are not appropriate methods to use for estimating ex post load impacts for a PTR program.

The ideal method for evaluating this PTR pilot depends on the sample size that can be obtained. Two options existed for evaluating the pilot: (1) a randomized control trial (RCT) where participants are split into two equal sized groups (A and B) with one group called for each PTR event while the other is held as a control, or (2) a difference-in-differences analysis using a matched control group, where participants are matched up with similar non-participants and the difference in usage on event days is compared to the difference in usage on non-event days to infer the impact of the program.

On November 1, 2018 Nexant met with Duke Energy for the Project Initiation Meeting, which included a discussion of the merits of each analysis approach and resulted in a decision to proceed with the difference-in-differences analysis using a matched control group. The matched control group approach was decided on because it simplifies the program design and implementation, and maximizes the value to participants via providing the most opportunities to earn credits.

To conduct the difference-in-differences analysis, Nexant will compare participant load to a matched control group on PTR event days. Customers who did not sign up for the program—non-participant customers—have been shown in the past to not reduce electricity usage on PTR event days. As such, these customers are appropriate candidates for selection into the control group in the ex post analysis. Nexant will match PTR participants with non-participant customers—the control group—based on similar usage during event-like days. The impact estimates will be based on the difference in loads for the participant and control group customers on the event day minus the difference in load between the two groups on similar, non-event days. By accounting for differences between the participant and control groups on non-event days, this methodology accounts for any remaining dissimilarities between the two groups that were not controlled for by the statistical matching process.

The matched control group method used for this analysis is superior to a within-subjects analysis because it eliminates the problem of model misspecification. Any reference load model based on loads observed at non-event times requires the modeler to make assumptions about the relationships between load, time, and temperature. If this assumed function does not reflect the true relationships between load, time, and temperature, the model can produce incorrect results. In contrast, the matched control group deals with this problem by assuming that the customers who behave similarly to PTR customers during non-event periods would also behave similarly during event periods. This eliminates the need to specify load as a function of weather.

Nexant has experience using matched control groups and difference-in-differences analysis to estimate load impacts for PTR programs based on our work on SCE's Bring Your Own Thermostat (BYOT) peak time rebate program from 2013 through 2015. Nexant has also used difference-in-differences analysis in the context of an RCT to evaluate the impact of ComEd's 2015 PTR/Smart Thermostat pilot as well as OG&E's 2015 PTR/Smart Thermostat pilot and more than a dozen additional evaluations over the past several years. In all instances, Nexant was responsible for developing the experimental design and producing load impact results.

One important caveat for this evaluation is that the pilot will recruit customers on an opt-in basis, meaning that any results cannot be applied to a default, or opt-out, enrollment program without calibrating the expected load impacts to account for behavioral differences. Customers who opt-in to a demand response program tend to be more cognizant of their electricity usage and will often consciously look for ways to reduce their usage compared to a typical customer who has been defaulted onto a program.

The specific activities for the impact evaluation are described below.

Consult with pilot design team (Completed) – Nexant worked closely with the pilot design team to understand the study goals, project timing, data availability, and the marketing plan. Key questions that were addressed by DEK during this phase include what program design elements needed to be tested (i.e., incentive levels, notification methods, event frequency, etc.), what the preferred recruitment strategy was, what data would be available for power analysis, the control group selection process, and ex post load impact estimation. Based on this information, Nexant provided feedback on the number of customers that needed to be included in the marketing effort, the data that would be needed for the power analysis, the weather conditions that should be targeted for PTR events, the desired number of events to call, and a flexible strategy for adjusting event triggers if weather conditions are too mild to reach the number of events needed, and other factors.

Perform power analysis and develop sample size recommendation (Completed) – Nexant analyzed DEK AMI data once it became available at the end of summer 2018 in a power analysis. The results informed what sample size was required to estimate impacts given assumptions about expected effect size and the desired level of statistical precision. With this as input, Nexant made a recommendation to DEK regarding whether to pursue the A/B RCT design or, alternatively, to call all participants for each event and develop a control group using statistical matching.

Develop and present a detailed EM&V plan to Collaborative (Completed) – After the experimental design, recruitment strategy, and impact evaluation plan were developed, Nexant presented a detailed EM&V plan to the Collaborative and answered any questions they had about the proposed evaluation methodology.

Select control group – Nexant will select the control group using a propensity score match to find non-participant customers who have similar load shapes to program participants. For this process, Nexant will use AMI data (and perhaps other variables depending on what is available) to identify control group customers with similar electricity usage on event-like days. Ideally, a full year of AMI data will be available at the time of control group selection. In this procedure, Nexant will use a probit model to identify control customers who were similar to treatment customers in terms of observable characteristics such as hourly use and average daily use for proxy event days. The probit model will estimate a score for each customer with the assumption that observable variables affect a customer's decision to participate in PTR. A probit model is a regression model designed to estimate probabilities—in this case, the probability that a customer would enroll. The propensity score can be thought of as a summary variable that includes all relevant observable information about whether a customer would enroll in the program. Nexant will match each customer in the participant population with the customer in the non-participant population that has the closest propensity score.

Estimate ex post load impacts – After matching and validating the control groups for participating customers, Nexant will estimate load impacts using a difference-in-differences methodology. Nexant will calculate the estimated impacts as the difference in average loads between participant and control customers on each event day, minus the small difference between the two groups on the chosen event-like days. This calculation will control for residual differences in load between the groups that were not eliminated through the matching process, thus reducing bias.

Present results to Collaborative – Once the pilot has been implemented and ex post load impacts have been produced, Nexant will prepare a presentation summarizing the results and share it with the Collaborative.

3 Process Evaluation

Nexant's process evaluation will collect information from pilot participants, non-pilot participants, and pilot implementation staff. Leveraging insights from the impact evaluation, the process evaluation's goals are 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 PTR if it is implemented as a customer program.

Specifically, the evaluation will address the following research questions:

- Does the pilot's bill credit motivate behavior change?
- Did Duke Energy calculate baselines and bill credits correctly?
- Was the marketing campaign successful?
- 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 cost-effective, reasonable enhancements, if any, could be made to continue PTR?

Process evaluation activities for the DEK PTR pilot rely on a mix of interviews and surveys designed to obtain information sufficient to inform the research objectives itemized above. Billing data (participants' hourly electricity usage and bill credits) and pilot marketing materials from Duke Energy are also required for the process evaluation. Table 1 indicates the data collection activity that will support each of the research questions.

Table 1: Process Evaluation Research Questions and Data Sources

Process Evaluation Objective	Pilot Marketing Materials	Interviews with Staff	Marketing Surveys	Post-event Surveys	Billing Data
Does the bill credit motivate behavior change?			X	X	
Were baselines and bill credits calculated correctly?					X
Marketing campaign successful?	X	X	X		
Participants educated and motivated to use the program?		X		X	
Notifications reaching participants for effective response?		X		X	X
What enhancements should be made?	X	X	X	X	X

Process evaluation activities include the following:

Conduct in-depth interviews with key pilot stakeholders – Our interviews will include staff with responsibilities that cover pilot management, marketing, billing, and customer service, and/or other utility staff with insight into pilot planning, operations, emerging issues, and customer experience. Our budget includes 5 interviews will be conducted by telephone, where interviews may last anywhere between 30 and 90 minutes, depending on the interview agenda specific to each interviewee. These interviews will be a primary source for identifying pilot strengths and weaknesses overall, but they will also be an important perspective to consider in assessing the success of the marketing campaign, participant education, and event notification. This activity will be initiated with Nexant developing a draft interview guide for all planned interviews, soliciting input on the draft guides from Duke Energy, and revising the guides into final documents. After the interviews are conducted, interview notes will be coded to facilitate review and key findings will be written and documented in the evaluation report.

Review marketing and compare with that of other PTR programs (Completed) – Nexant's process evaluation staff reviewed Duke Energy's marketing materials and channel strategies and conducted a comparison with the materials, strategies, and pilot/program characteristics used in other PTR programs in North America. This cross-jurisdictional benchmarking will provide Duke Energy with important context within which to place their pilot outcomes and may point to changes that would benefit a full program roll-out. In short, while the marketing surveys described below will provide some absolute metrics as to the success of the marketing effort, this review will serve to bench those metrics against the experience and strategies of other utilities.[2]

Implement marketing surveys (Completed) – A survey of the population that was targeted for enrollment will be another key source of information for assessing the success of the marketing campaign. Two sub-populations were surveyed: participants and non-participants. All pilot participants were invited to complete a survey that asked about what marketing channels they were aware of, what aspects of the pilot attracted them, and what motivated them to participate. A sample of non-participants[3] were asked about whether they were aware of marketing for the pilot. "Non-aware" non-participants were briefly queried to collect information on what other marketing channels (if any) would have been more effective for communicating with them. Nexant surveyed the "aware" non-participants for reasons why they declined to participate, and to gauge the extent to which they have any interest in DSM programs and pilots, and if so, what their interests are. The survey inquired whether the bill credit was sufficient or insufficient as an incentive for participating. The survey also inquired about satisfaction with Duke Energy to see how well it may correlate with the choice to participate, and what concerns both participants and non-participants may have with participating in the program. Additionally, the survey collected household demographics to investigate how demographics may vary across the participants

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[2] Note that the marketing success of the DEK PTR pilot may also be expressed in terms of cost effectiveness of the marketing spend. If Duke Energy can provide Nexant with the marketing costs of the pilot and the value of the energy saved by the pilot, we can also report the success of the pilot's marketing strategies on the basis of cost effectiveness.

[3] We suggest sampling 800 customers that were in the population of DEK customers who received marketing for the pilot but did not elect to participate; given our experience with surveying residential Duke Energy "non-participant" customers, we expect to receive at least 200 completed non-participant surveys.

and non-participants, and aware non-participants and non-aware non-participants. It may be that certain communications channels are more or less effective with different demographic groups. These data could produce insights to be used in rolling out a PTR program with revised marketing messages and/or channels that result in fewer customers falling into the non-aware non-participant and/or aware non-participant groups.

Conduct post-event surveys (1 of 2 Completed) – Nexant will conduct two post-event surveys: one in winter (completed), and one in summer. Immediately following a single PTR event (each season), we will conduct a mixed-mode survey to obtain feedback from participants to estimate awareness of the event and to collect information on actions customers take to reduce load and their motivations for those actions. The post-event surveys will also collect 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 program works. The post-event survey will assess satisfaction with the bill credit offering, with the event notification process, and of the pilot overall.

To ensure that the survey accurately assesses the experiences of participants before and during a PTR event, the surveys will need to be finalized and fully programmed prior to the beginning of the season so that it can be deployed within 24 hours of an event. Working with Duke Energy and the impact evaluation team, we will prepare random samples of participant households for each season to receive the post-event survey. This sample will be linked to the survey software and ready to deploy. Any participants for whom we have email addresses will receive an email invitation with a link to the survey URL. Up to half of the expected sample (35 households) will be surveyed by phone to ensure completes by both modes. Depending on the design of the pilot pertaining to event triggers and any minimum/maximum number of events that can be called, we propose to carefully consider the timing of the post-event survey, whether to conduct the survey at the earliest possible opportunity each season, or to wait for an event in the middle of the season (after participants have already experienced some events), or to target the end of the season.

Examine participant response data – In addition to the post-event survey that will gather data about PTR event awareness, experience, and attitudes, Nexant will also examine the billing data to search for patterns of non-event response. Depending what patterns of non-response there may be, they could identify different kinds of problems. For example, if the same relatively small number of customers don't respond to the majority of events, it could be because they don't care or because the notification channel is not effective (e.g., it's going to an email account they only check once a week). Or, if we find that 90% of all participants respond on all events but one, where there is only 50% response, then it would indicate there was some kind of technical breakdown (e.g., a delivery problem somewhere in the notification system). Another potential scenario is that it may be that the percentage of customers responding to the notification goes up and down a lot across events but is random across customers, it might indicate that notifications are more or less effective depending on the day they are sent, perhaps holding steady Monday through Wednesday and falling off starting Thursday afternoon.

It will be important to examine the customer response data for any of these telling patterns that can yield useful evaluation insights for program planning.[4]

Validate load reduction and bill credit calculations – Nexant will request all the hourly electric interval data necessary and documentation of baseline calculation procedures to validate Duke Energy's load reduction estimates for each event and all bill credits applied to monthly billing statements. This will be a straightforward application of Duke Energy's business procedures to validate their calculations of bill credits earned by each participant. We must state with caution, however, that this activity is not the same as the potential research question, "were pilot participants properly identified for bill credits and paid accordingly?" with the view towards comparing the bill credits paid out to individuals to their individual customer load impacts. PTR load impacts can only be assessed at the pilot level, rather than the individual customer level – if it were possible to do so, PTR programs would pay credits based on those load impacts rather than baselines.

[4] It will also be possible to validate the self-reported response rates recorded in the post-event surveys using this data.

4 Timeline & Budget

The project timeline is driven primarily by the schedule DEK has outlined for the PTR pilot, including presentations to the collaborative. Many of the evaluation tasks have been completed as of this update to the evaluation plan. However, they are included in the table below in order to reflect the comprehensive scope of work for the evaluation.

Task	Budget	Due Date[5]
Project Kickoff Meeting	$2,950	Completed
Power Analysis Data Management	$3,925	Completed
Perform Power Analysis	$4,275	Completed
Develop Experimental Design Recommendation	$900	Completed
M&V Presentation to Collaborative	$5,200	Completed
Marketing Materials Review	$5,380	Completed
Field Marketing Survey	$15,100	Completed
Winter Post Event Surveys	$10,075	Completed
Project Calls & Meetings	$3,600	Ongoing
Ex Post Analysis Data Management	$3,925	7/31/2021
Match Control Group Selection	$7,850	7/31/2021
Ex Post Analysis - Post Winter 2020/2021	$16,050	7/31/2021
Summer Post Event Surveys	$10,075	7/31/2021
In-Depth Interviews with Key Pilot Stakeholders	$6,300	9/30/2021
Ex Post Analysis - Post Summer 2021	$16,050	1/31/2022
Validate Load Reductions Calculations	$3,250	1/31/2022
Participant Response Data Analysis	$5,280	1/31/2022
Draft and Final Report	$12,000	3/31/2022
Presentation to Collaborative	$2,930	TBD
Total Budget	**$135,115**	

[5] Due dates are subject to change based on pilot and evaluation needs agreed upon between Duke Energy and Nexant.

5 Kentucky Peak Time Rebate Pilot Cost & Schedule

Milestone	Completion Date	Milestone Payment
Project Kickoff Meeting	8/1/2018	$2,950
Power Analysis Data Management (optional)	8/31/2020	$3,925
Perform Power Analysis	8/31/2020	$4,275
Develop Experimental Design Recommendation (optional)	8/31/2020	$900
M&V Presentation to Collaborative	10/1/2018	$5,200
Project Calls & Meetings	4/30/2022	$3,600
Ex Post Analysis Data Management	7/31/2021	$3,925
Match Control Group Selection (optional)	7/31/2021	$7,850
Ex Post Analysis - Post Winter 2020/2021	7/31/2021	$16,050
Ex Post Analysis - Post Summer 2021	1/31/2022	$16,050
Validate Load Reductions Calculations	1/31/2022	$3,250
In-Depth Interviews with Key Pilot Stakeholders	9/30/2021	$6,300
Summer Post Event Surveys	7/31/2021	$10,075
Marketing Materials Review (optional)	10/31/2020	$5,380
Field Marketing Survey	10/31/2020	$15,100
Winter Post Event Surveys	2/28/2021	$10,075
Participant Response Data Analysis (optional)	1/31/2022	$5,280
Draft and Final Report	3/31/2022	$12,000
Presentation to Collaborative	TBD	$2,930
Maximum Payments		**$135,115**

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Status Update for Duke Energy Kentucky Energy Efficiency and Demand Response Programs; 2021-2023

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

Residential Customer Programs	Program/Measure	Last Evaluation completion	Next Evaluation ==>	Q1 2021	Q2 2021	Q3 2021	Q4 2021	Q1 2022	Q2 2022	Q3 2022	Q4 2022	Q1 2023	Q2 2023	Q3 2023	Q4 2023
Low Income Neighborhood	Neighborhood	2/27/2015			M&V	M&V	M&V	Report							
Low Income Services	Refrigerator Replace		TBD												
	Weatherization/Payment Plus	7/31/2013													
My Home Energy Report	MyHER	2/1/2014									M&V	M&V	Report		
Residential Energy Assessments	HEHC	8/7/2020													
Residential Smart Saver®	HVAC	9/21/2015					M&V	M&V	M&V	M&V	Report				
	Specialty Bulbs/Online Savings Store	6/22/2015				M&V	M&V	M&V	Report						
	Water Measures	9/25/2020*													
	Multi-Family	12/26/2019						M&V	M&V	M&V	M&V	M&V	Report		
Power Manager		8/13/2020							M&V	M&V	M&V	Report			
Peak Time Rebate Pilot	Peak Time Rebate	N/A		M&V	M&V	M&V	M&V	Report							
Non-Residential Customer Programs	**Program/Measure**			**Q1 2021**	**Q2 2021**	**Q3 2021**	**Q4 2021**	**Q1 2022**	**Q2 2022**	**Q3 2022**	**Q4 2022**	**Q1 2023**	**Q2 2023**	**Q3 2023**	**Q4 2023**
Small Business Energy Saver		4/7/2017							M&V	Report					
Smart $aver® Non-Res, Custom		3/1/2016		M&V	M&V	Report									
Smart $aver® Non-Res, Prescriptive		7/24/2019										M&V	M&V	M&V	M&V
PowerShare		2/14/2017					M&V	M&V	Report						
Pay For Performance		N/A	TBD												

[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.
* Revised report

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

REPORT

2019 Power Manager Evaluation Report

Submitted to Duke Energy Kentucky

August 31, 2020

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1 Executive Summary

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

1.1 Impact Evaluation Key Findings

The impact evaluation is based on a randomized control trial. All Power Manager program participants who had a load control device installed by the start of the summer were randomly assigned to one of six groups – a primary group made up of approximately 55% of the population, and five research groups, each made up of 9% of the population. During each event, one or more of the smaller research groups (each comprising approximately 1,000 customers) is withheld as a control group in order to provide an estimate of energy load profiles absent a Power Manager event. During the summer of 2019, approximately 12,000 households were actively participating in Power Manager and had load control devices.

Table 1-1 summarizes the demand reductions attained during each event in 2019. Impacts were estimated using an RCT approach for all but two events. By design, the PJM test event called on September 10 dispatched the full program population and did not withhold a control group. The event on September 12 was intended to withhold a control group, but instead dispatched all participants due to programming error. As a result, a RCT design could not be applied. Instead, impacts for these events were estimated using a within-subjects approach, summarized in Section 5. The event called on July 10 included a side-by-side test of emergency and normal operations in order to estimate the incremental demand reductions due to emergency operations.

A few key findings are worth highlighting:

- Demand reductions are -0.9 kW per household for the average general population event.
- On average, emergency shed produces impacts (-0.98 kW) that are similar to normal shed events.
    - Emergency shed impacts are 0.08 kW greater than normal shed impacts.
- In general, the magnitude of demand reductions grows when temperatures are higher and resources are needed most.
- The difference in impacts between customers who signed up for the moderate and high load control options is minimal and within the range of uncertainty.

- The time-temperature matrix predicts -1.06 kW load reduction per household for a 1-hour event beginning at 4:00 PM. Because this value represents the expected impact achievable during a "typical" event at 94°F, Nexant recommends its use as the deemed savings value for 2019.
- The greatest impact was observed during the August 19 emergency shed event, where the average customer shed was -1.21 kW.

Table 1-1: Load Impacts for Individual Events

Event Date	Type	Event Period	Reference Load	Impact	90% Confidence		% Impact	90% Confidence		Daily Max
					Lower	Upper		Lower	Upper	
7/10/2019	Emergency	4PM - 5PM	3.28	-0.99	-0.91	-1.08	-30%	-33%	-28%	91°F
	Normal	4PM - 6PM	3.28	-0.61	-0.52	-0.70	-19%	-21%	-16%	91°F
7/19/2019	Emergency	4PM - 5PM	3.36	-0.97	-0.83	-1.10	-29%	-33%	-25%	92°F
	Normal	4PM - 6PM	3.44	-0.85	-0.76	-0.94	-25%	-27%	-22%	92°F
8/19/2019	Emergency	4PM - 5PM	3.73	-1.21	-1.09	-1.34	-33%	-36%	-29%	94°F
	Normal	4PM - 6PM	3.80	-1.17	-1.08	-1.27	-31%	-33%	-28%	94°F
8/20/2019	Normal	12PM - 1PM	2.81	-0.42	-0.34	-0.51	-15%	-18%	-12%	90°F
	Normal	1PM - 2PM	2.88	-0.47	-0.39	-0.55	-16%	-19%	-13%	90°F
	Normal	2PM - 3PM	2.95	-0.23	-0.15	-0.32	-8%	-11%	-5%	90°F
9/10/2019	PJM Test	4PM - 5PM	3.34	-1.09	-0.99	-1.18	-33%	-35%	-30%	95°F
9/12/2019	Emergency	4PM - 5PM	3.31	-0.98	-0.89	-1.05	-29%	-32%	-27%	93°F
	Normal	4PM - 6PM	3.37	-0.83	-0.76	-0.89	-25%	-26%	-23%	93°F
9/30/2019	Emergency	4PM - 5PM	3.09	-0.75	-0.62	-0.87	-24%	-28%	-20%	94°F
	Normal	4PM - 6PM	3.17	-0.71	-0.62	-0.80	-22%	-25%	-19%	94°F
Average General Population Event			**3.48**	**-0.90**	**-0.85**	**-0.96**	**-26%**	**-24%**	**-28%**	**93°F**

1.2 Demand Reduction Capability

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

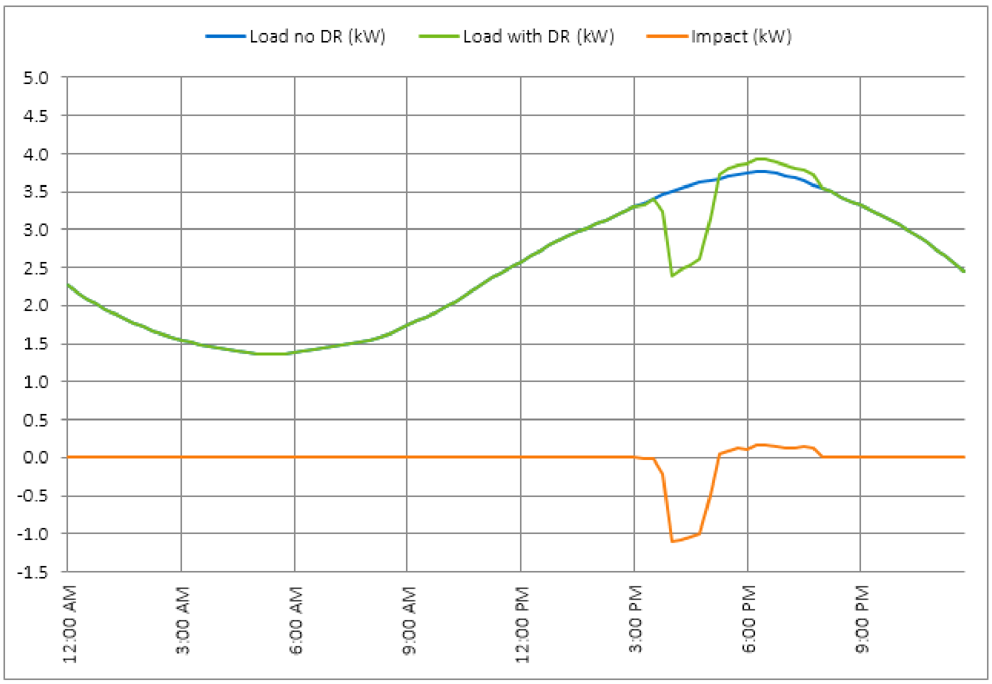
In an ideal program year, a large number of events would be called under a variety of different weather conditions, dispatch windows and cycling strategies so that demand reduction capability could be estimated for a wide range of operating and planning scenarios. In actuality, opportunities for program events can be sporadic and based on uncertain weather projections, such that they occur infrequently and under fairly similar conditions. The time temperature matrix is based on the eleven 2019 events on five event days with daily maximum temperatures ranging from 90°F to 95°F.

Figure 1-1 shows the demand reduction capability of the program if emergency shed becomes necessary on a day with a maximum temperature of 94°F for a 1-hour event duration. Individual customers are expected to deliver -1.06 kW demand reduction. Because there are approximately 11,664 customers, the expected aggregate system load reduction is -12.4 MW.

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

Inputs	
Dispatch Type	Emergency Dispatch
Option	Overall
Event Start	4 PM
Event Duration (Hours)	1
Daily Max Temp (°F)	94
# Customers	11,664

Event Window Average Impacts		
Load without DR	3.56	kW per customer
Load with DR	2.50	kW per customer
Impact per customer	-1.06	kW per customer
Impact (MW)	-12.35	MW
% Impact	-29.7	%



1.3 Process Evaluation Key Findings

The process evaluation was designed to inform efforts to continuously improve the program by identifying strengths and weaknesses, opportunities to improve program operations, adjustments likely to increase overall effectiveness, and sources of satisfaction or dissatisfaction among participating customers. The process evaluation consisted of telephone interviews with key program managers and implementers, a post-event survey implemented immediately after an event, and a nonevent day survey implemented on a day with event-like temperatures but without a load control event being called.

Key findings from the process evaluation include:

- 68 Power Manager participants were surveyed within 24 hours of the August 19 event, which had a high temperature of 94°F with a heat index of 97°F.
- 74 Power Manager participants were interviewed during a hot nonevent day, July 18, which had a high of 89°F with a heat index of 98°F. The nonevent day survey was used to establish a baseline for comfort, event awareness, and other key metrics.
- Only 11% of respondents on the event day reported that their homes were uncomfortable, while all of them experienced a load control event that afternoon. By comparison, 14% of Power Manager customers surveyed on a hot nonevent day reported they felt uncomfortably hot. This small difference is not statistically significant—we cannot conclude that there is a difference in customers' thermal discomfort due to Power Manager events.
- Sixty-four percent of Power Manager customers are likely to recommend the program to others, and 79% are likely to remain enrolled. Event respondents are significantly more likely than non-event to report that they intended to remain enrolled in the Power Manager program
- Sixty-five percent of all respondents are familiar with the Power Manager program. Many suggestions (10 of 23; 43%) for improvement from customers spoke to perceived communication gaps from Duke Energy.
- There were no differences in levels of agreement between event and non-event participants with statements about whether or not an event had occurred recently, about any thermal discomfort, nor about perceptions of the cause of any discomfort. In short, customers are not able to reliably perceive Power Manager curtailment events.
- The current approach to communications amongst program stakeholders has been effective in building professional collegiality and helps to make the program run smoothly, especially when problems arise.
- The "Assets" module of the Yukon system offers opportunities to increase granularity of load control events. As customer saturation becomes an increasingly pertinent issue, "Assets" may offer a way to address it.

2 Introduction

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

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

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

2.1 Key Research Questions

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

2.1.1 Impact Evaluation Research Questions

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

2.1.2 Process Evaluation Research Questions

- What is the extent to which participants are aware of events, bill credits, and other key program features?
- What is the participant experience during events?
- What are the motivations and potential barriers for participation?
- What are the processes associated with operations and program delivery?

- What are program strengths and areas for potential improvement?

2.2 Program Description

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

Power Manager events typically occur from May through September in DEK territory, but are not limited to these months. Participants receive financial incentives for their participation based on the cycling option they are currently enrolled in. Upon program enrollment, Power Manager customers select either moderate or high load control. Approximately 61% of Power Manager devices in DEK are enrolled in the moderate load control option and the remaining 39% are enrolled in the high load control option.[1] The payments received by participants include a one-time installation credit – $25 for moderate load control and $35 for high load control – plus bill credits for cycling events. The bill credits for 2019 participation were $18 for the high cycling option, $12 for the moderate cycling option, and $6 for the low cycling option..

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

Table 2-1: DEK Cycling Levels by Event Type

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

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

2.3 Participant Characteristics

Duke Energy serves approximately 130,000 residential customers in DEK service territory, located in the northern portion of Kentucky. By the start of summer 2019, slightly more than 12,000 devices were part of Power Manager.[2] Of those units, approximately 61% were enrolled in the moderate load control option.

Table 2-2: Device Count by Control Option

Control Option	# Accounts	# Devices	% of Program
Low	17	17	0.1%
Moderate	7,164	7,417	61.4%
High	4,483	4,636	38.5%
Total	**11,664**	**12,070**	**100%**

Figure 2-1 depicts program enrollment over time and only includes customers who are currently enrolled in the program.

Figure 2-1: DEK Power Manager Program Participation Growth

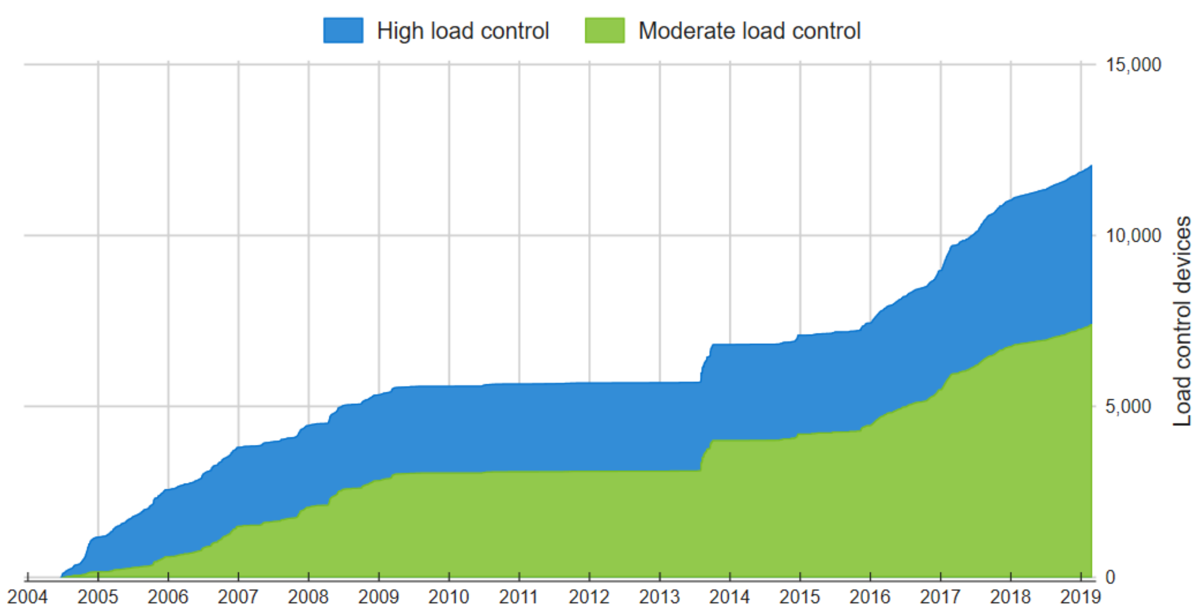
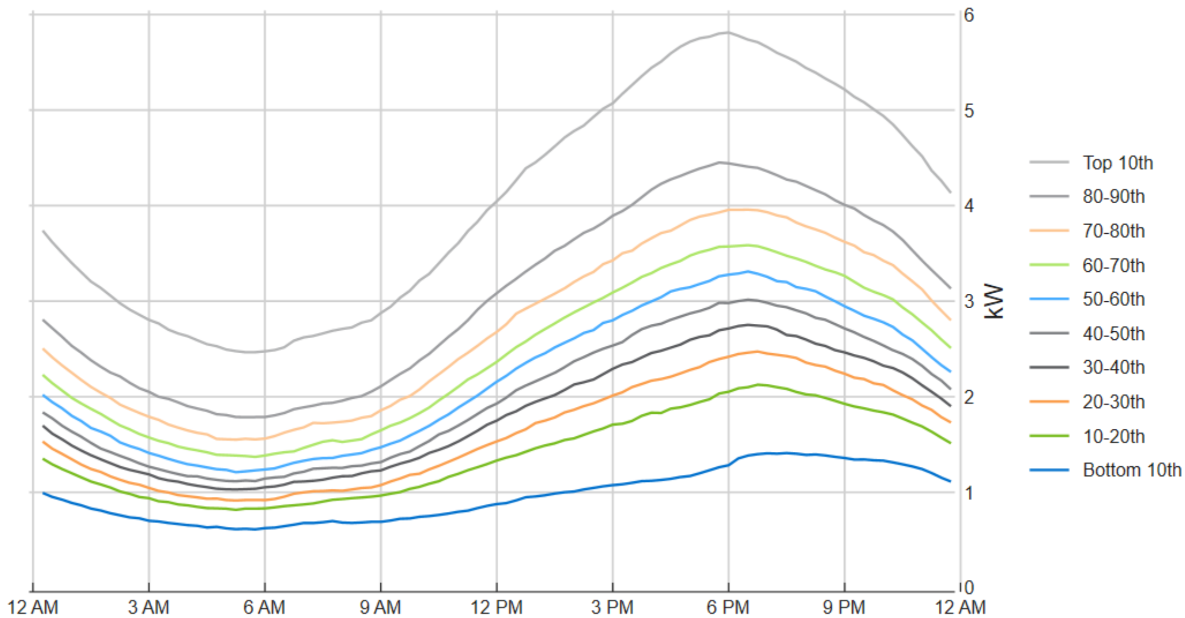


Figure 2-2 shows the hourly household loads for different customer groups. The customers were classified into ten equally sized groups, known as deciles, based on their household consumption during hot, non-event days. Each line represents the hourly loads for the average customer in each decile.

[2] 11,664 accounts were enrolled in the program, totaling 12,070 load control devices (1.03 devices per count).

Figure 2-2: Household Loads by Size Decile



Household loads varied substantially, reflecting different occupancy schedules, comfort preferences, and thermostat settings.[3] As with any program, some enrollees use little or no air conditioning during late afternoon hours on hotter days. These customers are, in essence, free riders. The bulk of the costs for recruitment, equipment, and installation have already been sunk for these customers and, as a result, removing these customers may not improve cost effectiveness substantially. However, given the availability of smart meter data, we recommend assessing nonparticipant afternoon loads on hotter days prior to marketing in order to target customers who are cost effective to enroll.

2.4 2019 Event Characteristics

Duke Energy dispatched Power Manager events on seven days in 2019. All general population events occurred between 4:00 PM and 6:00 PM. Emergency shed was dispatched six times: five during a general population event window, and once as a result of PJM required test events. All of the emergency events were dispatched between 4:00 PM and 5:00 PM. The side-by-side dispatch framework on July 10 allowed for direct comparison of emergency shed performance compared to general dispatch. Additionally, on August 20 three cascading events were called back-to-back-to-back. Table 2-3 summarizes 2019 event conditions.

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

Table 2-3: 2019 Event Operations and Characteristics

Event Date	Event Type	Event Window	# Customers	Control Group	Daily Max	Notes
7/10/2019	Emergency	4PM - 5PM	1,092	10,584	91°F	Feeder 1 dispatched
	Normal	4PM - 5PM	1,080	10,572	91°F	Feeder 2 dispatched
7/19/2019	Emergency	4PM - 5PM	1,057	1,080	92°F	Feeder 5 dispatched (except high option Gen1 devices)
	Normal	4PM - 6PM	9,527	1,080	92°F	Feeders 1, 3, 4, 10 dispatched
8/19/2019	Emergency	4PM - 5PM	1,065	1,092	94°F	Feeder 4 dispatched
	Normal	4PM - 6PM	9,507	1,092	94°F	Feeders 2, 3, 5, 10 dispatched
8/20/2019	Normal	12PM - 1PM	1,092	8,438	90°F	Feeder 1 dispatched
	Normal	1PM - 2PM	1,080	8,438	90°F	Feeder 2 dispatched
	Normal	2PM - 3PM	1,054	8,438	90°F	Feeder 3 dispatched
9/10/2019	PJM Test	4PM - 5PM	11,664	-	95°F	All customers dispatched
9/12/2019	Emergency	4PM - 5PM	1,057	-	93°F	Feeder 5 dispatched No control group
	Normal	4PM - 6PM	10,607	-	93°F	Feeders 1, 2, 4, 10 dispatched No control group
9/30/2019	Emergency	4PM - 5PM	1,080	1,065	94°F	Feeder 2 dispatched
	Normal	4PM - 6PM	9,519	1,065	94°F	Feeders 1, 3, 5, 10 dispatched

3 Methodology and Data Sources

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

3.1 Data Sources

The impact analysis relied on four key datasets:

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

The data was provided by Duke Energy to Nexant in a single data request, except for the weather data, at the end of the 2019 Power Manager season. The weather data was sourced from the NOAA website. All subsequent analysis relied on a combination of the datasets.

3.2 Data Management and Cleaning

Thorough data cleaning and validation of all data was performed to ensure impacts were estimated using only reliable observations from customers who were properly dispatched on event days. The analysis benefitted from a full population-based approach, allowing Nexant to logically exclude customers having incomplete or questionable load data, while simultaneously maintaining large enough sample sizes to produce highly precise estimates.

During the course of the analysis, Nexant uncovered a combination of feeder programming and Yukon system errors that caused glitches in a number of event dispatches. In general, the affected events were characterized by limited portions of a specific feeder group that were not dispatched according to program planning, or otherwise displayed signs of their devices not being controlled during an event as planned. In these cases, the analysis was largely unaffected, as Nexant was able to detect and exclude specific households whose systems did not behave as expected on given event days. One particular event, called on September 12, was affected by an entire feeder being erroneously dispatched, rather than withheld as control according to event planning. In this case, absent a valid control group, Nexant applied a within-subjects analysis approach rather than the intended RCT design. Table 3-1 summarizes the dispatch issues that affected the 2019 Power Manager events.

Table 3-1: Summary of Dispatch Issues

Affected Segment(s)	Affected Event(s)	Summary of Issue	Resolution
Feeder 2	7/10/2019	Feeder 2 devices ramped in randomly over the first 30 minutes of the event, rather than instantaneously.	None; analysis unaffected.
Feeder 5	7/19/2019	High cycling option customers who had Gen1 devices were not dispatched as planned due to programming error.	Affected segment was excluded from the analysis for this event only.
Feeder 3	9/12/2019	Feeder 3 customers were dispatched rather than being withheld as control as planned.	Within-subjects approach, rather than RCT, was used to estimate impacts for this event.
Customers with outlier usage	7/19/2019 8/19/2019 9/30/2019	A portion of control groups observed abnormal usage patterns during events, resulting in biased reference loads.	Customers with abnormal usage (10%) were removed from the analysis.

Nexant was able to effectively work around the issues described in Table 3-1 by excluding affected customers from the analysis or, in the case of the September 12 event, adjusting the analysis approach to fit the reformed data. The result is an aggregation of statistically valid event-level impact estimates, despite the obstacles described above.

3.3 Randomized Control Trial Analysis

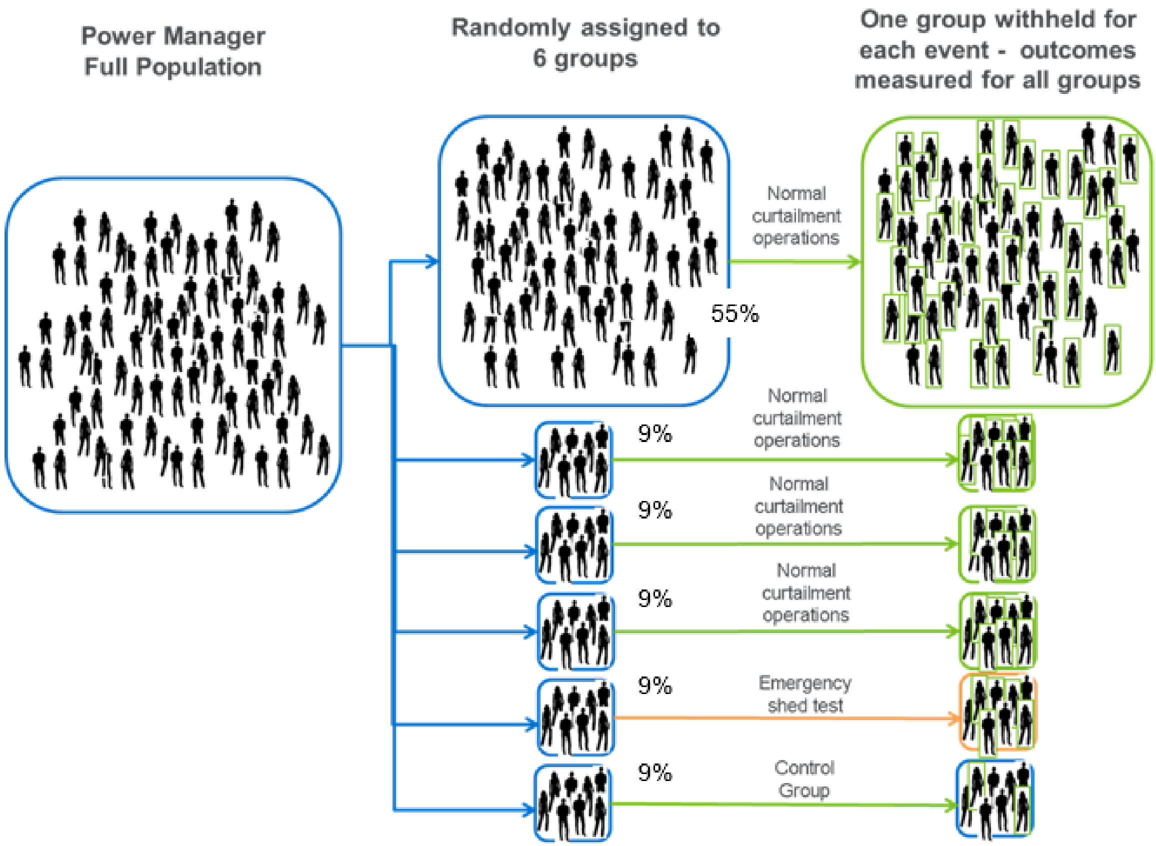
Randomized control trials are well-recognized as the gold standard for obtaining accurate impact estimates and have several advantages over other methods:

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

The RCT design randomly assigns the Power Manager population into six groups – a primary group consisting of 55% of the population and five research groups, each consisting of 9% of the population. For each event, groups are assigned as either treatment or control according to Duke Energy's operational plan.[4] All devices assigned to the treatment group are controlled during the event window, while devices assigned to the control group are withheld and continue to operate normally throughout the event period. As a result of random group assignment, the only systematic difference between the treatment and control groups is that one set of customers is curtailed while the other group was not. Figure 3-1 shows the conceptual framework of the random assignment.

[4] By design, the PJM-required test event called on September 10 dispatched all program participants and therefore, no control group was withheld.

Figure 3-1: Randomized Control Trial Design



All customers who were enrolled in the program and had addressable load control devices installed by the start of the 2019 summer were randomly assigned into six distinct groups. Table 3-2 summarizes the feeder assignment, number of accounts, and number of devices in each group. By design, the primary general population group includes 55% of participants, approximately 6,300 participants. The remaining five research groups each include 9% of participants, or roughly 1,050 customers each. DEI customer counts are included for reference.

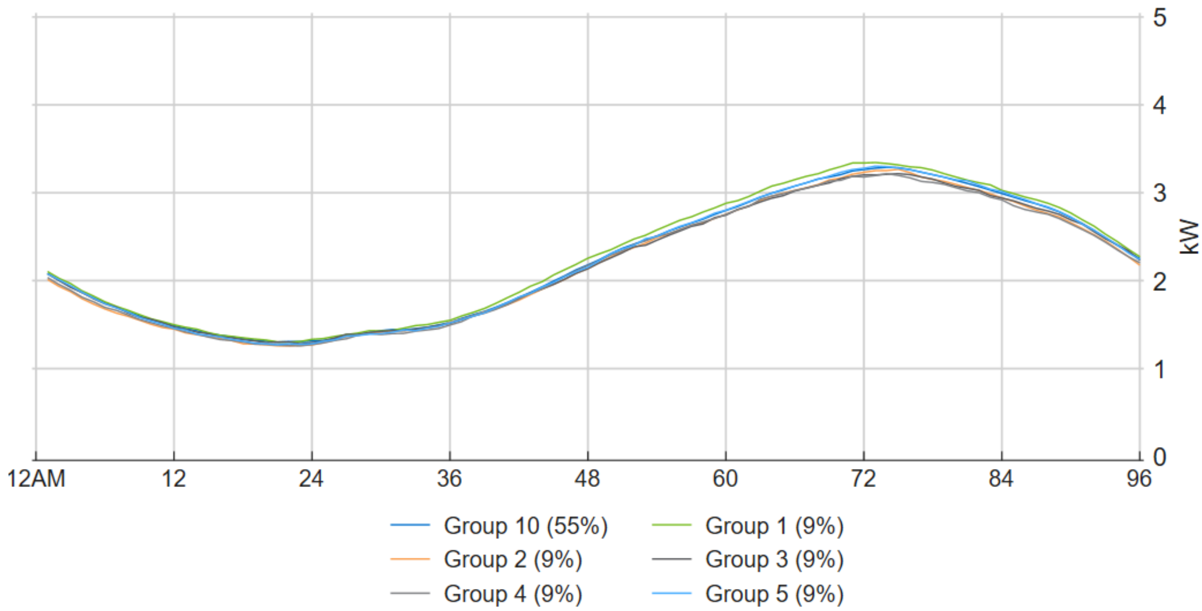
Table 3-2: Feeder Group Assignment

Feeder Group	DEK			DEI		
	# Accounts	# Devices	% of Population	# Accounts	# Devices	% of Population
10	6,316	6,548	55%	40,002	42,026	75%
1	1,092	1,133	9%	2,637	2,783	5%
2	1,080	1,113	9%	2,636	2,743	5%
3	1,054	1,078	9%	2,628	2,749	5%
4	1,065	1,101	9%	2,658	2,794	5%
5	1,057	1,097	9%	2,655	2,781	5%
Total	**11,664**	**12,070**	**100%**	**53,216**	**55,876**	**100%**

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

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

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



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

Impacts are calculated simply by taking the difference in loads between the treatment and control groups. However, additional statistical metrics, such as the standard error, are calculated in order to evaluate whether these differences are meaningful, as well as whether different cycling strategies could produce significantly different impacts. The standard error is then used to calculate the 90% confidence bands, which are additional measures used to describe the statistical accuracy of the impact estimate. Standard error is calculated using the formula shown in Equation 3-1.

Equation 3-1: Standard Error Calculation for Randomized Control Trial

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

Where:

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

3.4 Process Evaluation Methodology

Table 3-3: Summary of Process Evaluation Activities

Data Collection Technique	Description of Analysis Activities Using Collected Data	Sample Size	Precision / Confidence Level
Document and database review	Review of program documentation, including program manuals, customer communications, as well as the program database. These materials provide evidence of program operations, as well as how these operations are aligned with program savings and other goals.	NA	NA
Interviews of key contacts	Interviews with Duke Energy staff will document program processes, identify strengths/weaknesses and provide a foundation for understanding the customer experience.	4	NA
Post-event survey	Phone and web survey of Power Manager customers who experienced an event, to assess event awareness, satisfaction, customer experience and comfort during events, and motivations for participation.	68	90/10
Nonevent survey	Phone and web survey of Power Manager customers for whom an event was not called. Nonevent survey data provide a baseline with which to compare post-event responses, to establish levels of event awareness, satisfaction, customer experience and comfort during events, and motivations for participation.	74	90/10

The process evaluation included four primary data collection tasks in order to achieve the research objectives listed in Table 3-3.

Review program documentation and analyze program database—Process evaluation should be guided by a thorough understanding of the primary activities of any program, the marketing messages used to recruit and support participants, and any formal protocols that guide processes. For demand response programs, it is particularly important to understand the event notification procedures, any opt-out processes that exist, and how bill credits are communicated and applied. It is also important to understand how the program opportunity is communicated and the types of encouragement provided to participating households. These communications are often the source of program expectations, which can affect participant satisfaction. To support this task, Nexant requested copies of internal program manuals and guidelines as well as copies of marketing materials. The program database analysis consisted of an examination of the distribution of bill credits and incentive payments, program tenure, load curtailed per household, and other variables that inform indications of program progress.

In-depth interviews with key program stakeholders— Program stakeholders include program staff and implementation contractors with insight into program plans and operations, emerging issues, and the expected customer experience. The interviews conducted for the 2019 evaluation informed the customer survey design and confirmed the evaluation team's understanding of key program components.

Goals of the interviews included:

- Understanding marketing and recruitment efforts, including lessons learned about the key drivers of enrollment;
- Identifying "typical" Power Manager households, including characteristics of households that successfully participate for multiple years;
- Describing event processes;
- Understanding opt-out procedures;
- Understanding the customer experience;
- Confirming enrollment incentive levels and how event incentives are explained to customers;
- Identifying any numeric or other program performance goals (kW enrolled, number of households enrolled, notification timelines) established for Power Manager;
- Describing the working relationship between Duke Energy and the program implementer including the allocation of program responsibilities; and
- Understanding emergent and future concerns and plans to address them.

Post-event surveys—Guided by information obtained from stakeholder interviews and a review of program guidance documents (including any notification protocols), Nexant developed a survey for participating customers that was deployed immediately following a demand response event. The survey was designed to be deployed via phone and email to maximize response rate in the 24- to 48-hour window following an event. The post-event survey addressed the following topics:

- Awareness of the specific event day and comfort during the event;
- Any actions taken during the event to increase household comfort. Do participants report changing AC settings, using other equipment (including window units, portable units, or ceiling fans) to mitigate heat buildup? Were participants home during the event? Are they usually home during that time period?

- Satisfaction with the Power Manager program, the event bill credits earned, and the number of events typically called;
- Expectations and motivations for enrolling: What did participants expect to gain from enrollment? To what extent are they motivated to earn incentive payments versus altruistic motivations such as helping to address electricity shortfalls during periods of high peak demand and/or reducing the environmental effects of energy production?; and
- Retention and referral: Do participants expect to remain enrolled in the program in future years? Would they recommend the program to others?

To ensure that the survey accurately assessed the experiences of customers during a curtailment event, questions were finalized and fully programmed prior to the event, to enable deployment within 24 hours after an event. Working with Duke Energy, Nexant prepared a random sample of participant households prior to event notification to receive the post-event survey. This sample was linked to the survey software and ready to deploy as soon as the event ended. Any participants for whom email addresses were available received an email invitation with a link to the survey URL. Up to half of the expected sample (34 households) were surveyed by phone to ensure completes by both modes and improve representativeness.

Nonevent program surveys—In addition to the post-event survey, the evaluation team prepared a survey to be deployed immediately following a hot, nonevent day. This nonevent day survey was nearly identical to the post-event survey to facilitate comparison with the results of the event day survey, with only references to specific event awareness removed. Like the post-event survey, the nonevent survey was developed, approved, and programmed prior to the demand response season to enable immediate deployment on a sufficiently comparable nonevent day. The nonevent survey sample was developed prior to the demand response season and linked to the programmed survey. Similar to the post-event survey, a survey link was sent via email to participants with email addresses, simultaneous with the phone deployment, improving the representativeness of the sample.

4 Randomized Control Trial Results

One of the primary goals of the impact evaluation is to understand the load impacts associated with the Power Manager program under a variety of temperature and event conditions. General population events were targeted to understand the available load reduction capacity under a variety of temperature conditions during normal operations, while emergency shed events were used to demonstrate the program's capacity for short-duration events under more extreme conditions. In addition, one event day was used to dispatch groups of customers under normal operations and emergency shed operations simultaneously, allowing for a side-by-side comparison of impacts under the two scenarios. Also, three different one-hour cascading events were called on August 20. The events were called one hour apart, starting at noon, in order to gauge the effect of event timing on impacts. Section 4.1 presents overall program results for all event days, including general population and emergency shed events. Section 4.2 details the results of the side-by-side comparison of normal operations vs. emergency shed. Section 4.3 presents impacts by control option (moderate vs. high) for 2019 events.

4.1 Overall Program Results

The load impact estimates resulting from the RCT analysis for the general population events, as well as the research events that occurred side-by-side with normal operation, are presented in Table 4-1. The results included in the average general population event are highlighted in green. The events included in the average calculation are the normal cycling events from 4:00 PM to 6:00 PM. The load impacts presented for each event, along with their confidence intervals, are the average changes in load during the indicated dispatch windows. The results from the cascading event day on August 20 are presented as well. Results for the PJM test event, September 10, and the event on September 12, when no control group was held back, are presented separately in Section 5.

Table 4-1: Randomized Control Trial per Customer Impacts

Event Date	Type	Event Period	Reference Load	Impact	90% Confidence		% Impact	90% Confidence		Daily Max
					Lower	Upper		Lower	Upper	
7/10/2019	Emergency	4PM - 5PM	3.28	-0.99	-0.91	-1.08	-30%	-33%	-28%	91°F
	Normal	4PM - 6PM	3.28	-0.61	-0.52	-0.70	-19%	-21%	-16%	91°F
7/19/2019	Emergency	4PM - 5PM	3.36	-0.97	-0.83	-1.10	-29%	-33%	-25%	92°F
	Normal	4PM - 6PM	3.44	-0.85	-0.76	-0.94	-25%	-27%	-22%	92°F
8/19/2019	Emergency	4PM - 5PM	3.73	-1.21	-1.09	-1.34	-33%	-36%	-29%	94°F
	Normal	4PM - 6PM	3.80	-1.17	-1.08	-1.27	-31%	-33%	-28%	94°F
8/20/2019	Normal	12PM - 1PM	2.81	-0.42	-0.34	-0.51	-15%	-18%	-12%	90°F
	Normal	1PM - 2PM	2.88	-0.47	-0.39	-0.55	-16%	-19%	-13%	90°F
	Normal	2PM - 3PM	2.95	-0.23	-0.15	-0.32	-8%	-11%	-5%	90°F
9/30/2019	Emergency	4PM - 5PM	3.09	-0.75	-0.62	-0.87	-24%	-28%	-20%	94°F
	Normal	4PM - 6PM	3.17	-0.71	-0.62	-0.80	-22%	-25%	-19%	94°F
Average General Population Event			**3.48**	**-0.90**	**-0.85**	**-0.96**	**-26%**	**-24%**	**-28%**	**93°F**

Overall load impact decreases for the average customer ranged between -0.71 kW and -1.17 kW during normal operations, with an average of -0.90 kW.[5] The general population event days in 2019 all experienced similar maximum daily temperatures, ranging from 92°F to 94°F. As expected, the emergency shed event produced higher load impacts compared to general population events in 2019. The average load reduction under emergency conditions was -0.98 kW.

At least 5% of the population was held back as a control group during each event (excluding the PJM test event and the event on September 12 in order to establish the baseline. While withholding a control group is an essential component of the RCT research design, it adversely affects the aggregate performance of the program, since customers being withheld do not contribute load reduction to the total impact. For example, the aggregate impacts on August 19 totaled approximately 12.4 MW. Had all program customers been dispatched under normal operation on August 19, including those from the control group, the program would have delivered approximately 13.6 MW.

The results presented implicitly takes device inoperability into account. Because randomized group assignment was utilized effectively, each of the individual test groups accurately represents the overall percentage of customers with inoperable devices from among the entire population. As such, the estimated load impacts are appropriately de-rated by the non-working devices included in the test groups.

Normal shed event impacts are displayed graphically in Figure 4-1, with the average customer load profiles shown for the treatment and control groups. The events shown are the three normal shed events from 4:00 PM to 6:00 PM on July 19, August 19 and September 30 that

[5] The normal shed event on July 10 was excluded from this calculation due to the different ramp-in schedule on that event day.

were included in the average general population event. All of the events show a clear drop in treatment group loads during the event dispatch period, as well as a small snapback in energy usage during the hours immediately following the events.

Emergency shed event impacts are displayed graphically in Figure 4-2, with the average customer load profiles shown for the treatment and control groups. The events shown are the three emergency shed events from 4:00 PM to 5:00 PM on July 19, August 19 and September 30. All of the events show a clear drop in treatment group loads during the event dispatch period.

Figure 4-1: Average Loads and Impacts for Normal Shed General Population Events

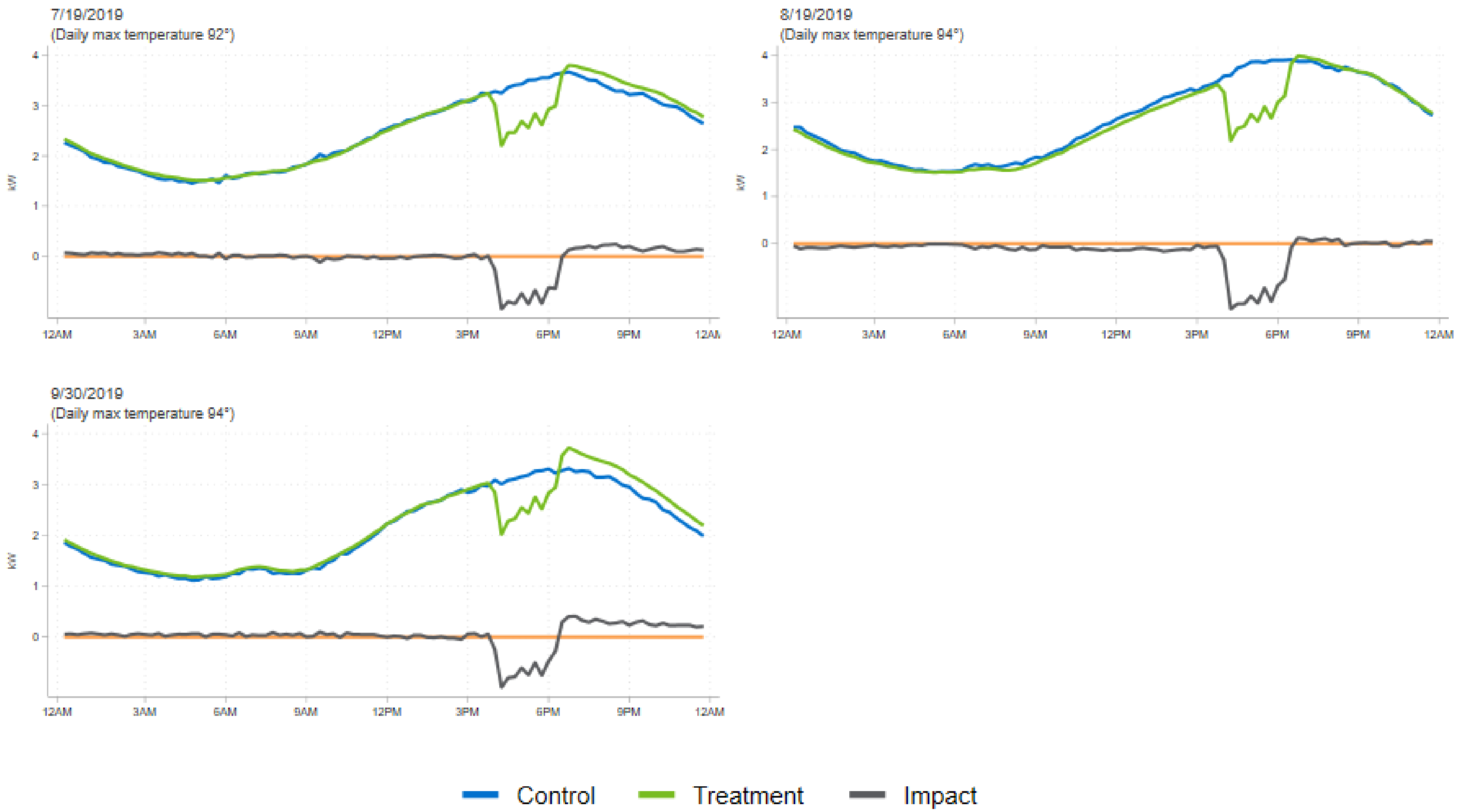


Figure 4-2: Average Customer Loads and Impacts for Emergency Shed Events

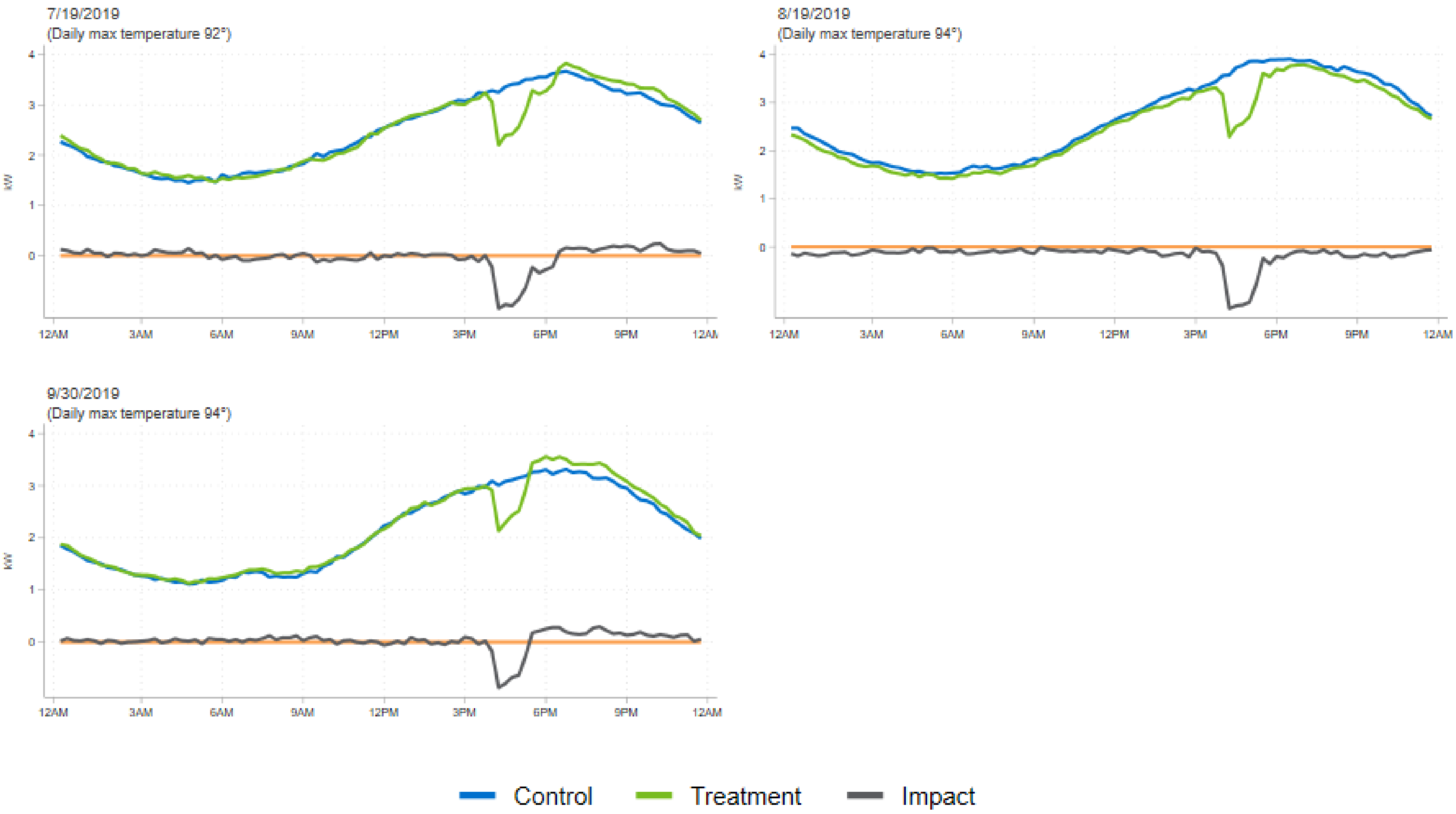
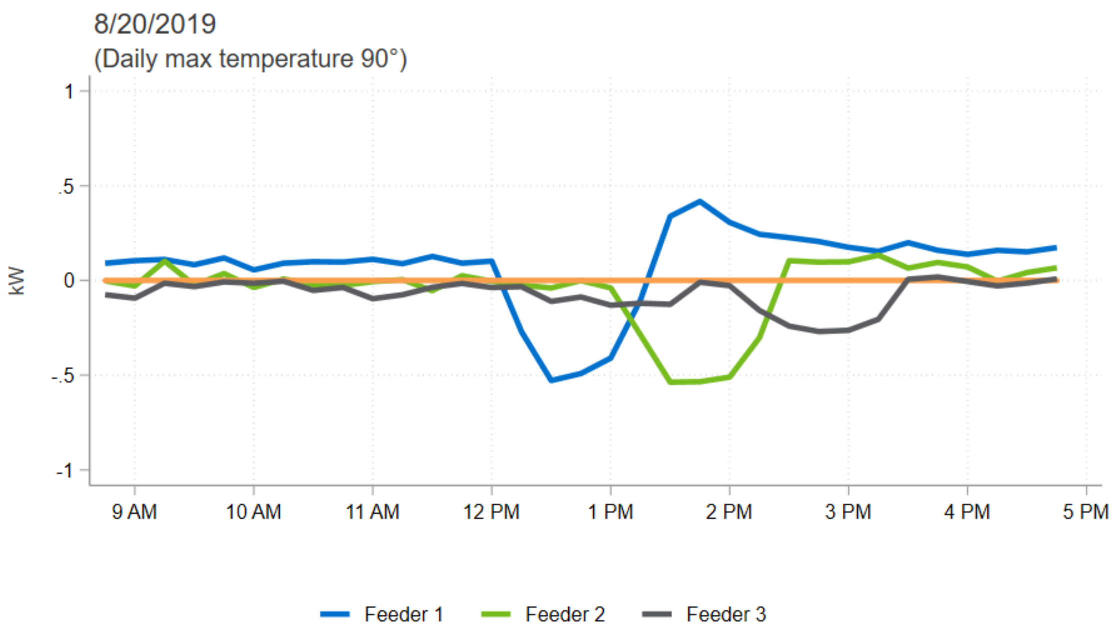


Figure 4-3 shows the results of the cascading event day on August 20. On this day, three consecutive one-hour events were called for different feeders starting at 12:00 PM. The first two events show similar impacts and load shapes but the third event, from 2:00 PM to 3:00 PM, was cut short because of rain. This caused a lower impact and different load shape than the first two event hours.

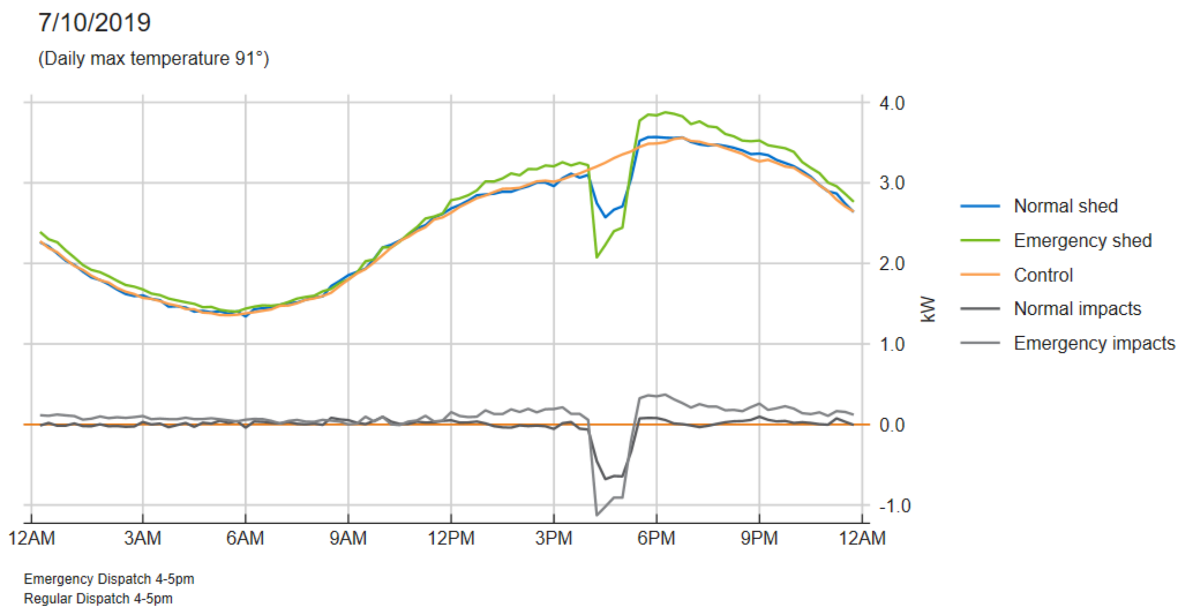
Figure 4-3: Cascading Event Impacts, August 20



4.2 Comparison of Normal vs. Emergency Conditions

The event called on July 10 dispatched feeder group 2 under normal conditions while simultaneously dispatching feeder group 1 under emergency conditions. This allows for a direct side-by-side comparison of emergency shed to normal event operations. Impacts for these events for both normal and emergency operations are presented together in Figure 4-4. It should be noted that the normal event operations (group 2) had dispatching issues for the first 30 minutes of the event when the switches were ramping in randomly, potentially lowering the observed impacts.

Figure 4-4: Load Profiles for Emergency vs. Normal, July 10

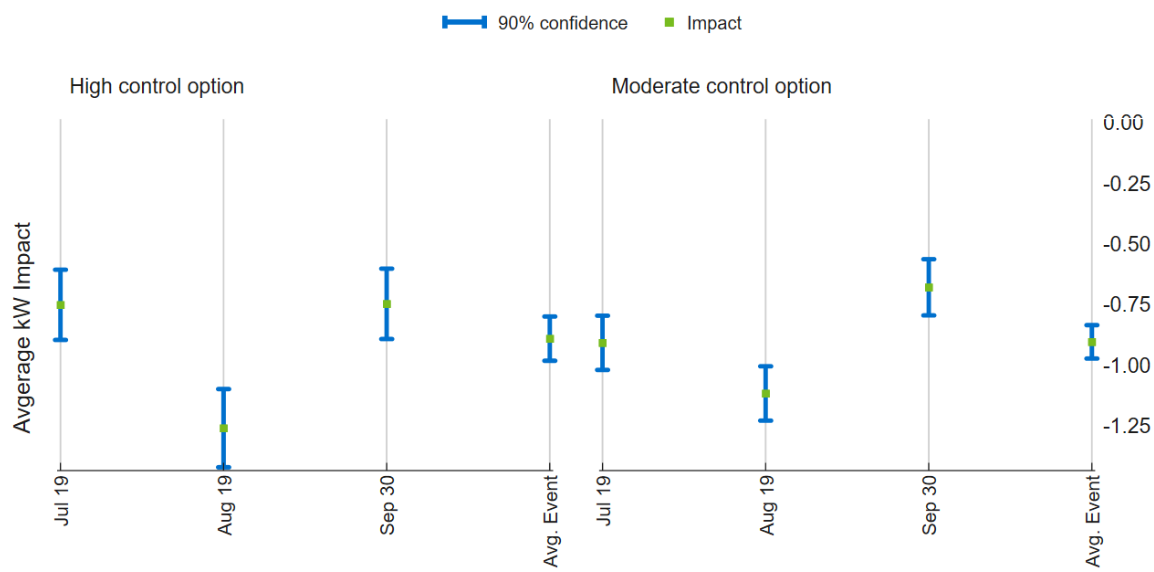


A key takeaway from the side-by-side comparisons is that the customers dispatched under emergency shed options appear to have produced load impacts that are larger than the customers dispatched under normal operations on the same day. This is typical of emergency operations which typically produced slightly larger impacts than normal operations (0.98 kW compared to -0.90 kW on average.

4.3 Impacts by Load Control Option

Figure 4-5 compares the load impact estimates for customers enrolled in the moderate vs. high load control options, as well as 90% confidence intervals, for each general population event called in 2019. Across all events, there were mixed results in terms of impacts between the moderate and high load control options. However, the differences in average per-premise impacts were never greater than 0.16 kW in either direction. On average, customers with the high load control option produced slightly lower average impacts of -0.89 kW compared to those with the moderate control option with -0.91 kW. In addition, because there were fewer customers in the high load control option subgroup, the confidence intervals for these point estimates are considerably wider. As a result, any differences in point estimates that do exist are statistically insignificant due to uncertainty. This is also reflected in the average event load impact for each group.

Figure 4-5: Comparison of Load Impacts by Control Option



4.4 Key Findings

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

- Demand reductions were -0.9 kW per household for the average general population event.
- The emergency shed event on August 19 produced the highest load impacts of -1.21 kW, larger than each of the normal shed events.
  - The emergency operations on this event day only produced lightly larger impacts that the normal operations (1.17 kW).
- In general, the magnitude of demand reductions grows when temperatures are higher and resources are needed most.
- The difference between impacts from customers enrolled under the moderate and high load control options is minimal and within the range of uncertainty.
- On average, customers with the high load control option produced slightly smaller impacts (-0.89 kW) compared to those with the moderate control option (-0.91 kW).

5 Within-Subjects Results

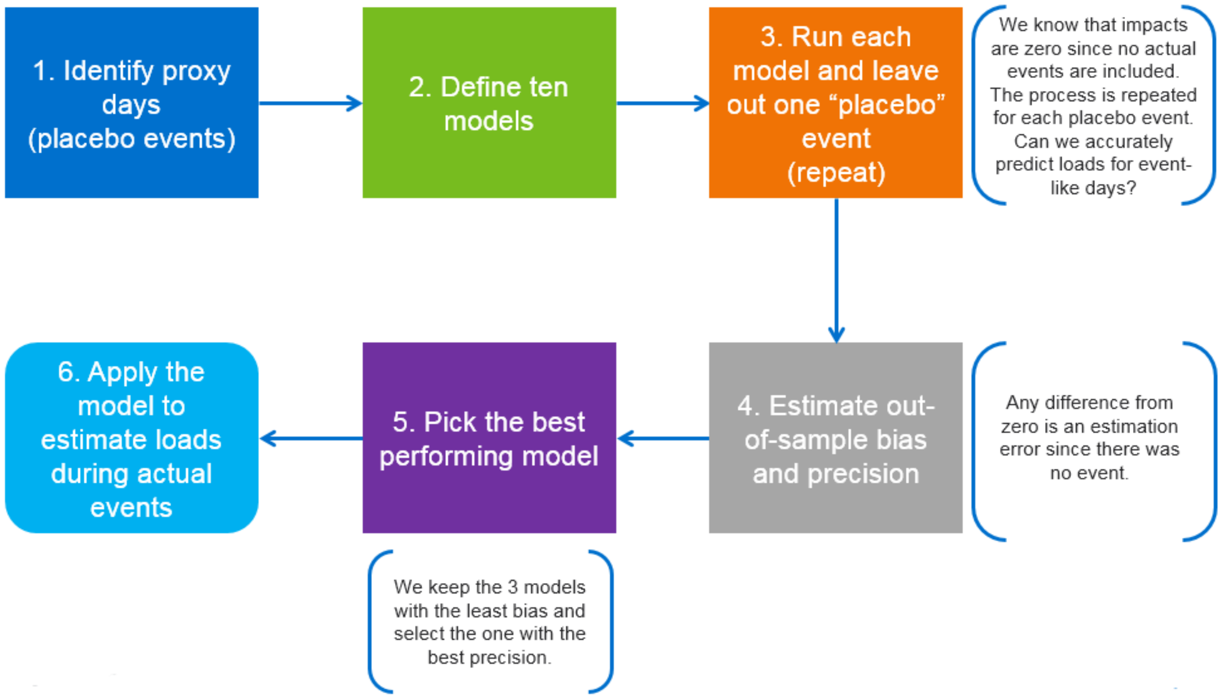
In addition to the regular and emergency shed events described in Section 4, Duke Energy dispatched one PJM test event on September 10 and one event where no control group was held back on September 12. The purpose of the PJM test event was to assess the full extent of program capability for demand reduction under emergency conditions. Under this scenario, the full program population is dispatched for the event and no customers are withheld as a control group. Absent a control groups for these events, Nexant employed a within-subjects analysis approach in order to quantify impacts.

5.1 Within-Subjects Analysis Design

In order to quantify impacts of the PJM test event, Nexant modeled the relationship between weather and customer loads on non-event days in order to establish the counterfactual. This approach relies on identifying comparable non-event days and works because the program intervention is introduced on some days, and withheld on other days that could otherwise be considered event-worthy, allowing us to observe load patterns with and without load control.

Using non-event days with similar temperature conditions, regression modeling was applied to estimate the demand reduction as the difference between the predicted baseline loads and the actual event day loads. In order to identify the regression model that best predicts the counterfactual, a rigorous model selection process was applied, whereby ten distinct model specifications were tested and ranked using various accuracy and precision metrics. The best performing model was selected and used to estimate the counterfactual for actual event days. Figure 5-1 summarizes the regression model selection process. Appendix A goes into greater detail on the process and displays the specifications tested.

Figure 5-1: Within-Subjects Regression Model Selection



5.2 Within-Subjects Event Impacts

Load impacts for the September 10 PJM test event and the September 12 event are shown in Table 5-1. The average per household load impact was estimated to be -1.09 kW across the event period on September 10. This day had the highest maximum temperature of any of the event days at 95°F. The average per household load impact on the September 12 for the normal cycling event was estimated to be -0.83 kW and the emergency cycling event was estimated to be -0.98 kW. These impact estimates are consistent with the range of impact estimates found for the shed events via RCT.

Table 5-1: Within-Subjects per Customer Impacts

Event Date	Type	Event Period	Reference Load	Impact (kW)	90% Confidence		% Impact	90% Confidence		Daily Max Temp
					Lower	Upper		Lower	Upper	
9/10/2019	PJM Test	4PM - 5PM	3.34	-1.09	-0.99	-1.18	-33%	-30%	-35%	95°F
9/12/2019	Emergency	4PM - 5PM	3.31	-0.98	-0.89	-1.05	-32%	-27%	-32%	93°F
	Normal	4PM - 6PM	3.37	-0.83	-0.76	-0.89	-26%	-23%	-26%	93°F

Figure 5-2, Figure 5-3, and Figure 5-4 show the predicted reference loads, observed loads and impacts for each of the events.

Figure 5-2: PJM Test Event Impacts, September 10

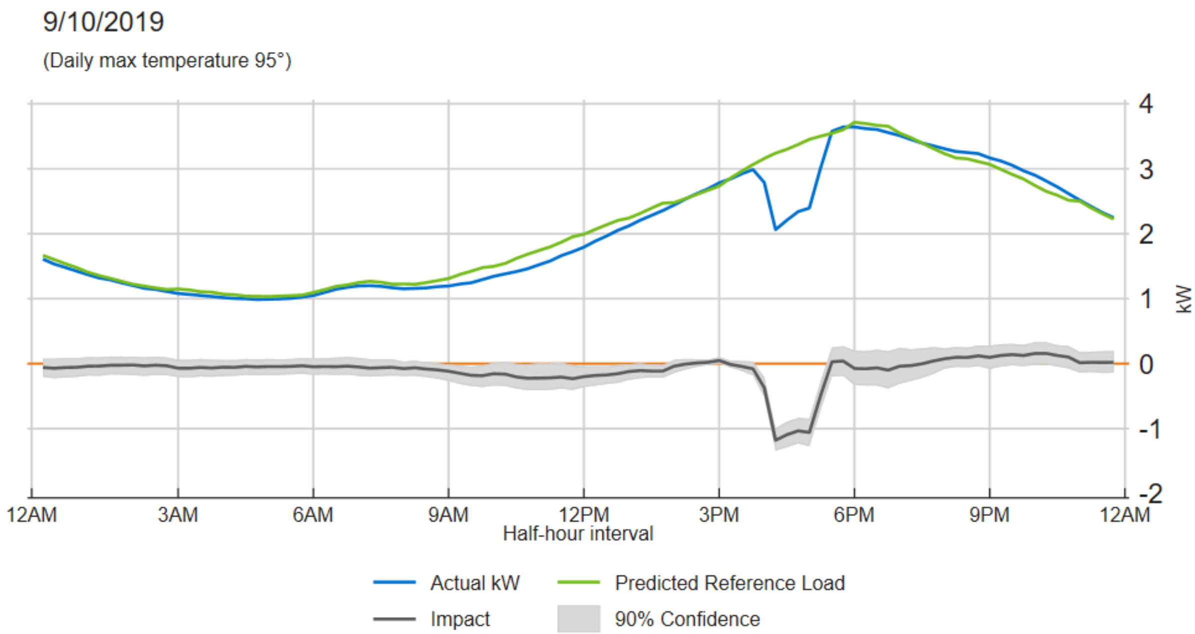


Figure 5-3: Normal Shed Event Impacts, September 12

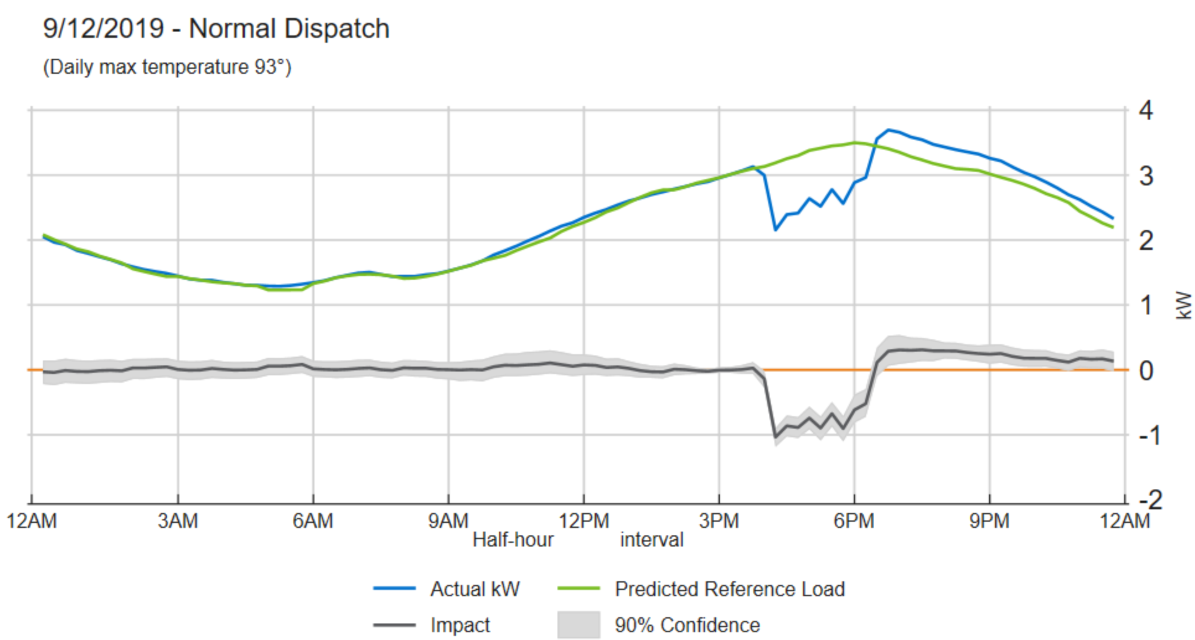
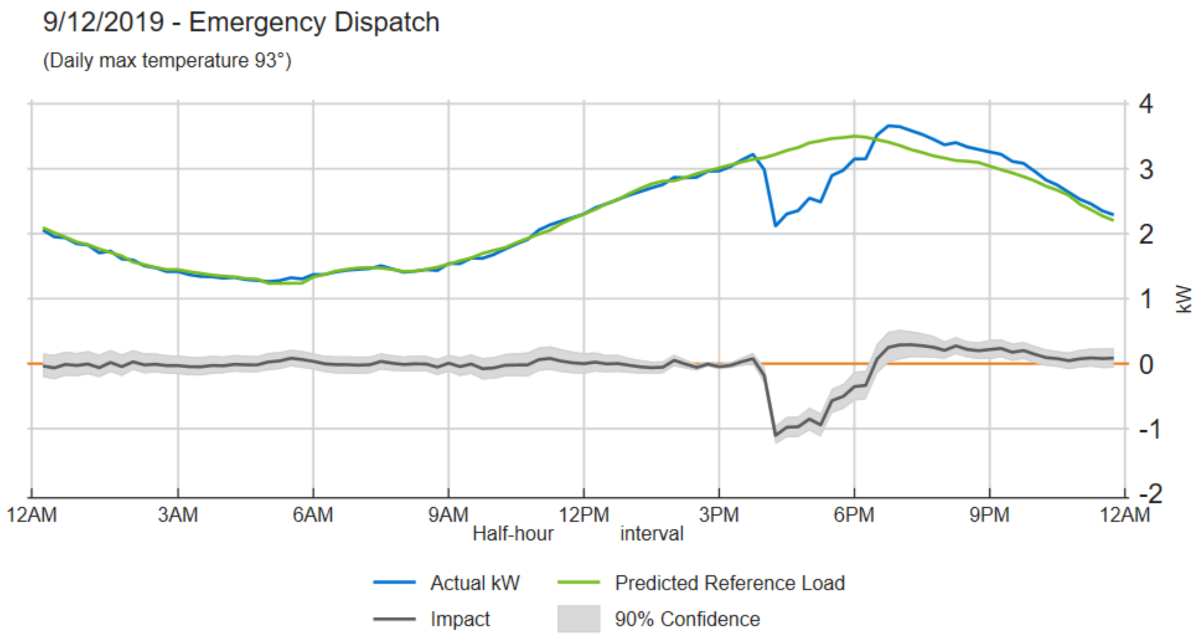


Figure 5-4: Emergency Shed Event Impacts, September 12



6 Demand Reduction Capability

A key objective of the 2019 impact evaluation was to quantify the relationship between demand reductions, temperature, hour of day, and cycling strategy. This was accomplished by estimating loads under historical weather conditions and applying observed percent load reductions for the 2019 events. The resulting tool, referred to as the time-temperature matrix, allows users to predict the program's load reduction capability under a wide range of temperature and event conditions. For purposes of reporting program capability, Emergency 1 conditions are used, where both moderate and high customers are cycled at 75% shed.

In an ideal program year, a large number of events would be called under a variety of different weather conditions, dispatch windows and cycling strategies so that demand reduction capability could be estimated for a wide range of operating and planning scenarios. In actuality, opportunities for program events can be sporadic, and based on uncertain weather projections, such that they occur infrequently and under fairly similar conditions. In 2019, events were called under a rather narrow range of temperature conditions, with daily maximum temperatures on event days ranging from 90°F to 95°F. As a result, the ability to predict demand reduction capability across a broader range of conditions was somewhat inhibited.

6.1 Methodology

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

Figure 6-1: Weather Sensitivity of Load Impacts

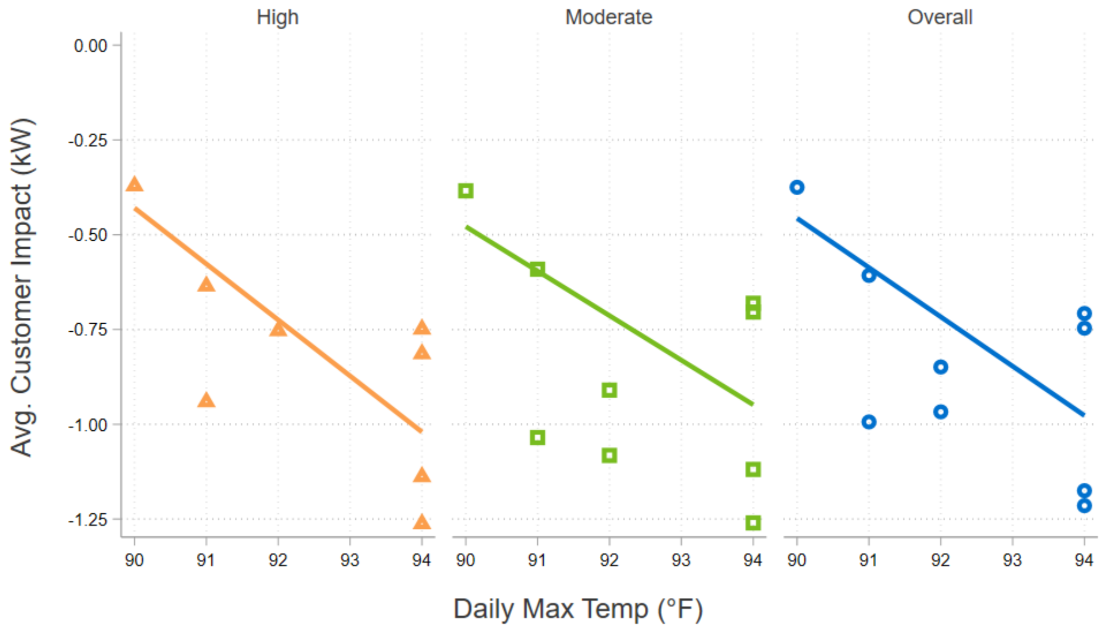
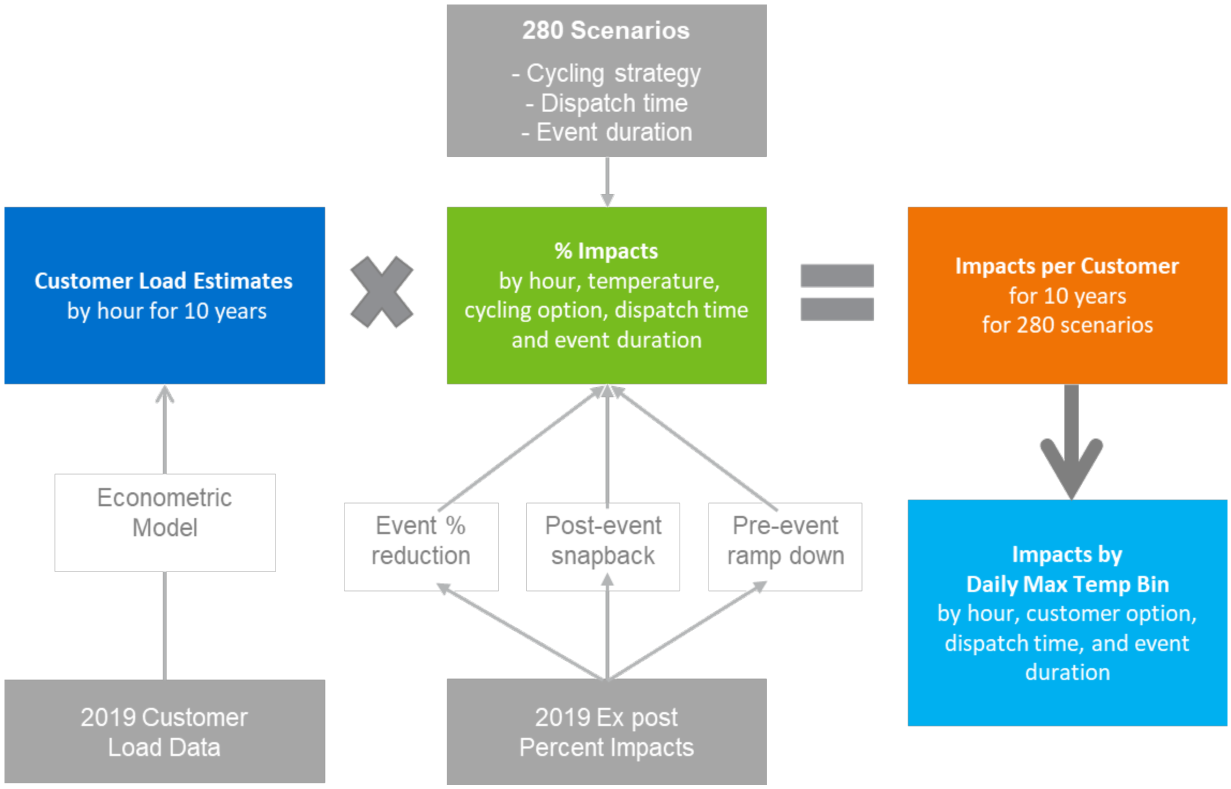


Figure 6-2 summarizes the process used to develop the time-temperature matrix for estimating demand reduction capability under various scenarios.

Figure 6-2: Time-Temperature Matrix Development Process



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

- Estimates of customer loads were developed by applying 2019 AMI data to the same regression models used to estimate impacts. All weekdays with daily average temperatures above 70°F were included in the models. The 2019 usage patterns were applied to actual weather patterns experienced over the past ten years rather than hypothetical weather patterns.
- Estimates of the percent reductions were based on three distinct econometric models: load control phase-in, percent reductions during the event, and post-event snapback. The models were based on the percent impacts and temperatures experienced during 2019 events.
- A total of 280 scenarios were developed to reflect various cycling/control strategies, event dispatch times, and event lengths.
- Estimated impacts per customer were produced by combining the estimated household loads, estimated percent reductions, and dispatch scenarios. The process produced estimated hourly impacts for each hot weekday during 2010-2019 under 280 scenarios.
- Multiple days were placed into 2-degree temperature bins and were averaged to produce an expected load reduction profile for each temperature bin.

6.2 Demand Reduction Capability for Emergency Shed

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

Figure 6-3 shows the demand reduction capability of the program if emergency shed becomes necessary on a day with 94˚F maximum temperature. Individual customers are expected to deliver -1.06 kW of demand reduction over a one-hour event window. Because there are approximately 11,664 customers enrolled in Power Manager, the expected aggregate reduction is 12.4 MW

Figure 6-3: Load Reduction Capability Emergency Shed at 94°F Maximum Temperature

Inputs	
Dispatch Type	Emergency Dispatch
Option	Overall
Event Start	4 PM
Event Duration (Hours)	1
Daily Max Temp (°F)	94
# Customers	11,664

Event Window Average Impacts		
Load without DR	3.56	kW per customer
Load with DR	2.50	kW per customer
Impact per customer	-1.06	kW per customer
Impact (MW)	-12.35	MW
% Impact	-29.7	%

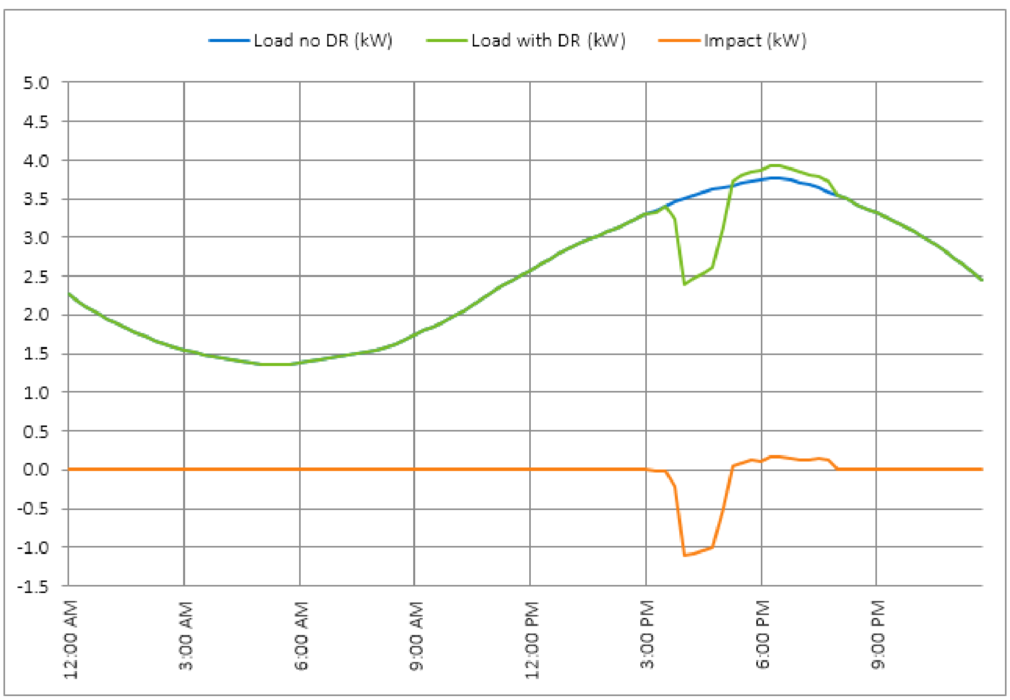


Table 6-1: Average Predicted Impacts by Maximum Daily Temperature and Event Start

Daily Maximum Temperature	Event Start Time				
	1:00 PM	2:00 PM	3:00 PM	4:00 PM	5:00 PM
86°F	0.41	0.43	0.46	0.48	0.50
88°F	0.53	0.56	0.59	0.62	0.65
90°F	0.66	0.70	0.73	0.77	0.80
92°F	0.80	0.84	0.89	0.93	0.96
94°F	0.88	0.94	1.0	1.06	1.1
96°F	1.02	1.09	1.15	1.2	1.25
98°F	1.15	1.23	1.29	1.35	1.37
100°F	1.01	1.13	1.23	1.31	1.4

6.3 Key Findings

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

- While emergency operations are rare and ideally avoided, they represent the full demand reduction capability of Power Manager.
- Power Manager demand reductions grow as temperatures increase, and with deeper cycling. At the same time, peak household loads available for curtailment also increase with temperature.
- If emergency shed becomes necessary on a 94°F maximum temperature day, Power Manager can deliver -1.06 kW of demand reductions per household during a 1-hour event.
- Because there are approximately 11,600 Power Manager customers, the expected aggregate reduction totals 12.4 MW.
- The event start time also influences the magnitude of reductions, which are generally larger during hours when customer loads are highest.

7 Process Evaluation

Process evaluation, particularly when combined with the insight obtained from impact evaluation, informs efforts to continuously improve programs by identifying program strengths and weaknesses, opportunities to improve program operations, program adjustments likely to increase overall effectiveness, and sources of satisfaction or dissatisfaction among participating customers. The primary objectives for the process evaluation component of the evaluation include:

- Assessing the extent to which participants are aware of events, bill credits, and other key program features;
- Understanding the participant experience during events: comfort, occupancy, thermostat adjustments, and strategies employed to mitigate heat;
- Identifying motivations and potential barriers for participation, including expectations, sources of confusion or concern, intention to stay enrolled, and likelihood of recommending the program to others;
- Documenting the operations, recruitment, enrollment, outreach, notification, and curtailment activities associated with program delivery; and
- Identifying program strengths and potential areas for improvement.

7.1 Survey Disposition

Nexant developed a survey for customers participating in the Power Manager program that was deployed immediately following a Power Manager event. In addition to the post-event survey, a nonevent survey was also deployed immediately following a hot, nonevent day. This nonevent day survey was identical to the post-event survey to establish a baseline and facilitate comparison with the results of the event day survey. Both the event and nonevent surveys were administered to Power Manager participants. The survey was administered via phone and web to maximize response rates during the 24 hour window directly following a Power Manager event. The survey addressed the following topics:

- Awareness of the specific event day, including reasons for event day awareness (increased temperature in home, etc.)
- Any actions that increased household comfort during the Power Manager event. Do participants report changing AC settings, using other equipment (including window units, portable units, or ceiling fans) to mitigate heat buildup? Were participants home during the event? Are they usually home during that time period?
- Satisfaction with the Power Manager program and its attributes
- Expectations and motivations for enrolling. What did participants expect to gain from enrollment? To what extent are they motivated to earn incentive payments versus altruistic motivations such as helping to address electricity shortfalls during periods of high peak demand and/or reducing the environmental effects of energy production?

- Do participants expect to remain enrolled in the program in future years? Would they recommend it to others?

Since event awareness and thermal comfort are primary areas of inquiry for the survey, the nonevent baseline data provides the opportunity to net out any propensity for thermal discomfort or belief that a Power Manager event is occurring that would naturally happen on any hot day of the summer. In this way, it is possible to evaluate whether statistically significant differences in event awareness and reports of thermal discomfort exist between customers who actually experience a Power Manager event and customers who do not.

The survey was completed by 68 customers on an event day (the event group) and 74 customers on a hot nonevent day (the nonevent or baseline group). All surveys were conducted on the day of the event or the nonevent, and the overall response rate was 4.7%. The survey plan was to survey about 50% of respondents by phone and 50% by web, but on the event day more people were reached by telephone than expected. The distribution of survey completions across the survey modes is shown in Table 7-1. All responses in this section summarizing survey results have been weighted to reflect the survey design for 50% of completions by phone and web each. The temperature on the event day was a high of 94°F with an average temperature of 93.5°F during the event period. Temperatures during the nonevent day were somewhat cooler than during the event day. The high temperature during the nonevent day was 89°F, the average temperature during the event period was 86°F. Maximum and average heat indexes are hotter than ambient temperatures on the two survey days. The average heat indexes during the event period were 91°F and 97°F for nonevent and event days, and maximum heat indexes were 98°F and 97°F for nonevent and event days, respectively.

Table 7-1: Survey Disposition

<table>
<tr><th>Total Survey Responses</th><th>Survey Responses by Group</th><th>Confidence / Precision Level</th><th>Date</th><th>Temperature</th><th>Phone/ Email Distribution</th><th>Response Rate</th></tr>
<tr><td rowspan="4">142 Responses</td><td rowspan="2">68 Event Responses</td><td rowspan="2">90/10</td><td rowspan="2">Monday, August 19</td><td rowspan="2">High 94° F (avg. event temp. 93.5° F)</td><td>60% Phone</td><td>4.1%</td></tr>
<tr><td>40% Email</td><td>5.3%</td></tr>
<tr><td rowspan="2">74 Baseline Responses</td><td rowspan="2">90/10</td><td rowspan="2">Thursday, July 18</td><td rowspan="2">High 89° F (avg. event temp. 86° F)</td><td>74% Phone</td><td>5.4%</td></tr>
<tr><td>26% Email</td><td>3.8%</td></tr>
</table>

Most households surveyed have two or fewer residents; about 9% of event and 18% of nonevent baseline households have five or more residents. There was no apparent systematic difference in the age of respondents between the event and nonevent baseline groups. The mean age of respondents is 57 years and the most commonly reported level of education was a bachelor's degree: 24% of respondents said that they graduated from college. Nearly as many (23%) have a graduate or professional degree and 21% have some college or an associate degree.

7.2 Program and Event Awareness

The customer surveys were designed with the key objective of evaluating participants' awareness of Power Manager events, but a few questions were also included to gauge participants' general awareness of the program and its key features. Every respondent who was contacted to complete the survey was a Power Manager participant at the time of the survey, and a majority of the respondents, 65%, reported that they are in fact familiar with the Power Manager program.

Every Power Manager participant who was randomly selected to receive the post-event survey (the event group), experienced an actual Power Manager event that day, Monday, August 19. A total of 68 customers completed the post-event survey. A small portion (10%) of event group respondents reported that their homes were uncomfortable that day, while all of them experienced a load control event that afternoon. As a program with no pre-event notification, a decrease in thermal comfort in the home is the key factor for assessing event awareness. In Kentucky, with only 10% of respondents stating that they were uncomfortable on the day that they were surveyed, event awareness by that measure is quite low. However, it could also be that a number of those respondents would say that their home was uncomfortably hot at times on any hot day of the year, regardless of whether or not the Power Manager program had a load control event. To control for this possibility, another randomly selected group of Power Manager participants were also surveyed on a hot day when a Power Manager event did not occur, Thursday, July 18. A total of 14% of respondents reported that their home was uncomfortable on this nonevent day. The difference in the percentage of respondents in the post-event survey and the nonevent survey that stated that their homes were uncomfortable that day (10% and 14%, respectively), is not statistically significant, so we cannot conclude that the Power Manager event caused customers any additional discomfort. The response frequencies are tabulated in Table 7-2.

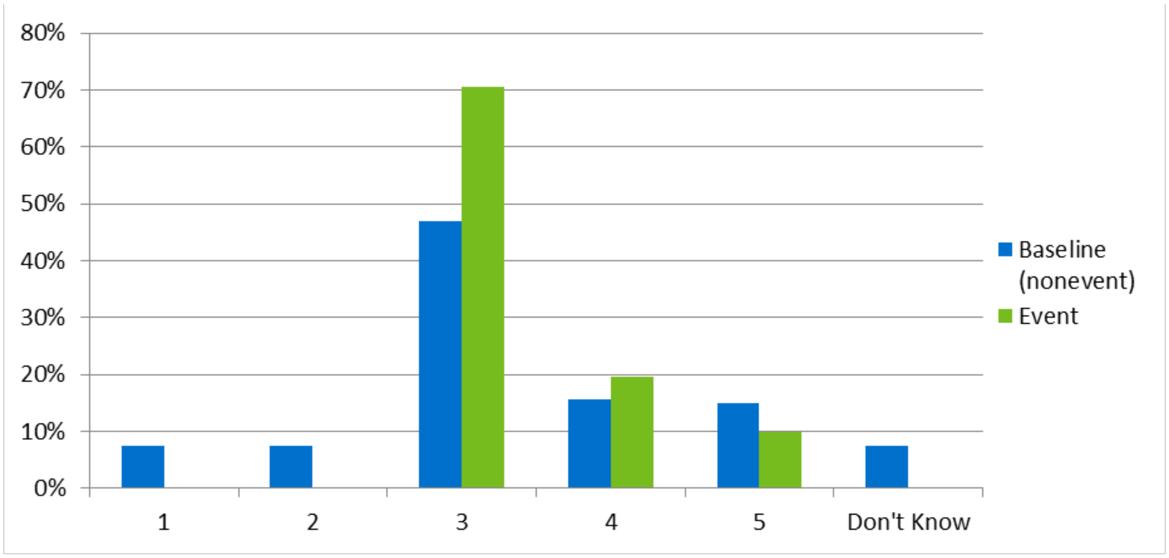
Table 7-2: Was there any time today when the temperature in your home was uncomfortable? Response Frequencies Weighted by Mode, N_t = 68 and N_c = 74

Response	Event	Nonevent (Baseline)
Yes	10%	14%
No	82%	78%
Don't know	7%	8%

Of those relatively few customers (8 post-event and 9 nonevent survey respondents) who reported that they were uncomfortable at some time during the day of the survey, over half (8 people) reported becoming uncomfortable between 3:00 and 5:00 pm. The rest were distributed throughout the day, from 1:00 am to 8:30 pm. Asked when the period of thermal discomfort in their home ended, there was a shift in responses towards later in the day, with 9 respondents reporting that their homes stopped feeling uncomfortable between 7:00 and 9:00 pm. Two respondents listed times earlier than 12:00 pm, and two more respondents said that their homes stopped being uncomfortable at 10:00 pm or later.

These customers who reported thermal discomfort were also asked to rate their discomfort using a five point scale, where 1 represents "not at all uncomfortable" and 5 represents "very uncomfortable." Frequencies of the responses are summarized in Figure 7-1. However, at least in part due to the small number of customers reporting thermal discomfort, the survey does not present evidence that Power Manager events led to customers reporting higher degrees of discomfort.

Figure 7-1: Please rate your discomfort using a scale of one to five, where one means "not at all uncomfortable" and five means "very uncomfortable." Response Frequencies Weighted by Mode, N_t = 8 and N_c = 9



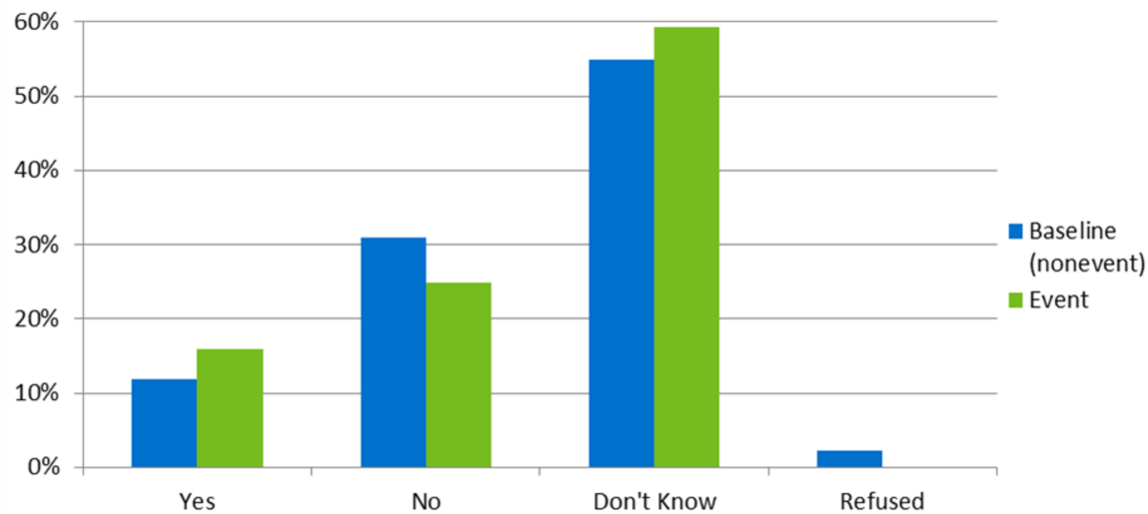
Those respondents who reported that their homes had been uncomfortably hot that day were asked what they think caused the discomfort. The most commonly reported rationale is that the discomfort in their home was due to the hot weather; 70% of event respondents and 62% of nonevent respondents gave that reason. The second most common response category was that Duke Energy was controlling the customer's air conditioner, with 21% of event customers selecting this option; no baseline customers thought that their homes were uncomfortable due to Duke cycling their air conditioners. 15% of baseline customers and 0% of event customers believed that their homes were uncomfortable due to their air conditioners not working properly. Table 7-3 summarizes the responses given to this survey question, across event and nonevent baseline customers and altogether. Again, due to this sample size, no conclusions may be drawn about the effect of Power Manager events on customers' perceptions regarding the cause of any discomfort.

Table 7-3: What do you think caused the temperature to be uncomfortable? Response Frequencies Weighted by Mode, N_t = 8 and N_c = 9

Reason	Event	Baseline (Nonevent)	All
It was a very hot day	70%	62%	65%
Duke Energy was controlling air conditioner	21%	0%	9%
Air conditioner doesn't work properly	0%	15%	9%
Air conditioner unit was not on	0%	8%	4%
Other	10%	16%	13%

All survey respondents were also asked directly whether or not they thought a Power Manager event had been called in the past few days. The most common response was "don't know," where 59% of event customers and 55% of nonevent customers stated that they didn't know if there was a Power Manager event in the past few days. The prevalence of "don't know" responses here is not surprising in light of the fact that Duke Energy does not actively notify participants of load control events. Figure 7-2 presents response frequencies for event and nonevent respondents; the differences between event and nonevent responses to this question were not statistically significant. Across all respondents, 57% did not know if there was a Power Manager event recently, 14% thought that there was an event recently, and 28% did not think that there was an event recently; an additional 1% of survey respondents declined to say whether or not they thought an event had happened in the past few days.

Figure 7-2: Do you think a Power Manager event occurred in the past few days? Response Frequencies Weighted by Mode, N_t = 68 and N_c = 74



The relatively few respondents (10 event and 8 nonevent) who thought there was a Power Manager event recently were asked a few questions about the event(s) that they perceived to have happened. First, when asked on what day they thought the event occurred, 39% of the event customers correctly identified the event day; for comparison, 43% of nonevent customers identified the day of the survey as the event day (when in actuality there was no event that day).

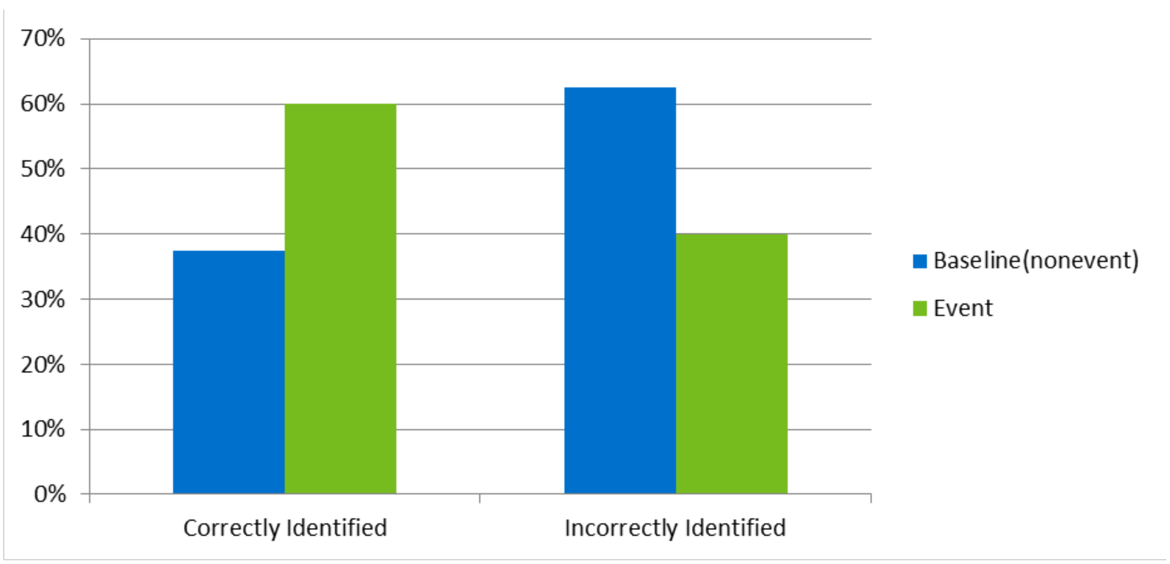
These customers were also asked to describe how they determined that a Power Manager event was occurring, and the responses are summarized in Table 7-4. The most common response, given by 35% of these 18 respondents, is that they concluded an event was occurring because the temperature inside their home went up. The next most commonly reported rationale that an event occurred was due to it being a hot day outside, with 31% of respondents giving this reason.

Table 7-4: How did you determine that an event was occurring? Response Frequencies Weighted by Mode, N_t = 10 and N_c = 8

Reason	Event	Baseline (Nonevent)	All
It got warmer inside - the inside temperature went up	40%	27%	35%
It was a hot day outside - I knew from the temperature outside	27%	36%	31%
Did not hear the air conditioner running like I knew it should	14%	19%	16%
Saw a red light on the switch	0%	9%	4%
Some other way	6%	0%	4%
Don't know	13%	9%	11%

These respondents who thought there was a Power Manager event recently were also asked what time they thought the event occurred and whether or not they were home at that time. 54% of event respondents reported that they were home during the event, compared to 23% of non-event respondents. When asked what time they thought the event occurred, respondents were offered three response options: 12:00 pm – 2:59 pm, 3:00 pm – 4:59 pm, and 5:00 pm – 7:00 pm. Because the event window (4:00 pm – 6:00 pm) spanned two time periods, those who had answered that they had thought an event occurred in either of the latter time periods were recognized as having correctly identified the time of the event. Rates of successful identification were calculated and are shown in Figure 7-3.

Figure 7-3: About what time did you first notice this event? Response Frequencies Weighted by Mode, N_t = 10 and N_c = 8



7.3 Program Experience

Aside from occasional program communications to program participants, the primary way that Duke Energy customers experience the Power Manager program is during load control events. A large majority of survey respondents, 71%, stated that there is normally someone home between the hours of 12:00 and 6:00 pm on weekdays. Similarly, large proportions of respondents also reported that they are frequent users of their air conditioning systems. Table

7-5 shows the percentage of respondents who reported that they used their air conditioners every day for four different time periods and day type combinations. Generally, between 84% and 94% of the combined Power Manager survey respondents reported using their air conditioners every day, considering both weekdays and weekends, during both the afternoon and the evening. Statistically significant differences in response patterns were not observed between groups.

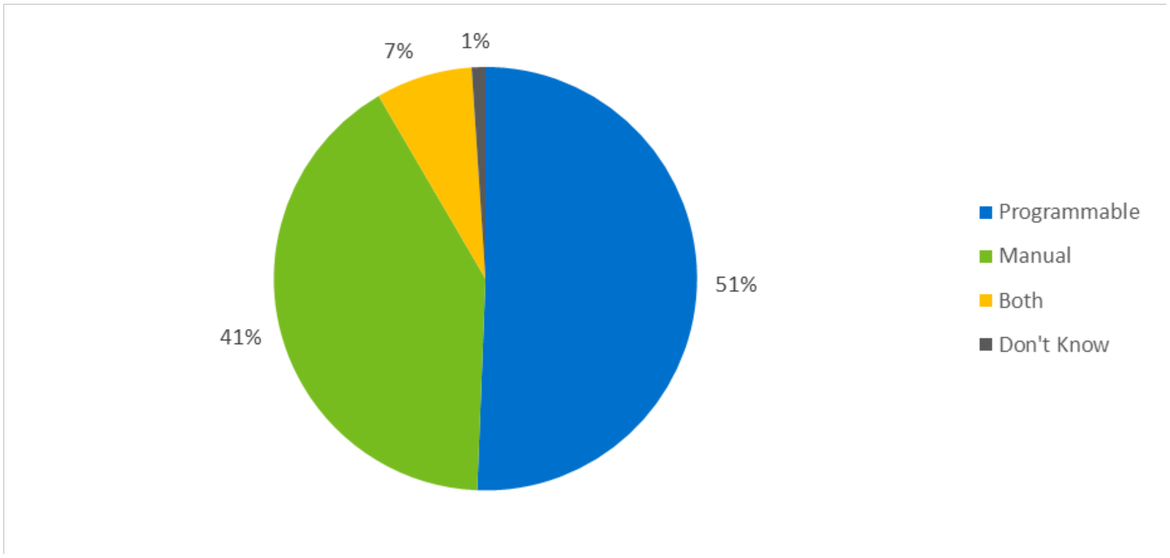
These survey responses confirm that Power Manager participants are largely at home and using their air conditioners during the times that an event is likely to be called. As such, monitoring participant comfort levels is confirmed to be an important evaluation activity so that thermal comfort can be maintained at high enough levels to retain customer satisfaction and participation.

Table 7-5: How frequently do you or someone else in your household use your air conditioning system?
Response Frequencies Weighted by Mode, N_t = 68 and N_c = 74

Day and Time	% of Event Respondents Responding "every day"	% of Nonevent Respondents Responding "every day"
...weekday afternoons (12-6 pm)	82%	87%
...weekend afternoons (12-6 pm)	91%	89%
…weekday evenings (6 pm-12 am)	96%	91%
…weekend evenings (6 pm-12 am)	89%	88%

In addition to occupancy patterns and frequency of air conditioning usage, Power Manager participants' experience with the program is affected by how they operate their air conditioning systems. Survey responses show that there is a mix of both manual and programmable thermostats installed in the homes of Power Manager participants. About half, 51%, have a programmable thermostat, while 41% of respondents say that they have a manual thermostat. Figure 7-4 summarizes the types of thermostat(s) that survey respondents reported.

Figure 7-4: What type of thermostat(s) do you have? Response Frequencies Weighted by Mode, N_t = 68 and N_c = 74



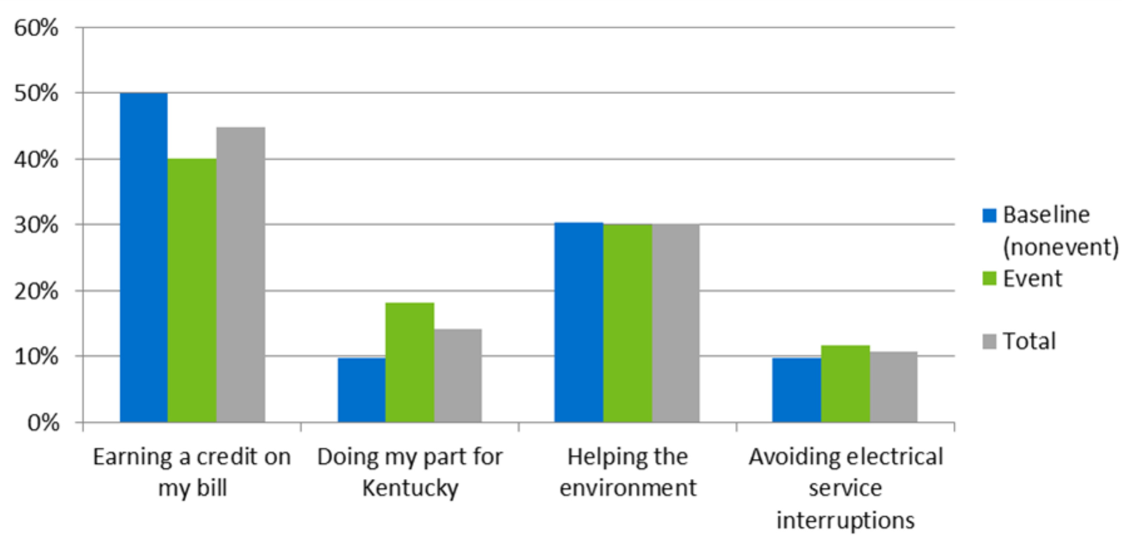
Among the customers who have programmable thermostats, 49% reported using the programmability feature to allow the thermostat to cool to different temperatures at different times, and a further 36% of customers set their thermostat at a constant temperature, representing 85% of respondents. Among customers without programmable thermostats, 48% say that they keep their thermostat set at a constant temperature. This relatively high incidence of using a thermostat setpoint should encourage thermal comfort associated with events. If during the course of an event, the home's internal temperature rises by one or two degrees, when the event is over, the thermostat will reliably detect the higher temperature and automatically cool the home to the desired temperature, without relying on the customer to feel uncomfortable first and manually turn the air conditioning on themselves. These reported air conditioning usage behaviors are supportive of the earlier finding that, on the whole, Power Manager participants are not aware of events when they occur.

In a similar vein, we asked customers who reported that they thought there was a Power Manager event recently whether or not they took any actions as a result of the perceived event. Only 5 customers (of 18 who said that they thought there was a Power Manager event) said they did something different because of the event. Three of the five reported using fans they do not normally use, but none of them used any extra air conditioning units. No customers left home to go somewhere cooler or changed their planned activities. Only one respondent reported contacting Duke Energy, and one person said that they turned off lights and other energy using devices. Customers also had the opportunity to provide descriptions of other actions that they may have taken in response to a perceived event; three customers did so and there were no common themes in their responses. Generally, responses to these questions provide further evidence that Power Manager events are not disruptive to participants' households.

7.4 Motivation and Potential Barriers for Program Participation

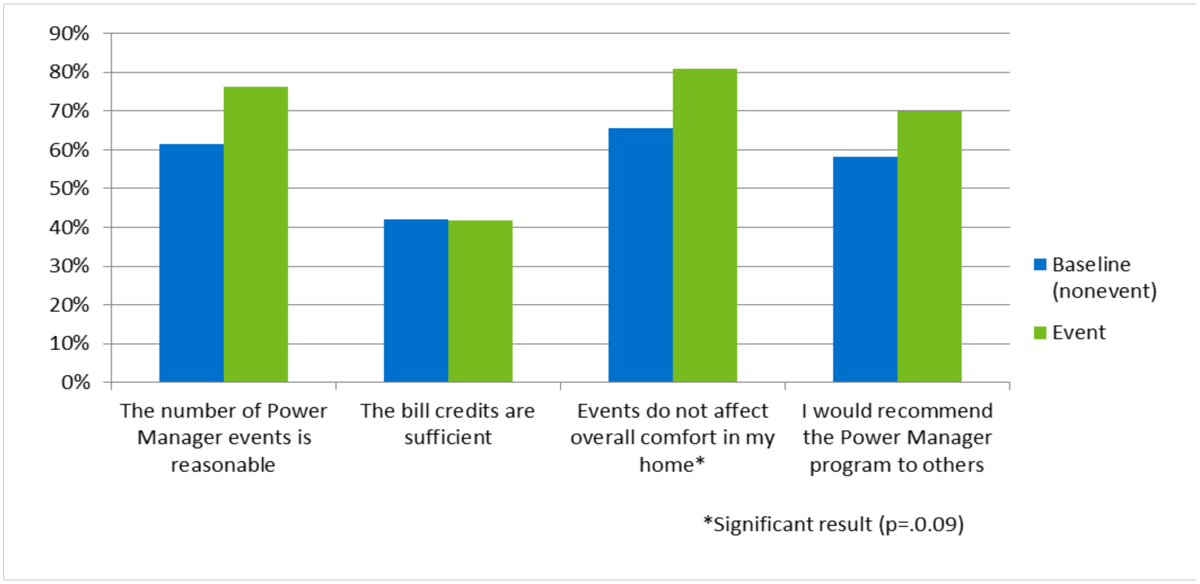
Respondents were provided with a list of possible reasons for enrolling and asked which reason was most important to them, and the survey responses reveal that Power Manager participants are motivated to be a part of the program by a diverse set of interests. The most frequently reported motivation is the bill credits, with 45% of respondents citing this as their most important motivator. Additionally, 30% of respondents said helping the environment was the most important reason for enrolling, 15% of customers stated that their motivation for enrolling was "doing my part for Kentucky", and 10% answered "avoiding electrical service interruptions". Figure 7-5 summarizes the survey responses, with the customers who responded "Don't know", or refused to respond, excluded. Differences in response patterns between event and nonevent baseline groups are not statistically significant.

Figure 7-5: Which of the following reasons was most important to you when enrolling? Response Frequencies Weighted by Mode, N_t = 68 and N_c = 74



Customers were asked to rate on a scale of 1 to 5, where 1 means "strongly agree" and 5 means "strongly disagree", their agreement with various positive statements about Power Manager. Customers generally agreed that they would recommend the Power Manager program to others and that the number of Power Manager events is reasonable. Event and nonevent baseline customers agreed with those statements roughly 60-80% of the time. However, only 42% of both event customers and nonevent baseline customers agree that the bill credits are sufficient. When asked if events affected overall comfort levels in their homes, 81% of event customers and 66% of nonevent respondents agreed with this statement. The difference between event and nonevent groups is significant at the 90% confidence level (p = 0.09), indicating that customers who experience the event are more likely to agree that events do not affect thermal comfort levels in their homes. The distribution of responses for these questions is shown in Figure 7-6.

Figure 7-6: How would you rate the following statements about Power Manager? Response Frequencies Weighted by Mode, N_t = 68 and N_c = 74



The survey concluded with an opportunity for customers to provide free-form suggestions on how they think the Power Manager program might be improved. Only 34% of respondents (48 of 142) offered suggestions, and the majority (25 of 48; 52%) of these suggestions stated that they didn't know of any ways for Duke Energy to improve their experience. Among those offering suggestions for improvement (23 of 48; 48%), there were four common requests. The first, mentioned by 6 of 23 people, reflected a desire for more bill credits. The second, mentioned by 5 people, mentioned improved communication from Duke Energy:

- "It would be better if we could have a better rebate from the power program."
- "Increase the credits to the bill."
- "Include more information on the energy bill about when events occurred – share the data."

The third most common comment, also reported by 5 people, expressed a desire for notification before or during an event. An additional 5 customers commented that the program works well, and/or is mostly imperceptible to them:

- "Make it easier to notice if it has kicked in or if a Power Manager event occurred."
- "Just an email alert when they are active."
- "Never really saw anything negative about it. Maybe tell more people about it."
- "…I have never noticed any interruption in service or any discomfort in the temperature in my home."
- "Things work fine to me."

Four people expressed frustration about a lack of credits on their bill. For the most part, these complaints revolve around not seeing credits appear on the bill, suggesting that customers would like to see them more prominently displayed. A few people suggested alterations to the program services or reach; other suggestions included easier methods of opting out of an event. Some of the comments in these areas include:

- "I would like to know when it is being managed. I am not even seeing a credit on my bills. This program does not seem worth it."
- "Easier to make overrides and easier to meet requirements."
- "It would nice to do the power saver around 1 to 3 pm so the house can cool down when we get home from work."

Table 7-6: What suggestions do you have for improving Power Manager? Response Frequencies Weighted by Mode, N_t = 26 and N_c = 22. Table 7-6 summarizes the free-form responses. Many responses fit into more than one coding category, thus the percentages add up to more than 100%.

Table 7-6: What suggestions do you have for improving Power Manager? Response Frequencies Weighted by Mode, N_t = 26 and N_c = 22

Statement	Frequency
Increased credits/incentives	13%
Better Communication	10%
Provide Notification of Events Occurring	10%
Doesn't Impact Me (the customer)	10%
Clarity on Bill	8%
Show Frustration	8%
Unsure/aware of program details; communicate them	6%
Alteration to services/reach of program (other than increase)	6%
Provide override option	4%
Increase Awareness of Program	4%
Miscellaneous	4%
Increase Services/Reach of Program	2%
No suggestion	52%

Responses were positive when participants were asked to rate the likelihood of staying enrolled in Power Manager, with a majority of respondents saying that they intend to stay in the program. Overall, 64% of respondents said they are "very likely" to remain enrolled. In addition, differences between event and nonevent responses were significant (p=0.07), with the primary difference being that the event group was more likely to report being "very likely" to remain in the program, and the nonevent group more likely to report being "somewhat likely". These responses are tabulated in Figure 7-7. Lastly, nine customers said they were not at all likely to stay enrolled, and gave varying reasons why. Their explanations are shown in Table 7-7.

Figure 7-7: How likely is it that you will stay enrolled in Power Manager? Would you say…?
Response Frequencies Weighted by Mode, N_t = 68 and N_c = 74

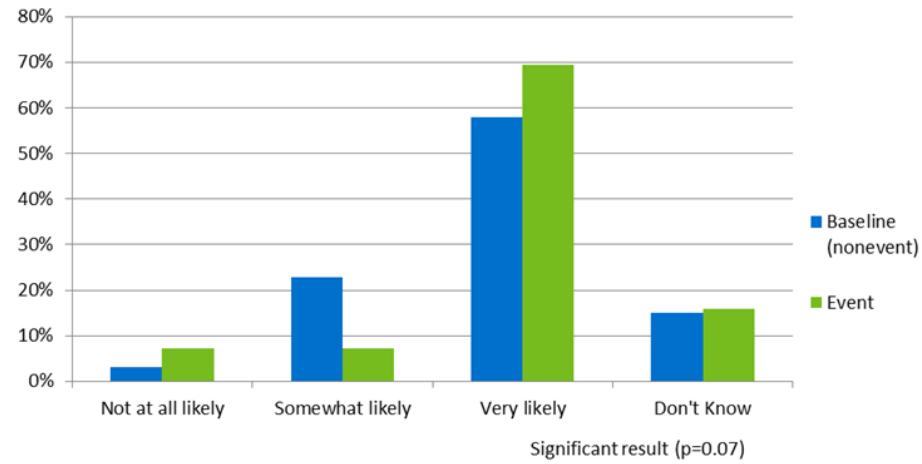


Table 7-7: Why are you not at all likely to stay enrolled in Power Manager? N_t = 6 and N_c = 3

Response	Group
I see no benefit or value to me or my pocket book.	Event
The people who installed the heating and air didn't like it.	Event
Moving.	Nonevent
I have no idea what it is.	Event
It's miserable.	Event
Duke is no longer going to be the energy provider.	Event
Don't know	Event
Because I don't want to risk an outage.	Nonevent
I want the ability to control my own air conditioning.	Nonevent

7.5 Interview Findings

Power Manager is a mature demand-side resource that is actively used in the course of operating the Duke Energy electric system in Kentucky. The demand savings delivered by Power Manager are made possible through the teamwork of internal and external stakeholders that manage the program's budget and goals, communicate with participants, maintain the Yukon event dispatch software, and interact with the customer at every stage of the program lifecycle: from enrollment, to device installation, to device removal. Three primary stakeholder groups – the Duke Energy program management team, Eaton Power Systems, and Franklin

Energy – work together to deliver Power Manager to customers. Nexant interviewed four individuals from these organizations.

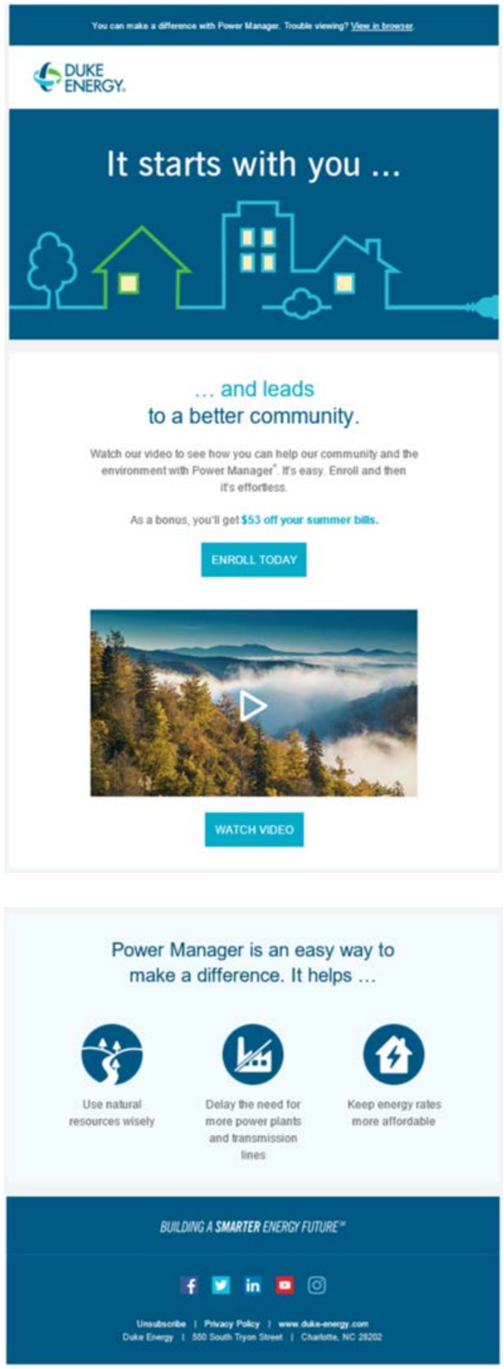
Overall, through the course of our conversations, we observe that Power Manager maintains a customer-focused orientation and is currently engaged in a number of initiatives to improve program operations and customer service. The remainder of this section describes the Power Manager offering in Kentucky and Duke Energy's activities to bring in new program participants and support annual enrollment goals. A description of summertime program operations follows, followed by an outline of work that continues after each load control season concludes to ensure Power Manager's continued success. This section concludes with a review of the activities that are planned or currently underway to further improve program operations and participating customer experience.

7.5.1 Program Offer and Enrollment Goals

Work to recruit new Duke Energy Kentucky participants into Power Manager takes place year-round. Duke Energy's 2019 enrollment goal for Kentucky was 400 customers. This annual enrollment target is calculated using energy savings goals and can be difficult to reach, given the relatively small customer list available to CustomerLink for use in outbound calling recruitment efforts. In 2019, Duke Energy enrolled 387 Kentucky participants.

Outbound calling is the predominant and most effective recruitment source for the Power Manager program. However, Duke Energy also engages in periodic email promotions for the program, an example of which is shown in Figure 7-8. Additionally, Duke Energy provides CustomerLink with customer participation data for other Duke Energy programs. Having the ability to refer to this information during recruitment calls helps CustomerLink staff increase effectiveness of their communications and credibility with potential Power Manager participants.

Figure 7-8: Duke Energy Power Manager Recruitment Email



As an outbound call center, CustomerLink is prepared to address common questions or concerns that Duke Energy customers who are not familiar with the program may have, in addition to describing the basic features of the program, many of which are friendly to the program participants. For example, outbound callers are ready to speak to the fact that Duke Energy's customer research has shown that the large majority of customers who are home during an event don't notice it, that there are generally only five to seven events each summer, and that events typically end by 6:00 pm, which is when many customers are just coming home from work. Another participant-friendly aspect of the program is that air conditioning units enrolled in the program are cycled rather than completely curtailed. Power Manager is also not called on weekends or weekday holidays. In Kentucky, customers are allowed to opt out of one Power Manager event per month, though very few participants take advantage of this option. The load control devices used by the program—switches that directly control the air conditioner's compressor—are a proven technology that does no harm to the customer's air conditioner or the home's electric distribution system. In addition, because the device is installed on the compressor, which is most typically outside the home, as opposed to being installed on fans or thermostats, this program design does not require a technician to enter the customer's home—preventing many possible problems and subsequent reductions in participant satisfaction.

The Duke Energy Kentucky program offer provides for two different cycling levels, determined by how much load shed the switches will yield during events through cycling (by cycling the air conditioner compressor's operation more or less during any given event hour). These options are called target cycling options, and two target cycling options are offered, Moderate cycling and High cycling. Customers are encouraged to enroll in Power Manager through a onetime enrollment incentive, provided as a bill credit on their Duke Energy bill: $25 for Moderate cycling and $35 for High cycling. Further, Duke Energy Kentucky Power Manager participants receive monthly payments from June through October: $3.60 per month for customers in the High cycling option, and $2.40 per month for customers in the Moderate cycling option. Duke Energy Kentucky also offers customers who wish to leave Power Manager a Low cycling option, which pays customers $1.20 per month. However, few customers enroll in the Low cycling option.

With only a modest financial incentive for participation, Duke Energy emphasizes messaging around community and environmental benefits to generate customer interest in the program. The program offer, which centers on the use of the outdoor switch, rather than an indoor programmable communicating thermostat, is generally found to be most successful with customer segments that are attracted to "set-it-and-forget-it" arrangements and those customers who would prefer not to have a service provider enter the home.

Franklin Energy is the third-party provider that manages Power Manager customer care and handles participants' inquiries about the program and requests for customer service, in addition to all fieldwork. Power Manager fieldwork ranges from scheduling and routing load control device installations, training and managing a staff of device installers, responding to any device service calls, and fulfilling customer requests to remove load control devices. Franklin Energy also manages and staffs all quality assurance inspections and fieldwork. In the past, Duke Energy would provide Franklin Energy with a sample of participating premises to test for device operability problems. However, Duke Energy now uses AMI data to help pinpoint potentially malfunctioning or missing devices and passes a prioritized list of these devices to Franklin Energy. With this targeted approach, quality control trips have been significantly reduced, while increasing the proportion of devices that are reconnected, and installed (due to missing switches), while also significantly increasing replacements. This improvement has allowed for a much higher reconnection rate per quality control trip, while also dramatically reducing the number of necessary trips, as well as the length of time Franklin Energy staff need to be on-site at a participant's residence.

7.5.2 Power Manager Program Operation and Maintenance

In terms of maintaining Power Manager as a reliable system resource for the Duke Energy Kentucky system operators, Eaton Power System plays an important role as the provider of the switches and as a resource to assist Duke Energy program staff in maintaining the Yukon software system, managing firmware issues that can arise from time to time, addressing the switches for normal service and evaluation, measurement and verification (EM&V) activities, and training Franklin Energy's switch installers. An annual all-hands Spring Training event hosted by Duke Energy brings all the Power Manager program stakeholders together to discuss the upcoming load control season's work.

These events were cited by all stakeholders as a crucial aspect of program operations. Not only do these meetings allow for in-depth coverage of upcoming issues of relevance, but they are also critical in maintaining the overall collegiality and professionalism that facilitates free communication amongst the stakeholders that is crucial for the quick resolution of any issues that emerge during the program season. In this communicative environment, stakeholders are more keenly aware of each other's responsibilities, knowledge base, and workload, and are thus able to more efficiently troubleshoot and find the appropriate staff for solving any problems. Additionally, weekly meetings between Duke Energy and Franklin Energy staff (which Eaton joins once a month), are another strategy that has been built in to head off any problems during the load control season.

Recent program operations improvements have been implemented by Eaton Systems, through the upgrade of their Yukon dispatch software with an "Assets" package. Yukon Assets ties Franklin Energy's program participation data to Duke Energy's customer information and program dispatch capabilities to provide greater flexibility in managing Power Manager events. This new software implementation allows Duke Energy to dispatch switches at different levels of geographic (i.e., ZIP code) or distribution system specificity. This functionality is not yet enabled in Kentucky. In addition, Duke Energy successfully implemented the "True Cycle" cycling algorithm in 2017. The True Cycle algorithm is used for normal Power Manager events; it uses participants' AC usage patterns to inform the optimal cycling strategy for each enrolled AC unit that best maintains the comfort within the home while still shedding the required load. During emergency events, the legacy cycling algorithm is used instead.

Close to the start of each summer load control season, Duke Energy sends Power Manager participants seasonal remind via U.S. Mail to: thank customers for their participation in the program, provide tips for having a comfortable experience with the program, and recognize the benefits of the program in terms of reducing system load and providing environmental benefits. An example of the cards mailed to participants prior to the 2019 load control season is shown in Figure 7-9.

Figure 7-9: Spring Reminder Postcard

Beyond the monthly credits that are present on customer's bills during load control season, these cards are usually the only communication customers are provided with from the program each year. Duke Energy does not notify Power Manager participants either in advance or during event dispatches. However, Duke Energy maintains a toll-free hotline that program participants may call to get updates on the status of whether or not the program is planning to dispatch an event or whether an event is in progress. At Duke Energy Kentucky, program managers must decide when load control events will be called by 10:30 am on a day-ahead basis. The event calling team involves staff in system operations and fuels in addition to demand response operations. These program stakeholders work together to anticipate in advance those days where Power Manager events are projected to be possible. Advance event discussion and preparation makes the day-of event calling process operate smoothly. In addition, PJM permits Duke Energy to dispatch emergency events to maintain the integrity of the grid. The load management resource that Power Manager provides is a critical piece of Duke Energy's fuel supply that is low-cost and quickly dispatchable.

Demand response operations staff maintain control of the decision to call nonemergency events. Power Manager is viewed as an important resource for the Duke Energy Kentucky system that depends on the participating customers' willingness to remain enrolled. Therefore, all events are called with a view towards whether or not it will be a detriment to the experience of the participants. Considerations taken in this area are the number of events that have already been called during the current summer (during that week and/or the summer overall), at what hours events are taking place, and at which level to cycle participants' AC units.

7.5.3 Program Monitoring and Postseason Program Maintenance

Duke Energy undertakes a number of activities both during the load control season and afterward to ensure that participants are satisfied with their Power Manager program experience and that the program is on track to provide an excellent customer experience going forward.

Franklin Energy, as the third-party contractor that manages Power Manager customer contacts, has service level agreements in place with Duke Energy that outline service benchmarks, with both penalties for nonperformance and opportunities for incentives when benchmarks are exceeded. There are specific benchmarks in place to ensure that, during event days in particular, customer calls coming into Franklin Energy are handled quickly, efficiently, and that accurate information is provided to the customers calling in. Additionally, Duke Energy program managers monitor the number of calls coming in to the toll-free notification line, in addition to the number of calls coming into the Franklin Energy call center to detect any emerging issues associated with the program experience. Device removal requests are also tracked for this purpose.

7.5.4 Upcoming Program Changes and Initiatives

Duke Energy is also engaged in initiatives to change the program offering to make it more attractive to customers and to improve program performance. Duke Energy Kentucky will be continuing to assess using its website as an additional source of event notification, making it easier for customers to access information about Power Manager events.

7.6 Key Findings

Key findings from the process evaluation include:

- 68 Power Manager participants were surveyed within 24 hours of the August 19 event, which had a high temperature of 94°F with a heat index of 97°F.
- 74 Power Manager participants were surveyed during a hot nonevent day, July 18, which had a high of 89°F with a heat index of 98°F. The nonevent day survey was used to establish a baseline for comfort, event awareness, and other key metrics.
- Only 11% of respondents on the event day reported that their homes were uncomfortable, while all of them experienced a load control event that afternoon. By comparison, 14% of Power Manager customers surveyed on a hot nonevent day reported they felt uncomfortably hot. This small difference is not statistically significant—we cannot conclude that there is a difference in customers' thermal discomfort due to Power Manager events.
- Sixty-four percent of Power Manager customers are likely to recommend the program to others, and 79% are likely to remain enrolled. Event respondents are significantly more

likely than non-event to report that they intended to remain enrolled in the Power Manager program

- Sixty-five percent of all respondents are familiar with the Power Manager program. The majority of suggestions (10 of 23; 43%) for improvement from customers spoke to perceived communication gaps from Duke Energy.
- There were no differences in levels of agreement between event and non-event participants with statements about whether or not an even had occurred recently, about any thermal discomfort, nor about perceptions of the cause of any discomfort. In short, customers are not able to reliably perceive Power Manager curtailment events.
- The current approach to communications amongst stakeholders has been effective in building professional collegiality and helps to make the program run smoothly, especially when problems arise.
- The “Assets” module of the Yukon system offers opportunities to increase granularity of load control events. As customer saturation becomes an increasingly pertinent issue, “Assets” may offer a way to address it.

8 Conclusions and Recommendations

8.1 Impact Evaluation Conclusions and Recommendations

Conclusion: Overall, the Power Manager program produces significant results in reducing peak load demand for Duke Energy's residential customers. On average, 2019 events achieved greater than 25% load reduction per household for general population events.

> **Recommendation:** Continue to promote the Power Manager program to DEK residential customers who exhibit high peak load consumption. Customers with higher-than-average peak loads remain the best candidates for program participation and have the greatest potential to contribute demand savings.

Conclusion: Emergency shed impacts were only slightly larger in magnitude compared to normal shed.

> **Recommendation:** Continue to reserve emergency shed events for the most extreme conditions. Emergency shed should be called on an as-needed basis and no longer for M&V purposes in order to simplify the program operations.

Conclusion: The difference in impacts between customers enrolled under moderate and high load control options was minimal and within the range of uncertainty.

> **Recommendation:** Consider a single incentive structure where all enrollees are dispatched under the same cycling strategy in order to simplify the program operations.

Conclusion: Complexities associated with feeder programming and event dispatch design for the M&V events led to a number of unanticipated ramifications with the impact analysis. M&V events designed to assess differences in shed type (i.e. side-by-side dispatches) and time-of-day dispatch (i.e. cascading events) only provided limited value due to the narrow range of event conditions.

> **Recommendation:** In the future, consider a simplified M&V design, whereby only a single control group is assigned and Duke Energy dispatches the Power Manager program as needed, and does not conduct M&V-specific events.

> **Recommendation:** Revisit the time-temperature matrix requirements and consider developing a model of program capabilities across a relatively modest band of temperatures, reflecting the current dispatch strategy. For example, reporting estimated impacts under a range of temperatures for a 1-hour event starting at 4pm.

> **Recommendation:** If Duke Energy is interested in development of a TTM that reflects program capabilities under a broader range of scenarios, Nexant recommends collecting data to inform the TTM based on implementing end-use metering for a small sample of

customers, rather than attempting the more complex RCT dispatches similar to the plans from the current evaluations.

8.2 Process Evaluation Conclusion and Recommendations

Conclusion: There were no differences in levels of agreement between event and nonevent participants with statements about whether or not an event had occurred recently, about any thermal discomfort, nor about perceptions of the cause of any discomfort. In short, customers are not able to reliably perceive Power Manager curtailment events.

> **Recommendation:** Continue to prioritize participant comfort and satisfaction during curtailment events.

Conclusion: Sixty-four percent of Power Manager customers are likely to recommend the program to others, and 79% are likely to remain enrolled. Event respondents are significantly more likely than non-event respondents to report that they intend to remain enrolled in the Power Manager program.

> **Recommendation:** Continue to prioritize operational practices that are focused on maximizing customer satisfaction in the design and implementation of the Power Manager program.

Conclusion: Sixty-five percent of all respondents are familiar with the Power Manager program. Additionally, many suggestions (10 of 23, 43%) for improvement from customers spoke to perceived communication gaps from Duke Energy. Mainly, these customers desire event notifications and more general information about the program.

> **Recommendation:** Evaluate Duke Energy's communication strategy: before, during, and after load control seasons, and consider changes. Improved communication can improve customer satisfaction and increase positive word-of-mouth awareness. One possibility is to provide end of season "thank you" postcards, on which customers could be reminded of how much money they saved, or be informed about what the program has accomplished in that load control season and their role in that. For example, "Because of your participation this year, Duke Energy was able to keep expensive fuel-oil source electricity off of the grid on a hot summer day."

> **Recommendation:** Prioritize making Power Manager event notifications available on the program website in order to provide customers more access to event information in addition to the existing communication protocols.

Conclusion: The most common motivations respondents reported for their participation in the Power Manager program were "earning a credit on my bill" (reported by 45% of those who offered a response) and "helping the environment" (reported by 30% of those who offered a response).

> **Recommendation:** Continue to emphasize messaging around bill credits and environmental benefits on customer communications.

Conclusion: Recruitment into the Power Manager program in Kentucky continues to be difficult. In other Duke Energy jurisdictions, environmental motivation for enrollment is more highly salient amongst program participants. Together, this suggests that an increased emphasis on this latter messaging in marketing material might help increase enrollment.

> **Recommendation:** Consider making environmental messaging more prominent on customer recruitment communications to motivate additional customers to participate.

> **Recommendation:** Consider mobilizing multiple low-cost recruitment efforts prior to the load control season, including (as was the case in 2019) emails, but also other cross-promotion efforts (such as inclusion in MyHER, Duke Energy newsletters, and social media campaigns).

Conclusion: The current approach to communications amongst stakeholders has been effective in building professional collegiality and helps to make the program run smoothly, especially when problems arise.

> **Recommendation:** Continue to prioritize inter-organizational communications with "spring trainings", fall meetings (when needed), weekly and monthly calls, and other existing communications approaches.

Conclusion: "Targeted" QC protocols, using AMI data to identify switches that may be malfunctioning or missing, have yielded strong results. This allowed Franklin Energy to complete fewer QC site visits than were budgeted for, while still seeing an increase in the proportion of reconnects, as well as significant increases in installation and replacements. Ultimately, this resulted in a much higher incidence rate, with decreased costs and more switches being brought back online.

> **Recommendation:** Continue to review protocols for this practice to further increase its effectiveness, as it is a cost-effective measure for increasing the number of units for use in curtailment events. Primarily, this may include fine-tuning the algorithm used to flag potentially problematic devices.

> **Recommendation:** Explore opportunities to leverage efficiency gains from the improved QC process into recruitment and communication efforts.

Conclusion: The "Assets" module of the Yukon system offers opportunities to increase granularity of load control events. As customer saturation becomes an increasingly pertinent issue, "Assets" may offer a way to address it.

> **Recommendation:** Evaluate the feasibility and cost of utilizing this capability at different scales, as it offers the ability to localize load control events and thus maximize savings by targeting areas that offer the most savings.

Appendix A Regression Models Tested

All regression models were performed on average customer loads throughout the summer, on days with similar weather conditions to those experienced on the September 10 and September 12 event days. All Power Manager participants for whom there was clean, reliable data for were included in the model.

For the individual event day impacts (ex post), the regression equation took the general form of Equation 2, which will be estimated using a dataset made up of hourly observations of the average load in the M&V sample.

Equation 2 represents a within-subjects approach in which the observations on nonevent days are used to predict the counterfactual load for Power Manager customers on event days. A few points are noteworthy. The only component that varied across the ten models tested was how the weather variables were specified. Table A-1 shows the weather variables and explains the underlying concept for each model tested. To improve precision, same-day loads for the pre-event hours of 2:00 to 4:00 PM were included to capture any differences between event and nonevent days that are not reflected in the model. The pre-event same day load variable functions as a same-day adjustment and is included because customers are not notified of the event in advance.

Equation 2: Ex Post Regression Model Individual Events

$$kW_{t,i} = a_i + \sum_{j=1}^{J} b_{i,j}\text{event}_{t,j} + c \cdot preeventkW_t + d_i \cdot weather_{i,t} + \sum_{k=1}^{7} e_{i,k}\text{dayofweek}_{i,k} + \sum_{l=5}^{10} f_{i,l}\, month_t + \varepsilon_{i,t}$$

Where:

a	Is the constant or intercept
$b_{i,j}$	Represents the treatment effect of Power Manager during each interval, *i*, and each event day, *j*
c-f	Are other model coefficients
i, k, l	*i, k and l* are indicators that represent individual 15 minute intervals (96 in a day), days of the week, and months of the year
t	Represents each date in the analysis dataset
event	Is a binary variable indicating whether Power Manager was dispatched on that day
preeventKW	Represents the same-day loads for the pre-event hours of 11am to 1pm. The variable functions as a same-day adjustment and is included because customers are not notified of the event in advance.
weather	12 different ways to specify weather were tested. Those are detailed in Table A-1
dayofweek	Are a set of mutually exclusive binary variables to capture day of week effects
month	Are a set of mutually exclusive binary variables to capture monthly or seasonal effects
ε	Represents the error term

Table A-1: Weather Variables by Model Tested

Model	Weather variables	Concept
1	Cooling Degree Hour Base 70°F (CDH)	The same hour temperature drives electricity use but air conditioner loads are only linear when temperatures are above 70°F
2	Cooling Degree Day Base 65°F (CDD)	The overall daily average temperature drives electricity use but air conditioner loads are only linear when average daily temperatures exceed 65°F
3	Daily Maximum Temperature	The daily maximum temperature drives air conditioner electricity use
4	Average temperature over the 24 hours immediately prior	Heat buildup over the 24 hours immediately prior to time period drives electricity use
5	CDH and CDD	Both the daily average temperatures and same hour temperatures drive air conditioner electricity use
6	Same hour CDH and average temperature over the 24 hours immediately prior	Air conditioner use if influenced both by the temperature during that hour and by average temperature over the 24 hours immediately prior
7	Same hour CDH and average CDH over the 6 hours immediately prior	Air conditioner use if influenced both by the temperature during that hour and by heat buildup, as measured by CDH, over the 6 hours immediately prior
8	Same hour CDH and average CDH over the 12 hours immediately prior	Air conditioner use if influenced both by the temperature during that hour and by heat buildup, as measured by CDH, over the 12 hours immediately prior
9	Same hour CDH and average CDH over the 18 hours immediately prior	Air conditioner use if influenced both by the temperature during that hour and by heat buildup, as measured by CDH, over the 18 hours immediately prior
10	Same hour CDH and average CDH over the 24 hours immediately prior	Air conditioner use if influenced both by the temperature during that hour and by heat buildup, as measured by CDH, over the 24 hours immediately prior

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Duke Energy Kentucky

Residential Energy Assessments Program Evaluation Report – Final

August 7, 2020

Opinion Dynamics

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1. Evaluation Summary

1.1 Program Summary

The Duke Energy Kentucky (DEK) Residential Energy Assessments (REA) program is a home assessment program that provides customers with a customized energy report that includes recommendations to help lower their energy bills. Customers also receive an Energy Efficiency Starter Kit that contains two LEDs, a low-flow showerhead, two faucet aerators (one kitchen faucet aerator and one bathroom faucet aerator), a 17-foot roll of weather stripping, and six outlet seals, which the auditor who performs the assessment installs free of charge. The auditor may install up to six additional LEDs based on the assessment findings. Auditors also encourage behavioral changes related to energy use and recommend higher-cost energy-saving investments to customers, such as a new HVAC system or energy-efficient appliances.

The REA program targets owner-occupied, single-family residences and relies primarily on direct mail marketing as well as bill inserts to promote the program. In March 2017, auditors began using a new tool called Clipboard that allows them to create reports with energy-saving tips and recommendations that are more customized than before. We established the program evaluation period as March 2017 through April 2018, which represents just over a full year since this change to the audit report structure was put in place. During this timeframe, a total of 587 unique DEK customers participated in the program.

1.2 Evaluation Objectives

This evaluation included assessment of impacts as well as a limited process evaluation, focusing on participant satisfaction.[1] In addition to DEK-specific research, the analyses presented in this report leverage results from two prior evaluations of the Duke Energy Ohio (DEO) REA Program.[2]

The overall objectives of this evaluation were to:

- Estimate household- and program-level net energy and demand savings;
- Determine the in-service rate (ISR) for each program measure;
- Estimate measure-level gross energy as well as winter and summer peak demand savings;
- Assess the likelihood that participants would have installed program measures had the energy efficiency kit not been provided (i.e., free-ridership [FR]);
- Document spillover (SO) associated with program participation;
- Develop DSMore inputs for the energy efficiency kit and additional LED bulbs; and
- Identify participant satisfaction with the program based on the DEK REA participant survey.

[1] Satisfaction results were based on a survey conducted with DEK customers who participated in the REA Program between May 2016 and April 2017. The team conducted a participant survey for a DEK REA Program evaluation, however Duke Energy staff asked the evaluation team to suspend work on this evaluation due to the overall portfolio suspension. Because we had not reported on these results or used them for an analysis, we used the information collected from the survey for this evaluation.

[2] *Duke Energy Ohio. Residential Energy Assessments Program Evaluation Report and Appendices – Final*. October 16, 2018 and *Duke Energy Ohio. Residential Energy Assessments Program - 2014 Program Evaluation Report*. November 30, 2015.

1.3 High-Level Findings

Table 1-1 presents the participant- and program-level net savings for the evaluation period (March 2017 through April 2018). The evaluation team typically estimates the net energy savings using a billing analysis approach. Due to issues with the DEK REA electric billing data (further detailed in Section 4), Opinion Dynamics staff recommended various approaches to estimate net savings and collectively, Duke Energy staff and the Opinion Dynamics team agreed on an alternative method that leverages engineering-based savings from installed program measures multiplied by the average ratio of billing analysis to engineering analysis savings from the past two DEO REA program evaluations[3] (referred to in this report as a "billing analysis multiplier"). Using this multiplier method allowed the evaluation team to approximate the savings that not only result from the measures included in the distributed kits and additional LEDs provided to program participants (both of which are reflected in the engineering estimates), but also the savings from behavioral changes that participants made following the assessment and from participant spillover (SO) (neither of which are reflected in the engineering estimates).

Table 1-1. Net Impact Savings Using Multiplier of DEO REA Billing and Engineering Analysis Savings

Net Participant Savings			Net Program Savings		
Energy (kWh)	Summer Peak Demand (kW)	Winter Peak Demand (kW)	Energy (MWh)	Summer Peak Demand (MW)	Winter Peak Demand (MW)
1,101	0.1228	0.1080	646.2	0.0721	0.0634

Engineering Analysis

The engineering analysis is based on deemed savings values from the 2018 DEO evaluation[4] and DEK-specific ISRs. Using information collected during the participant survey, we estimated DEK ISRs ranging from 41.3% for low-flow showerheads to 88.2% for LEDs. Table 1-2 presents the ISR estimates and relative precision values for the measures included in the energy efficiency kits. We designed our sample to achieve a relative precision of 10% with 90% confidence; however, for most measures, we were unable to achieve this target due to low rates of installation among the surveyed participants.

Table 1-2. DEK ISR Results and Relative Precision

	Kit Average	By Measure				
		LEDs	Low-Flow Showerheads	Faucet Aerators	Outlet Seals	Weather Stripping
Sample size (n)	75	61	75	66	61	17
Estimated ISR	52.3%	88.2%	41.3 %	41.7%	53.8%	58.8%
Relative precision (at 90% confidence)	9.7%	6.5%	22.8%	17.9%	22.6%	36.4%

Table 1-3 presents measure- and household-level gross impact results, estimated by applying the ISRs presented above to deemed savings values from the 2018 DEO evaluation. The table presents estimated

[3] Ibid.
[4] *Duke Energy Ohio. Residential Energy Assessments Program Evaluation Report and Appendices – Final*. October 16, 2018

gross savings for the kit only and for the kit plus additional LEDs, based on the average number provided per participant for the evaluation period.[5]

Table 1-3. DEK Gross Impact Results Per Home from Engineering Review (Inclusive of ISR)

Measure		March 2017–April 2018			
		Energy Savings (kWh)	Summer Peak Demand (kW)	Winter Peak Demand (kW)	Percent of Total kWh Savings
Residential Assessment Kit	LEDs 9W (2)	56.4	0.0044	0.0039	18%
	Low-Flow Shower Head (1)	56.4	0.0019	0.0038	18%
	Bathroom faucet aerator (1)	6.8	0.0006	0.0011	2%
	Kitchen faucet aerator (1)	41.0	0.0018	0.0036	13%
	Outlet Seals (6)	5.2	0.0005	0.0022	2%
	Weather Stripping (per roll)	37.2	0.0170	0.0084	12%
Total Kit Only		**202.9**	**0.0262**	**0.0230**	**65%**
Additional LEDs (average of 3.5 bulbs)		107.2	0.0084	0.0074	35%
Total Per-Home Estimate		**310.1**	**0.0346**	**0.0304**	**100%**

Billing Analysis Multiplier

As noted above, the DEK REA billing data received from Duke Energy was anomalous. Duke Energy staff and the Opinion Dynamics evaluation team therefore agreed to base program-level savings on the engineering-derived participant savings by applying a multiplier that equals the average ratio of billing analysis savings to engineering analysis savings from the past two completed DEO REA program evaluations. Table 1-4 presents the derivation of the multiplier used to develop net program impacts.

Table 1-4. Derivation of Multiplier Based on DEO Billing Analysis Results Applied to DEK REA Engineering Impacts

Evaluation Period	Engineering-based Annual Energy Savings (kWh)	Billing Analysis Annual Energy Savings (kWh)	Billing Analysis to Engineering Analysis Savings Ratio Multiplier
8/2013 – 12/2014	286	975	3.40
5/2016 – 4/2017	286	1,059	3.70
		Average	**3.55**

Note: The DEO REA billing analysis results are taken from the following two DEO REA evaluations: *Duke Energy Ohio. Residential Energy Assessments Program Evaluation Report and Appendices – Final*. October 16, 2018 and *Duke Energy Ohio. Residential Energy Assessments Program - 2014 Program Evaluation Report*. November 30, 2015.

The evaluation team multiplied the Total Per-Home Energy Savings estimate from the engineering analysis (310.1 kWh) by the multiplier value of 3.55 to arrive at the per participant net energy savings value of 1,101 kWh for the evaluation period.

[5] Participants were eligible to receive up to six additional LEDs per home. The average number installed for DEK REA participants equaled 3.5 LEDs per household.

Net-to-Gross Ratio (NTGR) Analysis

The evaluation team relied on NTGRs (defined as 1 – FR + SO) from the most recent DEO REA program evaluation summarized below in Table 1-5. FR survey questions reference kit measures, while SO survey questions focus on measures installed outside of the program for which no incentives were received but were likely influenced by participating in the REA program. The evaluation team estimated FR at the measure level and SO at the program level.

Table 1-5. DEO NTGR Results

Component	FR	SO	NTGR
Energy Efficiency Kit[a]	**26.6%**	**8.3%**	**81.7%**
LEDs	52.4%		55.8%
Low-flow showerhead	18.2%		90.1%
Faucet aerators[b]	11.9%		96.4%
Outlet seals	16.8%		91.5%
Weather Stripping	20.5%		87.8%
Additional LEDs[c]	**52.4%**		**55.8%**

[a] FR for the Energy Efficiency Kit is the DEK savings-weighted average of the measure-level FR values.

[b] FR questions for faucet aerators did not differentiate between kitchen and bathroom aerators.

[c] We estimated a single FR for LEDs in the kit as well as additional ones supplied.

DSMore Inputs

For planning purposes, Duke Energy requires separate per-participant savings values for the energy efficiency kit and the additional bulbs distributed to participants. To provide these estimates, the evaluation team subtracted the engineering-derived net savings of the average number of additional bulbs distributed (3.5 LED bulbs) from the per-participant net participant savings (inclusive of the kit and the additional LEDs). Taking this step ensures that savings from the additional bulbs are not double-counted for planning purposes (see Table 1-6).

Table 1-6. DEK DS More Inputs

DS More Inputs	Energy Savings (kWh)	Summer Peak Savings (kW)	Winter Peak Savings (kW)
Net energy efficiency kit savings per participant (excluding additional LEDs)	1,050.1	0.1172	0.0986
Net savings per additional LED bulb [a]	14.5	0.0016	0.0027

[a] Net savings per additional LED = ex ante gross savings per additional LED (as provided by Duke Energy) * NTGR for LEDs (55.8%)

1.4 Evaluation Recommendations

We developed the following recommendation based on the results of our evaluation:

- **Continue to reinforce to auditors that they should install all measures in distributed energy efficiency kits. If unable to install all measures, auditors should track the barriers that prevent them from doing so and develop tactics to overcome these barriers.** Information collected from the survey of customers who participated between May 2016 and April 2017 resulted in low installation rates (IR) with the exception of LEDs. However, through conversations with the program manager, the evaluation team learned that additional training of implementation staff occurred in the Spring of 2017 to address this issue and to instruct installers to document why measures were not installed. The evaluation team anticipates that the training should help auditors improve their IRs and therefore increase program savings. Additionally, if they document why measures are not installed and provide this information to the evaluation team, we can recommend strategies to overcome those barriers.

2. Program Description

The Duke Energy Kentucky (DEK) Residential Energy Assessments (REA) program is a home assessment program that provides customers with a customized energy report with recommendations to help lower energy bills. The program targets residents of owner-occupied, single-family households who have been in their homes for at least four months.

2.1 Program Design

The REA program has two main components. The first is the home energy assessment, branded to customers as the "Home Energy House Call" Program. During the assessment, auditors enter participants' homes to inspect and assess energy-centric equipment in the home, including their heating and cooling equipment and the state of the duct and home insulation. Auditors also look for places where customers could either make an improvement to equipment (e.g., replacing an outdated heat pump, removing older secondary appliances) or adjust the way that they use current equipment (e.g., adjusting the settings for their furnace fan, using window shades in the summer). These recommendations are meant to steer customers toward home improvements and behavioral changes that will help them save more energy.

The second component is a free kit of low-cost, energy-efficient measures. The Energy Efficiency Starter Kit consists of two 9W LEDs, two faucet aerators (one kitchen aerator and one bathroom aerator), a low-flow showerhead, outlet seals (a package of four outlet and two switch seals), and a 17-foot roll of closed-cell foam weather stripping. Customers can also receive up to six additional LEDs, as determined by the auditor, regardless of bulbs received from other Duke Energy programs.

In its program-tracking databases, DEK tracks the date that customers were entered into the database, the recommendations made by the auditor during the assessment, and the number of additional LEDs given to the customer.

2.2 Program Implementation

During the evaluation period, DEK contracted with Franklin Energy to implement the REA Program. The implementers used a multichannel marketing approach, including bill inserts and direct mail letters. In March 2017, auditors began using a new tool called Clipboard that allows them to create reports with tips and recommendations that are more customized than before. To capture this program modification, we established the program evaluation period to be March 1, 2017 through April 30, 2018, which represents just over a full year since this change to the audit report structure was put in place.

2.3 Program Performance

Over the evaluation period, the program served 587 unique participants. Based on our impact evaluation, the program saved participants, on average, 1,101 net kWh per household per year. Coincident net demand savings per household were 0.12 kW in summer and 0.11 kW in winter. Program net savings equaled 646 MWh and coincident demand savings of 0.07 MW in summer and 0.06 kW in winter.

3. Overview of Evaluation Activities

3.1 Program Staff Interview

Opinion Dynamics conducted an in-depth interview with the current REA program manager in August 2018. The purpose of the interview was to gauge the current environment of the REA Program, including the program's goals, successes, and challenges over the evaluation period. During the interview, the program manager described recent changes to the program's implementation. The most significant change to the program occurred in March 2017, when auditors began to use a new tool called Clipboard that allows them to create reports with tips and recommendations that are more customized than before.

3.2 Program Materials Review

Opinion Dynamics reviewed marketing and outreach materials and the program-tracking database. We found these program materials relating to the assessment, energy savings recommendations, and marketing to be complete and of high quality.

3.3 Participant Survey

Opinion Dynamics implemented a computer-assisted telephone interviewing (CATI) survey in the second half of November 2017 with customers who participated in the REA Program between May 2016 and April 2017.[6] The survey gathered data to verify participation in the program; develop measure-level rates of installation, persistence, and ISRs; and support a limited process evaluation that focused on customer satisfaction with the program and its various elements.

We based the survey sample design and sample size on customers who participated during the evaluation period. Of the 587 unique participants in the database, we drew a random sample of 421 valid telephone numbers. We used this sample to complete 75 participant telephone interviews.

The average length of the interviews was approximately 24 minutes; the response rate was 25%.

3.4 Engineering Analysis

Opinion Dynamics conducted an engineering analysis for the measures included in the Energy Efficiency Starter Kit and the additional LEDs. This analysis had the following objectives:

1. Update measure-level deemed savings values, based on the 2018 DEO REA evaluation[7] for each kit measure and ISRs from the 2017 DEK participant survey;

[6] Opinion Dynamics started to evaluate the DEK REA Program based on an earlier time period, but we did not complete this evaluation because Duke Energy EM&V staff instructed our team to cease activities for several months due to DEK's overall portfolio suspension. Once Duke Energy allowed us to re-start the evaluation, the team and Duke Energy staff agreed that we would use the data collected from this previously conducted survey since we had not had an opportunity to report on these results.

[7] Deemed savings from the 2018 DEO evaluation relied on algorithms and assumptions from the Ohio and Indiana TRMs as well as other secondary sources applicable to the DEK service territory.

2. Calculate per-participant savings; and
3. Develop a ratio between per-participant energy and demand savings that can be applied to the net energy savings to determine net demand savings.

In addition, we used the results of this analysis to estimate program-level net savings, since we were not able to conduct a billing analysis for this Program (see Section 4.2.2 below).

4. Impact Evaluation

Opinion Dynamics typically conducts a billing analysis to determine the net savings attributable to the REA Program for the evaluation period. A billing analysis compares the electric bills of customers who participated in the REA Program during the evaluation period to the electric bills of a comparison group comprised of future participants to assess energy savings that result from installing energy efficiency kit measures, any additional LEDs provided during the home assessment, and behavioral changes that participants make based on recommendations they receive during the home assessment.

Review of the billing data provided by Duke Energy staff for DEK REA Program participants appeared erroneous as the baseline ADC was unreasonably high relative to the baseline ADC values of REA participants from other Duke Energy jurisdictions, including DEO. For this reason, Duke Energy and the Opinion Dynamics team agreed to develop net participant and program savings based on the engineering-based gross energy savings estimated for the program. To account for the fact that engineering estimates do not capture any behavioral changes or spillover, we adjusted the engineering estimate through a “billing analysis multipler.”

The methodology and results of this analysis are summarized below.

4.1 Methodology

4.1.1 Engineering Analysis

As part of the impact evaluation, Opinion Dynamics conducted an engineering analysis for each measure contained in the REA Energy Efficiency Starter Kit. The team used the the engineering impacts to:

1. Estimate the net participant- and program-level kWh savings by multiplying the engineering-based savings by the “billing analysis multiplier”
2. Provide a ratio of kW coincident demand to kWh energy savings, which is then applied to the net energy savings to estimate net demand savings
3. Provide insight into the individual measure contributions to the overall kit savings

Two key components of the engineering analysis include (1) updates of per-unit measure savings and (2) development and application of measure-level in-service rates (ISR). Both components are discussed below.

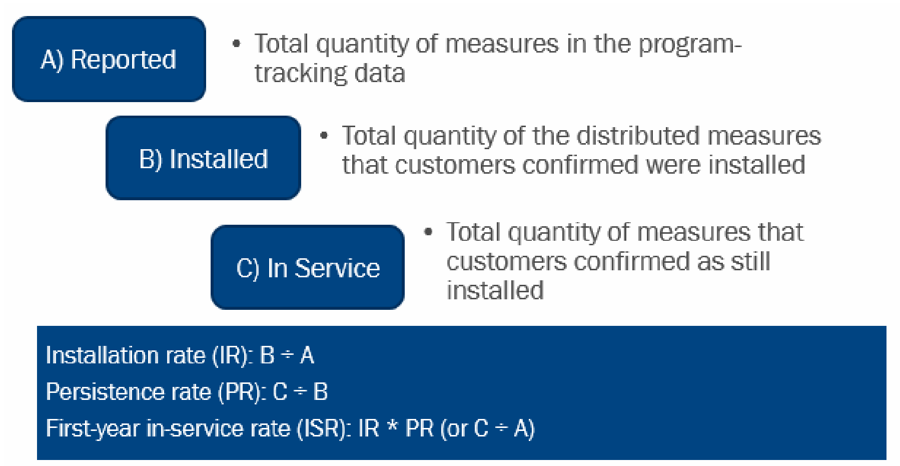
Per-Unit Measure Savings

We applied the per-measure savings from the 2018 DEO REA evaluation for each measure included in the kit. The 2018 DEO savings values rely on the Ohio TRM, IN TRM V2.2, and other applicable resources. The engineering analysis applies ISRs from the 2017 DEK participant survey to ensure only savings for installed measures are counted.

Installation Verification and Persistence

The evaluation team implemented surveys in November 2017 with 75 participants to verify measure installation and persistence to support development of measure-level ISRs. Our engineering estimates use these values in calculations for per-customer savings (Figure 4-1). Specifically, we asked participants to confirm the quantity of kit measures installed and, if applicable, to provide the corrected quantity. We then divided the number of measures verified by the respondent by the quantity they received in the kit. This Installation Rate (IR) is the first component of the total ISR. Where applicable, we also asked participants to confirm whether program measures remained installed in their homes to create a persistence rate (PR). We then created a measure-specific total ISR by multiplying the two components.

Figure 4-1. Installation Rate Components



4.1.2 Billing Analysis Multiplier

As noted above, billing data for DEK REA participants showed unexpectedly high baseline ADC values, compared to the ADC of participants in prior evaluations of REA programs in other Duke Energy jurisdictions, including the prior two DEO evaluations. The baseline ADC of DEK REA participants equaled 70.8 kWh. In comparison, the ADC values from the most recently completed DEO REA evaluations equaled 46.2 kWh and 44.8 kWh, respectively (see Table 4-1). The baseline ADC values for other Duke Energy jurisdictions ranged from 47.1 to 50.1 kWh. The evaluation team believes that the billing data provided for this evaluation is erroneous, as Duke Energy also reported the annual electricity usage of DEK residential customers to be equal to 11,394 kWh, which yields an ADC value of 31.2 kWh.[8]

Table 4-1. Baseline ADC for Duke Energy REA Participants in Various Jurisdictions

Jurisdiction	Evaluation Period	Average Daily Consumption
DEO	8/2013 – 12/2014	44.8
	5/2016 – 4/2017	46.2
DEI	1/2015 – 12/2015	50.1
DEC	5/2016 – 4/2017	47.6
DEP	4/2016 – 3/2017	49.8

[8] The annual electricity usage for the DEK residential customers was provided by Duke Energy staff in an email communication received on May 4, 2020.

Jurisdiction	Evaluation Period	Average Daily Consumption
DEK	3/2017 – 4/2018	70.8

Because of the data anomaly, Duke Energy staff and the Opinion Dynamics evaluation team agreed to base net participant-savings on the engineering-derived participant savings and apply a multiplier that equals the average ratio of billing analysis savings to engineering analysis savings from the past two completed DEO REA program evaluations. This ratio allows the evaluation team to approximate the savings typically estimated through a billing analysis, which capture savings from behavioral changes and spillover, both of which are not included in the engineering estimates. Table 4-2 presents the engineering-based annual energy savings and the billing analysis energy savings used to develop the multiplier.

Table 4-2. Derivation of Multiplier Based on Billing to Engineering Analysis Savings from Previous DEO REA Evaluations

Evaluation Period	Engineering-based Annual Energy Savings (kWh)	Billing Analysis Annual Energy Savings (kWh)	Billing Analysis to Engineering Analysis Savings Ratio Multiplier
8/2013 – 12/2014	286	975	3.40
5/2016 – 4/2017	286	1,059	3.70
		Average	**3.55**

Note: The DEO REA billing analysis results are taken from the following two DEO REA evaluations: *Duke Energy Ohio. Residential Energy Assessments Program Evaluation Report and Appendices – Final*. October 16, 2018 and *Duke Energy Ohio. Residential Energy Assessments Program - 2014 Program Evaluation Report.* November 30, 2015.

4.2 Impact Results

4.2.1 Engineering Analysis Results

This section provides the results of the engineering analysis, including ex post deemed savings values, survey-based ISRs, and per-participant gross energy and demand savings.

The evaluation team relied on the 2018 DEO REA deemed savings as summarized in Table 4-3. For more details around the assumptions and algorithms used to derive these savings see the deemed savings review in the DEO REA Program Evaluation Report.[9]

Table 4-3. Ex Post Deemed Savings for Energy Efficiency Starter Kit Measures

Measure	Ex Post Deemed Savings Per Unit (kWh)	Ex Post Deemed Savings Per Kit (kWh)[a]
LED	31.95	63.90
Low-flow shower head	136.46	136.46
Bathroom faucet aerator	16.21	16.21
Kitchen faucet aerator	98.45	98.45
Outlet Gaskets	1.61	9.66
Weather stripping	3.72	63.22
Energy Efficiency Kit	N/A	387.90

Note: These values do not include ISRs.

[a] Energy efficiency kits contain two LEDs, six outlet seals and 17 feet of weather stripping; the per-unit value for weather stripping is for one foot.

Except for LEDs, the evaluation found relatively low ISRs for measures included in the kit. Many participants reported that auditors often do not install all kit measures during the assessments, resulting in low IRs. However, PRs are greater than 90% for all measures except low-flow showerheads, suggesting that once installed, most measures stay in place.

Table 4-4 summarizes the IR, PR, and in-service rate (ISR) for each kit measure.

Table 4-4. DEK Measure-Level IRs, PRs, and ISRs

Measure	IR	PR	ISR
LED	92.2%	95.8%	88.2%
Low-flow shower head	48.0%	86.1%	41.3%
Bathroom faucet aerator	45.5%	94.2%	41.7%
Kitchen faucet aerator			
Outlet seal	53.8%	100.0%	53.8%
Weather stripping	64.7%	90.9%	58.8%
Additional LEDs [a]	100.0%	95.8%	95.8%

[9] *Duke Energy Ohio. Residential Energy Assessments Program Evaluation Report and Appendices – Final*. October 16, 2018. Prepared for Duke Energy by Opinion Dynamics.

Source: 2017 DEK REA Program Participant Survey

[a] The IR of additional LEDs is assumed to be 100%. The PR is based on survey responses related to LEDs provided in the kit.

To calculate per-participant engineering gross impacts, we multiplied the deemed savings values by the average distributed quantity of each measure included in the kit and measure-level ISRs. Table 4-5 shows the resulting estimated energy and demand savings for each measure included in the kit. In addition to the kit measures, the program reported distributing 2,056 additional LEDs to customers during the assessments, an average of 3.5 LEDs per household. Energy savings from lighting (both kit LEDs and additional LEDs) contribute approximately 53% of the energy savings for each household. These estimates of energy savings include the ISRs presented in

Table 4-4 above.

Table 4-5. Engineering Analysis Gross Impact Results

Measure		March 2017–April 2018			
		Energy Savings (kWh)	Summer Peak Demand (kW)	Winter Peak Demand (kW)	Percent of Total kWh Savings
Residential Assessment Kit	LEDs 9W (2)	56.4	0.0044	0.0039	18%
	Low-Flow Shower Head (1)	56.4	0.0019	0.0038	18%
	Bathroom faucet aerator (1)	6.8	0.0006	0.0011	2%
	Kitchen faucet aerator (1)	41.0	0.0018	0.0036	13%
	Outlet Seals (6)	5.2	0.0005	0.0022	2%
	Weather Stripping (per roll)	37.2	0.0170	0.0084	12%
Total Kit Only		**202.9**	**0.0262**	**0.0230**	**65%**
Additional LEDs (average of 3.5 bulbs)		107.2	0.0084	0.0074	35%
Total Per-Home Estimate		**310.1**	**0.0346**	**0.0304**	**100%**

Using the estimated savings from Table 4-5, we calculated an overall kW per kWh savings ratio from the engineering analysis. Table 4-6 displays two different ratios: one for the kit only and one for the kit plus additional LEDs.

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

	Total Gross Energy Savings (kWh)	Summer Coincident Peak Savings (kW)	Winter Coincident Peak Savings (kW)	Summer Ratio Multiplier (summer demand/energy savings)	Winter Ratio Multiplier (winter demand/energy savings)
Kit only	202.92	0.0262	0.0230	0.0001290	0.0001133
Kit + additional LEDs	310.11	0.0346	0.0304	0.0001116	0.0000981

4.2.2 Program-level Savings

Opinion Dynamics multiplied the participant-level engineering-based gross energy savings for the DEK REA Program of 310.1 kWh (which includes measures in the energy efficiency kits and savings from the average number of additional LEDs provided) by the multiplier value of 3.55 to arrive at per participant net savings equal to 1,101 kWh and peak demand savings equal to 0.1128 kW and 0.1080 kW in summer and winter, respectively. Multiplying these savings by the number of DEK REA participants who participated during the evaluation period results in net program energy savings of 646.2 MWh. The net summer and winter peak demand savings are 0.0721 MW and 0.0634 MW.

Table 4-7. Net Impact Savings Using Multiplier of DEO REA Billing and Engineering Analysis Savings

Net Participant Savings			Net Program Savings		
Energy (kWh)	Summer Peak Demand (kW)	Winter Peak Demand (kW)	Energy (MWh)	Summer Peak Demand (MW)	Winter Peak Demand (MW)
1,100.9	0.1228	0.1080	646.2	0.0721	0.0634

5. Net-to-Gross Analysis

5.1 Methodology

The net-to-gross analysis for the DEK REA program relied upon the free-ridership and spillover results from the DEO REA program evaluation. The NTGR includes consideration of free-ridership (FR) and spillover (SO). These concepts are defined as follows:

- Free-riders are program participants who would have completed the same energy efficiency upgrades or made the same behavioral changes without the program. FR scores represent the percentage of savings that would have been achieved in the absence of the program. FR scores can range from 0% (not a free-rider; the participant would not have completed the project without the program) to 100% (a full free-rider; the participant would have completed the project without the program). FR scores between 0% and 100% represent partial free-riders, i.e., participants who were to some degree influenced by the program to complete the energy efficiency upgrade.
- SO refers to additional energy efficiency upgrades participants made at the time of or after their participation in the DEK REA Program that were influenced by the program but for which they did not receive a program incentive. SO is estimated at the program level and expressed as a percentage of program savings.

FR and SO are based on the recently completed DEO evaluation. The NTGR is calculated as:

$$NTGR = 1 - FR + SO$$

5.2 Net-to-Gross Results

This section presents the DEO REA estimates of FR and participant SO, and the resulting NTGRs. The evaluation team used the NTGRs below to estimate the net ex post engineering-based savings for individual measures in the kits. Because we derived the billing analysis multiplier using results from previous billing analysis results, the savings are inherently net values. We derived both the FR and SO components of the NTGR from self-reported information from telephone interviews with DEO REA program participants. The final NTGR is the percentage of gross program savings that can be attributed to the program. Note that we developed the DEK REA-specific Energy Efficiency kit FR value by calculating a savings-weighted average of the FR values of measures in the kit.

Table 5-1 shows FR estimates at the measure level, and the SO estimate at the program level. We estimate program FR to equal 26.6% and program SO to equal 8.3%. The resulting NTGR for the REA program for the evaluation period is 81.7%. When applied to engineering gross estimates, the estimated SO rate of 8.3% represents an average of about 26 kWh per household.

Table 5-1. Measure-Level NTGRs

Component	FR	SO	NTGR
Energy Efficiency Kit [a]	26.6%	8.3%	81.7%
LEDs [b]	52.4%		55.8%
Low-flow shower head	18.2%		90.1%

Component	FR	SO	NTGR
Faucet aerators [c]	11.9%		96.4%
Outlet seals	16.8%		91.5%
Weather stripping	20.5%		87.8%

[a] FR for the Energy Efficiency Kit is the weighted average of the measure-level FR values.
[b] FR for LEDs applies to LEDs in the kit as well as additional ones supplied.
[c] FR questions for faucet aerators did not differentiate between kitchen and bathroom aerators.

6. Process Evaluation

6.1 Researchable Questions

Due to budget limitations, the evaluation team conducted a limited process evaluation based on previously collected data through a participant survey administered to DEK REA participants in 2017. We surveyed customers who participated in the DEK REA Program between May 2016 and April 2017. The process evaluation focuses on customer satisfaction with various program elements:

- the home energy audit (including scheduling, time taken to complete, and professionalism of the auditor)
- the types and quality of energy-efficient equipment provided to you during the audit
- the information provided in the audit report
- the savings seen since participating in the program
- the program overall

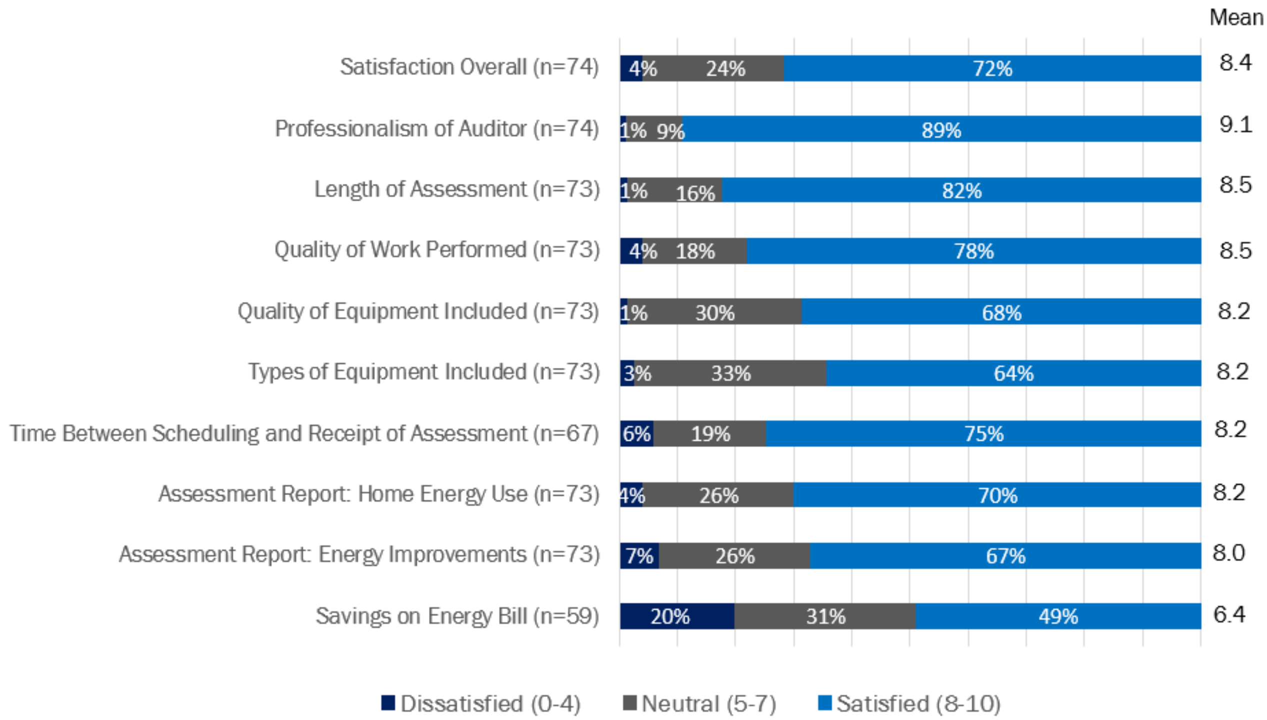
6.2 Methodology

The process evaluation relied primarily on our analysis of the participant survey questions related to satisfaction with various elements of the REA program.

6.3 Key Satisfaction Findings

Overall, program satisfaction was high across various aspects of the program. Seventy-two percent of customers said that they were "satisfied" with the program overall (see Figure 6-1). The areas of highest satisfaction relate to the professionalism of the auditor (9.1 out of 10), length of the assessment (8.9 out of 10) and to the quality of the auditor's work and the equipment in the kits (both with mean ratings of 8.5 out of 10). The rating related to savings on energy bills was the lowest-rated component of the program (mean rating of 6.4). With this one exception, all program aspects had a mean satisfaction rating of 8 or above out of 10 and low levels of dissatisfaction (a rating of 4 or less). The mean satisfaction rating of the program overall was 8.4 out of 10.

Figure 6-1. Program Satisfaction



7. Conclusions and Recommendations

Below we present the key findings from our evaluation, and, where applicable, accompanying recommendations.

Finding: Overall, Opinion Dynamics found that participants of the DEK REA program were satisfied with the program and its various elements. Participants were highly satisfied with the program, averaging a score of 8.4 out of 10. The program elements that rated most highly include the professionalism of the auditor and the quality of the auditor's work.

Finding: Similar to REA programs in other Duke Energy jurisdictions, not all measures from the Energy Efficiency Starter Kit were installed by auditors. Aside from LEDs, the installation rate of other kit measures varied from between 46% and 65%.

> **Recommendation: Continue to reinforce to auditors that they should install all measures in distributed energy efficiency kits. If unable to install all measures, auditors should track the barriers that prevent them from doing so and develop tactics to overcome these barriers.** Information collected from the survey of customers who participated between May 2016 and April 2017 resulted in low IRs with the exception of LEDs. However, through conversations with the program manager, the evaluation team learned that additional training of implementation staff occurred in the Spring of 2017 to address this issue and to instruct installers to document why measures were not installed. The evaluation team anticipates that the training should help auditors improve their IRs and therefore increase program savings. Additionally, if they document why measures are not installed and provide this information to the evaluation team, we can recommend strategies to overcome those barriers.

8. DSMore Inputs

For planning purposes, Duke Energy requires separate per-participant savings values for the energy efficiency kit and the additional bulbs distributed to participants. To provide these estimates, the evaluation team took the following steps:

1. We estimated **net savings per additional LED** by multiplying gross savings per additional LED by the LED NTG ratio of 55.8%.
2. We estimated **net savings of the kit exclusive of additional LEDs** by subtracting net savings for the average number of additional LEDs (3.5 bulbs) from per household savings based on engineering savings multiplied by a "billing analysis multiplier".

Developing these separate inputs ensures that savings from the additional bulbs are not double-counted for planning purposes, as we already included their savings in the billing analysis estimate.

Table 8-1 presents the development of the DSMore inputs.

Table 8-1. Development of DSMore Inputs

Data for Development of DSMore Inputs	Energy Savings (kWh)	Summer Coincident Demand (kW)	Winter Coincident Demand (kW)
Gross savings per additional LED bulb [a]	26.00	0.0029	0.0048
LED NTG ratio = 55.8%			
Net savings per LED additional bulb: Engineering analysis	14.51	0.0016	0.0027
Program savings per participant: Net savings analysis	1,100.89	0.1228	0.1080
Net Savings for additional LED Bulbs (average of 3.5 bulbs)	50.78	0.0057	0.0094
Net kit savings per participant (excluding additional LEDs)	1,050.11	0.1172	0.0986

[a] Gross savings per additional bulb is from the DSMore table provided by Duke Energy for the DEK REA Program.

The updated DSMore Inputs are included in the Microsoft Excel file: DSMore table DEK REA 202-07-06.xlsx

9. Summary Form

Residential Energy Assessments

Completed EM&V Fact Sheet

The REA program provides, free of cost, a home energy assessment, which includes a kit of low-cost energy efficiency measures. A report of recommended upgrades and behavioral changes is given to the customer at the end of the assessment.

Date	July 6, 2020
Region(s)	Duke Energy Kentucky
Evaluation Period	March 2017–April 2018
kWh Savings	646,222 kWh
Per Participant Net kWh	1,100.89 kWh
Per Participant Coincident Net kW	0.1228 kW (Summer) 0.1080 kW (Winter)
Measure Life	Not Evaluated
Net-to-Gross Ratio for Additional Bulbs only	55.8%
Process Evaluation	Yes, limited
Previous Evaluation(s)	No

Evaluation Methodology

The evaluation team conducted an engineering analysis, applying DEK-specific ISR estimates to deemed savings values from the last DEO REA evaluation. The evaluation team was not able to conduct a billing analysis due to data anomalies that could not be resolved. Instead we developed a multiplier based on the ratio of billing analysis results to engineering results from the two prior DEO RES evaluations and applied this multiplier to DEK engineering-based savings.

Results from the net savings analysis reflect savings associated with measures installed, assessment recommendations, SO, and potential behavioral changes from energy efficiency knowledge gained through participation in the REA program.

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Save Energy and Water Kits 2018 – 2019 Evaluation Report

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

April 6th, 2020

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1 Executive Summary

1.1 Program Summary

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

1.2 Evaluation Objectives and Results

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

1.2.1 Impact Evaluation

The evaluation team conducted the evaluation as detailed in this report to estimate energy and demand savings attributable to the DEK program. The evaluation was divided into two research areas - to determine gross savings and net savings (or impacts). Gross impacts are energy and demand savings estimated at a participant's home that are the direct result of the homeowner's installation of a measure included in the SEWKP kit. Net impacts reflect the degree to which the gross savings are a result of the program efforts and funds.

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

Table 1-1: Energy Savings per Kit

Kit Size	Population	Reported Energy (kWh)	Energy Realization Rate	Gross Verified Energy (kWh)
Small	734	672	47.5%	319
Medium	369	843	45.6%	384
Program Total	**1,103**	**729**	**46.7%**	**341**

Table 1-2: Demand Savings per Kit

Kit Size	Summer Demand (kW)			Winter Demand (kW)		
	Reported	Realization Rate	Gross Verified	Reported	Realization Rate	Gross Verified
Small	0.054	53.8%	0.029	0.077	49.7%	0.038
Medium	0.067	51.0%	0.034	0.075	60.9%	0.046
Program Total	**0.058**	**52.7%**	**0.031**	**0.076**	**53.4%**	**0.041**

Table 1-3: Program Level Savings

Measurement	Population	Reported	Realization Rate	Gross Verified
Energy (kWh)	1,103	804,315	46.7%	375,850
Summer Demand (kW)		64.2	52.7%	33.8
Winter Demand (kW)		83.9	53.4%	44.8

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

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

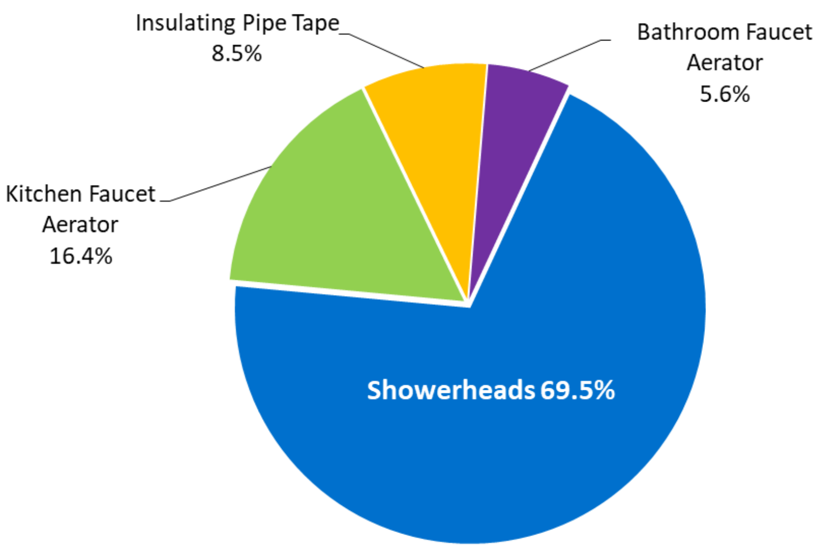


Table 1-4: DEK Verified Impacts by Measure

Measure	Energy Savings per unit (kWh)	Summer Demand Savings per unit (kW)	Winter Demand Savings per unit (kW)	Free Ridership	Spillover	Net to Gross Ratio
Low-flow Showerhead	177.5	0.0149	0.0206	11.5%	14.5%	103.0%
Low-flow Kitchen Aerator	55.7	0.0039	0.0051			
Low-flow Bathroom Aerator	9.6	0.0018	0.0024			
Pipe Wrap*	5.9	0.0007	0.0007			

* Savings for pipe tape is a per linear foot measurement

1.2.2 Process Evaluation

The process evaluation assessed opportunities for improving the program's design and delivery in the DEK service territory. It specifically documented participant experiences by investigating participating household responses to the kits and the extent to which the kits effectively motivate households to save energy.

The evaluation team reviewed program documents and conducted telephone and web surveys with households that received a kit (n=174). The team also conducted in-depth interviews with utility and implementation staff.

Program Successes

The 2018-2019 DEK SEWKP evaluation found successes in the following areas:

Most participants are satisfied with kit items and report high satisfaction with the program overall. Eighty-four percent of participants reported they were highly satisfied with the program overall, and less than 10% of participants reported dissatisfaction with each of the specific measures.

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

The program influenced household to install kit measures. Most participating households installed at least one measure from the kit and the vast majority of installed measures, once installed, remained installed. Participants were highly influenced by the program to install kit measures, as demonstrated by low free ridership rates. Further, 19% of respondents reported program-attributable spillover.

Program Challenges

The 2018-2019 DEK SEWKP evaluation found some challenges in the following areas:

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

Fewer participants are installing at least one measure. Slightly less than three-quarters of participants installed at least one measure. This reflects a decrease in installation rates for all four measures and is a lower in-service rate than seen in previous SEWKP evaluation cycles across Duke Energy jurisdictions.

1.3 Evaluation Conclusions and Recommendations

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

Conclusion 1: The program model is highly successful: it leverages low-cost measures to foster energy savings that would not have happened otherwise. Duke Energy's easy process for requesting and receiving a kit with free energy and water-saving items motivated over 1,100 customers to request and install energy saving measures in their home during the evaluation period. Most participants installed at least one measure from the kit, relatively few measures get uninstalled, and many participants reported installing additional energy saving items since receiving the kit. The majority of participants said they would not have installed any of the items on their own, as represented by low free ridership rates, and the program is reaching a diverse range of customers in terms of household characteristics and demographics.

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

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

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

Conclusion 3: Fewer participants are installing at least one measure. Seventy-two percent of participants reported installing at least one item from the kit, which is lower than the in-service rates seen for this program in the past evaluation cycle

> **Recommendation**: Monitor installation rates in other jurisdictions in upcoming evaluations to determine if this downward trend is specific to Ohio and Kentucky,

leveraging reincorporated survey questions that ask why participants did not install measures.

2 Introduction and Program Description

2.1 Program Description

2.1.1 Overview

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

2.1.2 Energy Efficiency Kit Measures

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

Table 2-1: Kit Measures and Quantity

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

2.2 Program Implementation

2.2.1 Participant Identification and Recruitment

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

2.2.2 Participation

For the defined evaluation period of July 1st, 2018 through June 30th 2019, the program recorded a total of 1,103 kit recipients in DEK. During survey recruitment of sampled customers, 0% of participants reported that their kit did not arrive in the mail.

2.3 Key Research Objectives

Over-arching project goals will follow the definition of impact evaluation established in the “Model Energy-Efficiency Program Impact Evaluation Guide – A Resource of the National Action Plan for Energy Efficiency,” November 2007:

> *“Evaluation is the process of determining and documenting the results, benefits, and lessons learned from an energy-efficiency program. Evaluation results can be used in planning future programs and determining the value and potential of a portfolio of energy-efficiency programs in an integrated resource planning process. It can also be used in retrospectively determining the performance (and resulting payments, incentives, or penalties) of contractors and administrators responsible for implementing efficiency programs”.*

Evaluation has two key objectives:

1) To document and measure the effects of a program and determine whether it met its goals with respect to being a reliable energy resource.
2) To help understand why those effects occurred and identify ways to improve the program.

2.3.1 Impact

As part of evaluation planning, the evaluation team outlined the following activities to assess the impacts of the DEK SEWKP:

- Quantify accurate and supportable energy (kWh) and demand (kW) savings for energy efficient measures implemented in participants’ homes;
- Assess the rate of free riders from the participants’ perspective and determine spillover effects;
- Benchmark verified measure-level energy impacts to applicable technical reference manual(s) and other Duke-similar programs in other jurisdictions.

2.3.2 Process

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

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

Motivation:

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

Program experience and satisfaction:

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

Challenges and opportunities for improvement:

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

Participant household characteristics:

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

2.4 Evaluation Overview

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

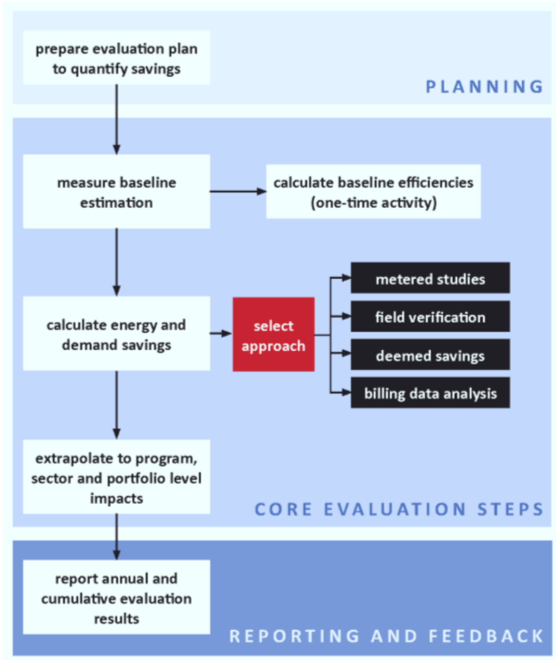
- **Task 1 –** Develop and manage evaluation work plan to describe the processes that will be followed to complete the evaluation tasks outlined in this project;
- **Task 2 –** Conduct a process review to determine how successfully the programs are being delivered to participants and to identify opportunities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

2.4.1 Impact Evaluation

The primary determinants of impact evaluation costs are the sample size and the level of rigor employed in collecting the data used in the impact analysis. The accuracy of the study findings is in turn dependent on these parameters. Techniques that we used to conduct our evaluation, measurement, and verification (EM&V) activities, and to meet the goals for this evaluation, included telephone and web-based surveys with program participants, best practice review, and interviews with implementation and program staff.

Figure 2-1 demonstrates the principal evaluation team steps organized through planning, core evaluation activities, and final reporting.

Figure 2-1: Impact Evaluation Process



The evaluation is generally comprised of the following steps, which are described in further detail throughout this report:

- **Participant Surveys:** The file review for all sampled and reviewed program participation concluded with a telephone and/or web-based survey with the participants. Table 2-2 below summarizes the number of surveys completed. The samples were drawn to meet a 90% confidence and 10% precision level based upon the expected and actual significance (or magnitude) of program participation, the level of certainty of savings, and the variety of measures.
- **Calculate Impacts:** Data collected via surveys enabled the evaluation team to calculate gross verified energy and demand savings for each measure.
- **Estimate Net Savings**: Net impacts are a reflection of the degree to which the gross savings are a result of the program efforts and incentives. The evaluation team estimated free-ridership and spillover based on self-report methods through surveys with program participants. The ratio of net verified savings to gross verified savings is the net-to-gross ratio as an adjustment factor to the reported savings.

2.4.2 Process Evaluation

Process evaluation examines and documents:

- Program operations
- Stakeholder satisfaction

- Opportunities to improve the efficiency and effectiveness of program delivery

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

Table 2-2: DEK SEWKP Summary of Evaluation Activities

Target Group	2018 Population	Sample	Confidence /Precision	Method
Impact Activities				
DEK Participants	1,103	174	90/5.8	Telephone/Web Survey
Process Activities				
DEK Participants	1,103	174	90/5.8	Telephone/Web Survey
Duke Energy Program Staff	n/a	1	n/a	Telephone IDI
Implementer Staff: EFI	n/a	1	n/a	Telephone IDI

3 Impact Evaluation

3.1 Methodology

The evaluation team's impact analysis focused on the energy and demand savings attributable to the SEWKP for the period of July 2018 through June 2019. The evaluation was divided into two research areas: to determine gross savings and net savings (or impacts). Gross impacts are energy and demand savings estimated at a participant's home that are the direct result of the homeowner's installation of a measure included in the program-provided energy saving kit. Net impacts are a reflection of the degree to which the gross savings are a result of the program efforts and funds. The evaluation team verified energy and demand savings attributable to the program by conducting the following impact evaluation activities:

- Review of DEK participant database.
- Completion of telephone and web-based surveys to verify key inputs into savings calculations.
- Estimation of gross verified savings using primary data collected from participants.
- Comparison of the gross-verified savings to program-evaluated results to determine kit-level realization rates.
- Application of attribution survey data to estimate net-to-gross ratios and net-verified savings at the program level.

3.2 Database and Historical Evaluation Review

Duke Energy provided the evaluation team with a program database for the SEWKP participation within each jurisdiction. The program database provided participant contact information including account number, address, phone number, email address (if available), and whether or not the participant was willing to be contacted. Because Duke Energy was able to provide both phone numbers and email addresses, we were able to design a sampling approach that could take advantage of both phone and web-based surveying.

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

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

Measure	DEK 2018 ex-ante savings[1] (kWh)	Ohio 2010 TRM[2] (kWh)	Illinois 2019 TRM[3] (kWh)	Indiana 2015 TRM[4] (kWh)	Mid-Atlantic 2018 TRM[5] (kWh)	Pennsylvania 2016 TRM[6] (kWh)
Showerhead (1.5 gpm)	171.0	165.3	155.5	293.9	390.1	363.9
Bathroom Faucet Aerator (1.0 gpm)	96.0	20.2	13.5	15.9	26.2	56.4
Kitchen Faucet Aerator (1.0 gpm)	79.0	20.2	105.6	122.2	200.8	145.0
Pipe Wrap	46.0	18.6	19.3	18.6	9.4	20.9

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

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

3.3 Sampling Plan and Achievement

To provide representative results and meet program evaluation goals, a sampling plan was created to guide all evaluation activity. A random sample was created to target 90/10 confidence and precision at the program level assuming a coefficient of variation (C_v) equal to 0.5.

3.3.1 DEK Sample

After reviewing the program database, we identified a population of 1,103 participants within our defined evaluation period. Based on this population, the evaluation team established sub-sample frames for phone and web-based survey administration. Customers who were flagged as "do not contact" in the participation database were excluded from the sample frame. As illustrated in Table 3-2 below, we completed a total of 174 surveys among Kentucky program participants between October 14th and 28th, 2019. This sample size resulted in a precision of ±5.8% at a 90% confidence interval.

Table 3-2: DEK Impact Sampling

Survey Mode	Sample Frame	Sampled Participants	Achieved Precision at 90% Confidence
Phone	313	43	90/5.8
Web-based	685	131	
Total	**998**[1]	**174**	

3.4 Description of Analysis

3.4.1 Telephone and web-based surveys

The evaluation team performed telephone and web-based surveys to gain key pieces of information used in the savings calculations. Results of the completed surveys were used to inform our program-wide assumptions as detailed in Table 3-3.

Table 3-3: Participant Data Collected and Used for Analysis

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

3.4.2 In-Service Rate

The in-service rate (ISR) represents the ratio of equipment installed and operable to the total pieces of equipment distributed and eligible for installation. For example, if 15 telephone surveys were completed for customers receiving 1 bathroom aerator each, and five customers reported to still have the aerator installed and operable, the ISR for this measure would be five out of 15 or 33%. In some instances equipment was installed, but may have been removed later due to homeowner preferences. In these cases the equipment is no longer operable and therefore contributes negatively to the ISR. In-service rates for each measure from all eligible survey respondents are detailed in Table 3-4.

[1] Differences in program participation and sample frame are due participants with "do not contact" designations

Table 3-4: DEK SEWKP In-Service Rates

Measure	Distributed	Installed	Removed	ISR
Showerhead	233	96	10	37%
Bathroom Faucet Aerator	348	92	8	24%
Kitchen Faucet Aerator	174	56	9	27%
Pipe Wrap*	174	51	0	29%

*Quantity of pipe tape packages

In-service rates for all measures are lower than reported values for past evaluations of the SEWKP in other service territories, but they're also aligned with ISRs from the 2018-19 SEWKP evaluation in the Duke Energy Ohio service territory. The cause of this drop is unknown at the moment, but may be due to introduction of email recruitment that lessens the effort needed to participate in the program and results in participants who are less committed to installing the equipment, program saturation within the targeted population that is now reaching into homes that are less motivated to completed installs, or market wide shifts in energy and water efficiency within the DEK service territory. The latter of these options will be tested as evaluations are completed for other Duke Energy service territories, but those results are unavailable at this time.

3.4.3 Kit Measure Savings

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

Demand savings coincident factors (CF) for the summer and winter seasons were estimated to align with peak demand periods for Duke Energy Kentucky[2] using the study on residential domestic hot water use referenced by the Ohio TRM[3]. This method takes into account the average hot water use by fixture type (showerhead, faucet aerator) during the peak period along with the probability of the evaluation daily hours of use occurring at the same time.

[2] Summer Demand Peak: July, 4pm to 5pm and Winter Demand Peak: January, 7pm to 8pm

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

3.4.3.1 Faucet Aerators

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

Equation 3-1: Faucet Aerator Energy Savings

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

Equation 3-2: Faucet Aerator Demand Savings

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

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

Input	Units	Aerator Savings Input		Source
		Kitchen	Bathroom	
ISR	n/a	27%	24%	Participant survey responses
ELEC	n/a	90%		Participant survey responses
ΔGPM	gpm	1.2		Baseline, federal code minimum Retrofit, product specification sheet
MPD	minutes/day	4.5	1.6	Indiana TRM v2.1
PH	people in home	2.7	2.5	Participant survey responses
DR	n/a	50%	70%	Indiana TRM v2.1
ΔT	°F	35.2	28.2	$Temp_{in}$, Ohio 2010 TRM $Temp_{out}$, Indiana TRM v2.1
FH	Units	1.0	1.9	Participant survey responses
RE	N/A	98%		Ohio 2010 TRM
CF, summer	n/a	0.0051	0.0023	Ohio 2010 TRM, adjusted
CF, winter	n/a	0.0067	0.0031	Ohio 2010 TRM, adjusted

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

3.4.3.2 Showerheads

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

Equation 3-3: Showerhead Energy Savings

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

Equation 3-4: Showerhead Demand Savings

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

Table 3-6: Inputs for Showerhead Savings Calculations

Input	Units	Showerhead Savings Input	Source
ISR	n/a	37%	Participant survey responses
ELEC	n/a	90%	Participant survey responses
ΔGPM	gpm	1.0	Baseline, federal code minimum Retrofit, product specification sheet
MS	minutes/shower	9.6	Participant survey responses
SPD	showers/person/day	0.73	Participant survey responses
PH	people in home	2.6	Participant survey responses
ΔT	°F	43.2	$Temp_{in}$, Ohio 2010 TRM $Temp_{out}$, Indiana TRM v2.1
SH	showers/home	1.33	Participant survey responses
RE	n/a	98%	Ohio 2010 TRM
CF, summer	n/a	0.0101	Ohio 2010 TRM, adjusted
CF, winter	n/a	0.0139	Ohio 2010 TRM, adjusted

3.4.3.3 Insulating Pipe Wrap

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

Equation 3-5: Insulating Pipe Wrap Energy Savings

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

Equation 3-6: Insulating Pipe Wrap Demand Savings

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

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

Input	Units	Pipe Wrap Savings Input	Source
ISR	n/a	30%	Participant survey responses
ELEC	n/a	90%	Participant survey responses
R_{ex}	n/a	1.00	Ohio 2010 TRM
R_{new}	n/a	3.00	Product specification sheet
L	linear feet	4.9	Survey Responses*
C	feet	0.20	Indiana TRM (Average of 1/2" and 3/4" pipe)
ΔT	°F	65	Ohio 2010 TRM
ηDHW	n/a	98%	Ohio 2010 TRM

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

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

3.5 Targeted and Achieved Confidence and Precision

We developed the SEWKP evaluation plan with the goal of achieving a target of 10% relative precision at the 90% confidence interval across both jurisdictions at the program level. Due to a high response rate from the web-based surveys, the evaluation team was able to surpass this target and achieve a high level of statistical precision. The final DEK sample yielded a relative precision of +/- 5.8% at the 90% confidence level (Table 3-8).

Table 3-8: Targeted and Achieved Confidence and Precision

Program	Targeted Confidence/Precision	Achieved Confidence/Precision
DEK SEWKP	90/10.0	90/5.8

3.6 Results

Measure-level and kit-level energy savings values for the DEK jurisdiction are detailed in Figure 3-1 and Table 3-9.

Figure 3-1: Gross Verified Energy Savings

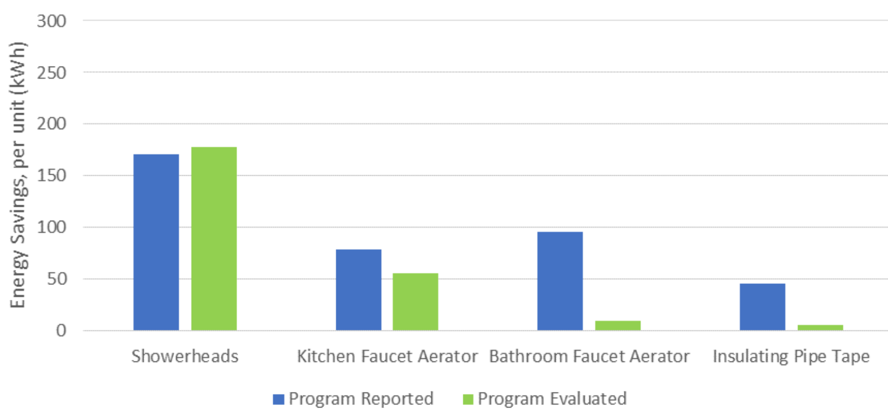


Table 3-9: Measure-Level Reported and Verified Gross Energy Savings

Measure	Reported Energy Savings, per unit (kWh)	Realization Rate	Verified Energy Savings, per unit (kWh)
Low-flow Showerhead	171.0	103.8%	177.5
Low-flow Kitchen Aerator	79.0	70.5%	55.7
Low-flow Bathroom Aerator	96.0	10.0%	9.6
Pipe Wrap*	46.0	12.9%	5.9

* Savings for pipe wrap is a per linear foot measurement

Measure-level and kit-level demand savings are detailed in Table 3-10.

Table 3-10: DEK Measure-Level Reported and Verified Demand Gross Savings

Measure	Summer Demand, per unit (kW)			Winter Demand, per unit (kW)		
	Reported	Realization Rate	Gross Verified	Reported	Realization Rate	Gross Verified
Low-flow Showerhead	0.0137	109.4%	0.0149	0.0195	105.6%	0.0206
Low-flow Kitchen Aerator	0.0063	61.4%	0.0039	0.0090	56.8%	0.0051
Low-flow Bathroom Aerator	0.0076	23.6%	0.0018	0.0108	21.8%	0.0024
Pipe Wrap*	0.0037	18.3%	0.0007	0.0053	12.8%	0.0007

* Savings for pipe wrap is a per linear foot measurement

The impact evaluation for the 2018-2019 program resulted in a program energy realization rate of 46.7% and a demand realization rate of 52.7% (summer) and 53.4% (winter) as presented in Table 3-11 and Table 3-12.

Table 3-11: Energy Savings per Kit

Kit Size	Population	Reported Energy (kWh)	Energy Realization Rate	Gross Verified Energy (kWh)
Small	734	672.0	47.5%	319
Medium	369	843.0	45.6%	384
Program Total	**1,103**	**729.2**	**46.7%**	**341**

Table 3-12: Demand Savings per Kit

Kit Size	Summer Demand (kW)			Winter Demand (kW)		
	Reported	Realization Rate	Gross Verified	Reported	Realization Rate	Gross Verified
Small	0.054	53.8%	0.029	0.077	49.7%	0.038
Medium	0.067	51.0%	0.034	0.075	60.9%	0.046
Program Total	**0.058**	**52.7%**	**0.031**	**0.076**	**53.4%**	**0.041**

Table 3-13 presents the reported and verified energy and demand savings for the 2018-2019 program year.

Table 3-13: Program Level Savings

Measurement	Population	Reported	Realization Rate	Gross Verified
Energy (kWh)	1,103	804,315	46.7%	375,850
Summer Demand (kW)		64.2	52.7%	33.8
Winter Demand (kW)		83.9	53.4%	44.8

4 Net-to-Gross Methodology and Results

The evaluation team used participant survey data to calculate a net-to-gross (NTG) ratio for SEWKP. NTG reflects the effects of free ridership (FR) and spillover (SO) on gross savings. Free ridership refers to the portion of energy savings that participants would have achieved in the absence of the program through their own initiatives and expenditures (U.S. DOE, 2014).[4] Spillover refers to the program-induced adoption of additional energy-saving measures by participants who did not receive financial incentives or technical assistance for the additional measures installed (U.S. DOE, 2014). The evaluation team used the following formula to calculate the NTG ratio:

$$NTG = 1 - FR + SO$$

4.1 Free Ridership

Free ridership estimates how much the program influenced participants to install the energy-saving items included in the energy efficiency kit. Free ridership ranges from 0 to 1, 0 being no free ridership and 1 being total free ridership.

The evaluation team used participant survey data to estimate free ridership. The survey used several questions to identify items that a given participant installed and did not later uninstall: respondents were only asked free ridership questions about items that remained installed by the date of the survey.

The evaluation team's methodology for calculating free ridership consists of two components, free ridership change (FRC) and free ridership influence (FRI), both of which range from 0 to .5 in value.

$$FR = FRC + FRI$$

4.1.1 Free Ridership Change

FRC reflects what participants reported they would have done if the program had not provided the items in the kit. For each respondent, the survey assessed FRC for each measure that the respondent installed and did not later uninstall.

Specifically, the survey asked respondents which, if any, of the currently installed items they would have purchased and installed on their own within the next year if Duke Energy had not provided them. For respondents who installed more than one of a given measure (bathroom

[4] The U.S. Department of Energy (DOE) (2014). *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures. Chapter 23: Estimating Net Savings: Common Practices.* Retrieved August 29, 2016 from http://energy.gov/sites/prod/files/2015/02/f19/UMPChapter23-estimating-net-savings_0.pdf.

aerators or showerheads) that indicated they would have installed either of the multi-count measures on their own, we asked them a follow up question that determined how many of the number installed through the program that they would have installed on their own.

For each measure, the evaluation team assigned one of the FRC values shown in the Table 4-1, based on the respondents' responses. FRC values range from 0.0 to 0.5.

Table 4-1: Free Ridership Change Values

What Respondent Would Have Done Absent the Program*	FRC Value
Would ***not*** have purchased and installed the item within the next year	0.00
Would have purchased and installed the item within the next year	$\frac{\text{Count respondent said would install on their own}}{\text{Count respondent installed through program}}$

*Survey response to: If you had not received the free efficiency items in the kit, would you have purchased and installed any of these same items within the next year?

4.1.2 Free Ridership Influence

FRI assesses how much influence the program had on a participant's decision to install (and keep installed) the items in the kit. The survey asked respondents to rate how much influence four program-related factors had on their respective decisions to install the measures, using a scale from 0 ("not at all influential") to 10 ("extremely influential"). The program-related factors included:

- The fact that the items were free
- The fact that the items were mailed to their home
- Information provided by Duke Energy about how the items would save energy and water
- Other information or advertisements from Duke Energy, including its website

Asking respondents to separately rate the influence of each of the four above items had on the decision to install each measure would have been overly burdensome. Therefore, while the survey assessed FRC for each measure type, it assessed collective FRI for all measures.

FRI is based on the highest-rated item in the FRI battery. The evaluation team assigned the following FRI scores, based on that rating (Table 4-2).

Table 4-2: Free Ridership Influence Values

Highest Influence Rating	FRI Value
0	0.50
1	0.45
2	0.40
3	0.35

Highest Influence Rating	FRI Value
4	0.30
5	0.25
6	0.20
7	0.15
8	0.10
9	0.05
10	0.00

4.1.3 Total Free Ridership

The evaluation team calculated total free ridership by measure by calculating

- First, measure-specific FR scores for each respondent by summing each respondent's measure-specific FRC score with their FRI score.
- Second, a measure-specific average FR score across all respondents, weighted by the number of units installed by each respondent.

The evaluation team then estimated overall program-level free ridership by calculating a savings-weighted mean of the measure-specific FR scores. Table 4-3 presents the measure-specific and overall FR estimates.

Table 4-3: Measure-Specific Free Ridership Scores

End-use	Measure-Specific Free Ridership
Showerhead	0.137
Kitchen Faucet Aerator	0.063
Bathroom Faucet Aerator	0.055
Pipe Wrap	0.077
Overall	**0.120**

4.2 Spillover

Spillover estimates energy savings from additional energy improvements made by participants who are influenced by the program to do so and is used to adjust gross savings. The evaluation team used participant survey data to estimate spillover. The survey asked respondents to indicate what energy-saving measures they had implemented since participating in the program. The evaluation team then asked participants to rate the influence the program had on their decision to purchase these additional energy-saving measures on a scale of 0 to 10, where 0 means "not at all influential" and 10 means "extremely influential."

The evaluation team converted the ratings to a percentage representing the program-attributable percentage of the measure savings, from 0% to 100%. The team then applied the program-attributable percentage to the savings associated with each reported spillover measure to calculate the participant measure spillover (PMSO) for that measure. We defined the per-unit energy savings for the reported spillover measures based on ENERGY STAR® calculators, gross verified savings from DEO Smart $aver Program Evaluations, and algorithms and parameter assumptions listed in the 2010 Ohio TRM and the Illinois TRM v7.0.

Since Duke Energy offered program incentives for a variety of energy-saving measures throughout the evaluation period, we compared the list of customers reporting measures as spillover against participation records for other Duke Energy programs that offered the measure. To avoid double-counting savings for measures already claimed by another Duke Energy offering, we excluded savings from measures that appeared in another program's tracking data from our estimation of spillover savings.

Participant measure spillover is calculated as follows:

$$PMSO = Deemed\ Measure\ Savings * Program\ Attributable\ Percentage$$

The evaluation team summed all PMSO savings (Table 4-4).

Table 4-4: DEK Sample PMSO, by Measure by Category

Measure Category	Total kWh for Category	Percent Share of kWh
HVAC	2,900	34%
Appliance	2,079	24%
LEDs	2,058	24%
Insulation	558	6%
Duct Sealing	476	6%
CFLs	224	3%
Water Heater	176	2%
Windows	170	2%
Total	**8,641**	**100%**

The evaluation team then calculated gross program savings associated with sampled participants by summing the products of each measure's average per household savings and the total sample size (Table 4-5).

Table 4-5: DEK Sample Gross Program Savings (n=143)

Measure	Average per Household Savings (kWh)	Verified Sample Savings (kWh)
Showerhead	236.9	41,457
Kitchen Faucet Aerator	55.7	9,752
Bathroom Faucet Aerator	19.2	3,365
Insulating Pipe Tape	28.9	5,057

Measure	Average per Household Savings (kWh)	Verified Sample Savings (kWh)
Total	**340.8**	**59,632**

The evaluation team then divided the summed jurisdictional PMSO values by the sample's gross program savings to calculate an estimated spillover percentage for the program:

$$Program\ SO = \frac{\sum PMSO}{\sum Sample\ Gross\ Program\ Savings}$$

$$DEK\ SO = \frac{8{,}641}{59{,}632}$$

These calculations produced a spillover estimate of 14.5% for the DEK program.

4.3 Net-to-Gross

Inserting the FR and SO estimates into the NTG formula (NTG = 1 – FR + SO) produces an NTG value of 1.01 for the program (Table 4-6). The evaluation team applied this NTG ratio to program-wide verified gross savings to calculate SEWKP kit net savings for the jurisdiction (Table 4-7).

Table 4-6: Net-to-Gross Results

Jurisdiction	Free Ridership	Spillover	NTG
DEK	0.115	0.145	1.030

Table 4-7: Program Level Savings

Measurement	Population	Gross Verified	Net-to-Gross Ratio	Net Verified
Energy (kWh)	1,103	375,850	103.0%	387,126
Summer Demand (kW)		33.8		34.8
Winter Demand (kW)		44.8		46.1

5 Process Evaluation

5.1 Summary of Data Collection Activities

The process evaluation is based on interviews and surveys with program staff, implementer staff, and households who received a kit during the program evaluation year (Table 5-1).

Table 5-1: Summary of Process Evaluation Data Collection Activities

Target Group	Method	Sample Size	Population	Confidence / Precision
Duke Energy program staff	Phone in-depth interview	1	N/A	N/A
Implementation staff: EFI	Phone in-depth interview	1	N/A	N/A
DEK participants	Mixed mode (web/phone) survey	174	1,103	90/±5.8

Comparisons with census data confirm that the DEK sample is fairly representative of income for the region, although higher income residents were slightly underrepresented and middle income residents were slightly overrepresented. Additionally, the sample demonstrated slightly greater educational attainment than that of the region.[5]

5.2 Process Evaluation Findings

Installation Rates

Nearly three-quarters (72%) of kit recipients installed at least one measure, each installing an average of two measures, and 5% of respondents reported initially installing at least one of each measure type. Half of kit recipients (50%) initially installed at least one of the showerheads, with roughly two-fifths (42%) reporting they installed at least one of the bathroom faucet aerators. A smaller portion reported installing kitchen faucet aerators (33%) or pipe wrap (30%). Of the respondents who received a medium-sized kit, about one-fifth (17%) installed both showerheads.[6] Regardless of kit size, participants installed an average of one bathroom aerator and one showerhead.

Of the respondents who installed at least one item from the kit, 17% said they later uninstalled at least one of the measures, and 4% uninstalled everything that they had initially installed. In total, 9% of all initially installed measures were uninstalled at the time of the survey. Kitchen faucet aerators and showerheads had the highest uninstallation rates, with over one-tenth of respondents who installed them later uninstalling them (16% for kitchen faucet aerators and 11% for showerheads). Respondents who uninstalled these water-saving measures most often

5 Region comparisons come from 2017 American Community Survey (Census) 5-year period estimates data for Boone, Campbell, and Kenton Counties served by DEK in Kentucky.

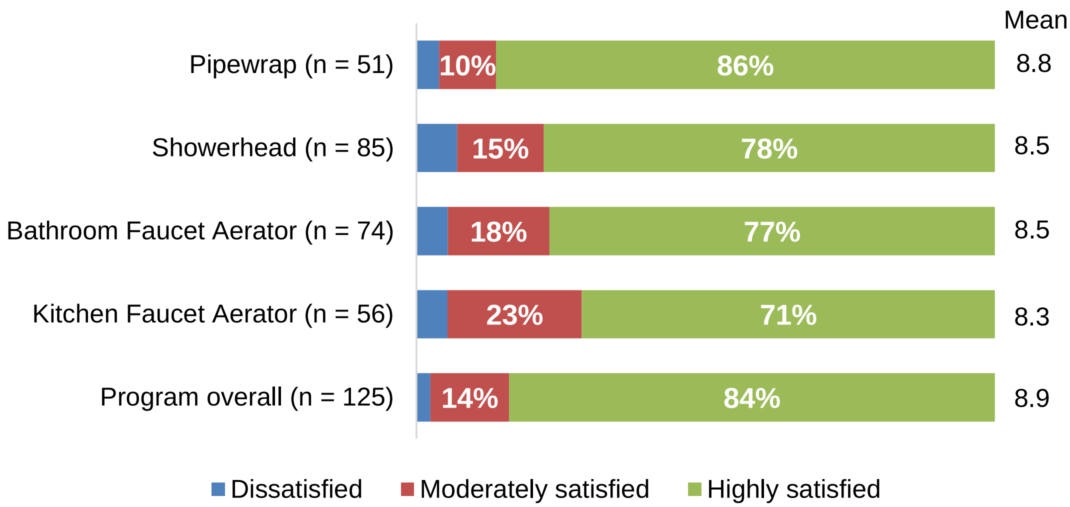
6 Forty-nine percent of medium kit recipients installed at least one of the two showerheads, 33% of whom installed both.

indicated they did so because they did not like how they worked, later elaborating that the water pressure provided was insufficient for their preferences.

Measure Satisfaction

Nearly all kit recipients reported moderate to high satisfaction with the items they installed from their kit (Table 5-1). We asked respondents to rate their satisfaction with all measures they installed, including those they later uninstalled to best gauge the experience of all participants. Respondents were most satisfied with the pipe wrap and kitchen faucet aerator.

Figure 5-1: Kit Recipient Satisfaction with Measures They Had Installed*



* Respondents rated their satisfaction with the measures on a scale ranging from 0 (“very dissatisfied”) to 10 (“very satisfied”). Dissatisfied indicates 0-4 ratings, moderately satisfied indicates 5-7 ratings, and highly satisfied indicates 8-10 ratings.

Kit Instructional Materials

In addition to energy-saving measures, the Save Energy and Water Kit includes a detailed instruction insert booklet that provides information on how to install the provided measures. Most respondents (77%) said they read the booklet, and among those who did, three-quarters (75%) found it highly helpful.[7] Duke Energy also offers a customer care hotline that participants can call for additional assistance, but only 1% of respondents took advantage of the service.

Additional Energy Saving Actions

Some respondents (41%) reported purchasing and installing additional energy efficiency measures since receiving their kit (Table 5-2). Participants most commonly reported installing LEDs (29%) or buying energy efficient appliances (15%). The majority of respondents (79%) who installed additional measures said DEK SEWKP at least partially influenced their decision to purchase and install additional energy-saving measures.

[7] We asked respondents to rate the helpfulness of the instruction booklet on a scale from 0 (“not at all helpful”) to 10 (“very helpful”). One-hundred and one of the 135 (or 75%) respondents who reported reading the booklet gave a rating of 8 or higher.

Table 5-2: Additional Energy Saving Measures Purchased by DEK Participants (Multiple Responses Allowed; n=174)

	Percent of Respondents Reporting Purchases After Receiving the Kit	Percent Reporting at Least Some DEK Program Influence on Purchase
At least one measure	41%	31%
LEDs	29%	23%
Efficient appliances	15%	10%
Efficient heating or cooling equipment	11%	7%
Air sealing	8%	7%
Efficient water heater	7%	5%
Insulation	5%	3%
Efficient windows	5%	3%
CFLs	5%	4%
Installed storm doors	3%	3%
Duct sealing	1%	1%
Other*	1%	1%

*Other measures included an awning and furnace air filters, each of which represented <1% of respondents

6 Conclusions and Recommendations

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

Conclusion 1: The program model is highly successful: it leverages low-cost measures to foster energy savings that would not have happened otherwise. Duke Energy's easy process for requesting and receiving a kit with free energy and water-saving items motivated over 1,100 customers to request and install energy saving measures in their home during the evaluation period. Most participants installed at least one measure from the kit, relatively few measures get uninstalled, and many participants reported installing additional energy saving items since receiving the kit. The majority of participants said they would not have installed any of the items on their own, as represented by low free ridership rates, and the program is reaching a diverse range of customers in terms of household characteristics and demographics.

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

Conclusion 2: The water-saving measures' low flow water pressure results in some minor dissatisfaction and uninstallation issues. Complaints of excessively low water pressure were the primary drivers of measure dissatisfaction and uninstallation. However, only a minority of participants were dissatisfied with or uninstalled water-saving items.

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

Conclusion 3: Fewer participants are installing at least one measure. Seventy-two percent of participants reported installing at least one item from the kit, which is lower than the in-service rates seen for this program in the past evaluation cycle.

> **Recommendation**: Monitor installation rates in other jurisdictions in upcoming evaluations to determine if this downward trend is specific to Ohio and Kentucky, leveraging reincorporated survey questions that ask why participants did not install measures.

Appendix A Summary Form

Save Energy and Water Kit Program

Completed EMV Fact Sheet

Description of program

The Duke Energy Save Energy and Water Kit Program (SEWKP) is an energy efficiency program that offers energy-efficient water fixtures and water pipe insulation to residential customers. The program is designed to reach customers who have not adopted energy-efficient water devices. The kits are provided to residents through a Direct Mail Campaign, allowing eligible customers to request to have the items shipped directly to their homes, free of charge.

Date	September 24, 2020
Region(s)	Kentucky
Evaluation Period	July 1, 2018 – June 30, 2019
Annual Gross MWh Savings	375.9
Per Kit Gross kWh Savings	387.1
Annual Gross MW Savings	Summer: 0.035 Winter: 0.046
Net-to-Gross Ratio	1.030
Process Evaluation	Yes
Previous Evaluation(s)	none

Evaluation Methodology

Impact Evaluation Activities

- Telephone/web surveys (n=174) and analysis of 4 unique measures

Impact Evaluation Findings

- Realization rates: 46.7% for energy; 52.7% for summer demand impacts; and 53.4% for winter demand
- Net-to-gross ratio: 103.0%

Process Evaluation Activities

- Telephone/web surveys with SEWKP participants (n=174) and analysis of 4 unique measures
- 1 interview with program staff
- 1 interview with implementation staff

Process Evaluation Findings

- The SEWKP influences participants to install kit measures and adopt new behaviors.
- Participants are generally satisfied with kit items and report high satisfaction with overall program.
- Low water pressure is the primary contributor to dissatisfaction among a small subset of participants.

Appendix B Measure Impact Results

Table B-1: Per Unit Verified Impacts by Measure – Key Measure Parameters

Measure Category	Gross Energy Savings (kWh)	Gross Summer Demand (kW)	Gross Winter Demand (kW)	Realization Rate (Energy)	Free Ridership	Spillover	Net to Gross Ratio	M&V Factor (Energy) (RR x NTG)	Measure Life
Low-flow Showerhead (1.5 gpm)	177.5	0.0149	0.0206	103.8%	13.7%	14.5%	100.8%	104.7%	10
Kitchen Faucet Aerator (1.0 gpm)	55.7	0.0039	0.0051	70.5%	6.3%		108.2%	76.3%	10
Bathroom Faucet Aerator (1.0 gpm)	9.6	0.0018	0.0024	10.0%	5.5%		109.0%	10.9%	10
Insulating Pipe Tape*	5.9	0.0007	0.0007	12.6%	7.7%		106.8%	13.4%	13

* Per linear foot

Appendix C Program Performance Metrics

This appendix provides key program performance metrics, or PPIs. See Chapter 5 for the underlying results and more detailed findings.

Figure C-1: DEK Program Experience PPIs

	Participants %	Participants n
Program experience & satisfaction PPIs		
Overall satisfaction with program	84%	125
Usefulness of kit instructions	75%	135
Satisfaction with kit measures		
Showerhead	78%	85
Kitchen faucet aerator	71%	56
Bathroom faucet aerator	77%	74
Pipe wrap	86%	51
Program influence on behavior PPIs		
Installed at least one kit measure	72%	175
Most common measure installed: *showerhead*	50%	175
Respondents reporting program attributable spillover	19%	175
Challenges and opportunities for improvement PPIs		
Measure with lowest installation rate: *pipewrap*	30%	175
Measure with highest uninstallation rate: *kitchen faucet aerator*	16%	58
Measure with highest dissatisfaction: *showerhead*	7%	85

Figure C-2: DEK Participant Demographics PPIs

Ownership Status	
Own	93%
Rent	5%
Refused / Don't know	2%

Household Size	
One to two	58%
Three	15%
Four	13%
Five +	11%
Refused / Don't know	3%

Education	
High school or less	18%
Some college	23%
Bachelor's degree	29%
Graduate degree	18%
Refused / Don't know	7%

Income	
<$30k	10%
$30k to <$60k	24%
$60k to <$75k	9%
$75k to <$100k	12%
$100k+	15%
Refused / Don't know	30%

Age	
18 to 34	12%
35 to 44	19%
45 to 64	31%
65 and older	21%
Refused / Don't know	17%

Figure C-3: DEK Participant Household Characteristics PPIs

Housing Type	
Detached	74%
Attached	12%
Mobile	5%
Apartment or condo	8%
Duplex or triplex	1%

Water Heater Fuel Type	
Electric	90%
Natural Gas	5%
Other	5%

Home Size		
Area (ft^2)	Small Kit	Medium Kit
Less than 1,000	15%	2%
1,000-1,499	34%	28%
1,500-1,999	25%	32%
2,000-2,999	19%	35%
3,000+	7%	4%

Number of Showers		
Count	Small Kit	Medium Kit
1	30%	18%
2	55%	72%
3	16%	8%
4+	0%	2%

Number of Kitchen Faucets		
Count	Small Kit	Medium Kit
1	93%	93%
2	6%	7%
3+	1%	0%

Number of Bathroom Faucets		
Count	Small Kit	Medium Kit
1-2	54%	35%
3-4	41%	58%
5+	5%	7%

Appendix D Instruments

D.1 Program Staff In-Depth Interview Guide

Introduction

Today, we'll be discussing your role in the SEWKP or water kit program. We would like to learn about your experiences in administering this program.

Your comments are confidential. If I ask you about areas you don't know about, please feel free to tell me that and we will move on. Also, if you want to refer me to specific documents to answer any of my questions, that's great – I'm happy to look things up if I know where to get the information.

I would like to record this interview for my note-taking purposes. Do I have your permission?

Roles & Responsibilities

Q1. Has your position at Duke Energy or your role in the water kit program changed at all since we spoke last year?

Program Delivery

Next, I'd like to learn more about how this program was delivered since your involvement. If the program implementation is different in 2019, please let me know.

Q2. Historically, the program used BRC mailers in the kit program. But recently you added some online components – which you told me about last year. Have these changes been rolled out to all jurisdictions? Have there been any changes since we last spoke?

Q3. Has Duke launched the upgrade store, where customers could upgrade to a higher-end item?

Q4. How popular or common are the upgrade requests?

Q5. How has the online channel been going? How successful is the online channel? How many kits come online vs. BRC?

Q6. Have you changed your BRC at all in the last year?

Q7. After the last time we spoke, you sent me a story board for a new video featuring a piggy bank character. I don't see that video online – was it ever made?

Q8. Are there any other changes to program delivery that have recently happened or are in the works?

Q9. EFI is still the implementer, right? Can you describe EFI's role? Any challenges with EFI lately? [IF NEEDED: what is EFI's role with the online component?]

Q10. Can you confirm the kit contents? Small with 1 showerhead, 2 bathroom aerators, 1 kitchen aerator, and one set of pipe wrap; and large with the same contents except two showerheads instead of one?

Q11. Have any kit items changed since we last spoke other than the kitchen aerator?

Q12. Are there any other program delivery components that are unique to a specific jurisdiction?

Evaluation

Q13. Is there anything else about the program that we have not discussed that you feel should be mentioned? Is there anything else you'd like to learn from the program evaluation?

Q14. We are about to start surveying participants. Are there any questions or topics you'd like us to add before we start surveying?

Q15. One thing we need to do each year is make sure any LEDs that survey respondents said they installed on their own weren't from any Duke programs. I know of the following ways to get free/discounted LEDs from Duke (and some of these may be out of date):

1. Online savings store
2. Home energy house calls
3. School kits
4. Buy down brick-and-mortar locator – was that discontinued?
5. Any others I'm missing?
6. And do these all apply to all jurisdictions?

Those are all of my questions. Thank you very much for your time.

D.2 Implementer Staff In-Depth Interview Guide

Introduction

[*Note: Interviewer will schedule calls ahead of time via email.*]

I would like to record this interview for my note-taking purposes. Do I have your permission?

Roles & Responsibilities

Q1. Can you describe your role in the SEWKP or water kit program?

Q2. How long have you been in this role?

Program Delivery

Q3. Can you describe your program processes? (From receipt of kit forms to sending kits)

Q4. [IF NOT DISCUSSED] Historically, the program used BRC mailers in the kit program. But recently Duke added some online components – can you tell me about this process?

Q5. I know the kitchen aerator was changed a year ago or so. Does the new one have three flow settings? What are they and what are they labeled as?

Q6. Have there been any other measure changes in the last year or so?

Q7. Are there any other changes to program delivery that have recently happened or are in the works?

Q8. Do these changes apply to all jurisdictions?

Q9. Are there any other program delivery components that are unique to a specific jurisdiction?

Q10. Are there any other issues unique to Kentucky that we should know about?

Q11. Are there any other issues unique to Carolinas that we should know about?

Q12. Are there any other issues unique to Progress that we should know about?

Q13. Are there any other issues unique to Ohio that we should know about?

Q14. What is the biggest challenge in implementing the water kit program?

Q15. If you could change one thing, what would it be?

Evaluation

Q16. Is there anything else about the program that we have not discussed that you feel should be mentioned?

Q17. We are about to start surveying participants. Are there any questions or topics you'd like us to add before we start surveying?

Q18. Is there anything else you'd like to learn from the program evaluation?

Those are all of my questions. Thank you very much for your time.

D.3 Participant Survey

Introduction/ Screening

[READ IF MODE=PHONE]

Q1. Hi, I'm _____, calling on behalf of Duke Energy. We are calling about the Save Energy and Water Kit you got from Duke Energy.
This kit included faucet aerators, one or two showerheads, and pipe wrap that can help you save water and energy in your home. Do you recall receiving this kit?

1. Yes
2. No [If no: Can I speak with someone who may know something about this kit?]
98. Don't know [If DK: Can I speak with someone who may know something about this kit?]

[INTERVIEWER INSTRUCTIONS: *If no adults are able to speak about the kit, thank and terminate.*]

Q2. [DISPLAY IF MODE=WEB]
We are conducting surveys about the Save Energy and Water Kit you got from Duke Energy. This kit included faucet aerators, one or two showerheads, and pipe wrap that can help you save water and energy in your home.
Do you recall receiving this kit?

1. Yes
2. No [TERMINATE]
98. Don't know [TERMINATE]

Motivation and Collateral

Q4. Did you read the included instructions on how to install the items that came in the kit?

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

[ASK IF Q4 = 1]

Q5. On a scale from 0 to 10, where 0 is not at all helpful and 10 is very helpful, how helpful were the instructions on how to install the items that came in the kit?

0. Not at all helpful
1.
2.
3.
4.
5.
6.
7.
8.

9.
10. Very helpful
98. Don't know

[ASK IF Q5<7]
Q6. What might have made the instructions more helpful?
[RECORD VERBATIM ANSWER]

Assessing Measure Installation

[DISPLAY IF KIT_SIZE=SMALL]
We'd like to ask you about the energy and water saving items included in your kit. The kit contained a showerhead, faucet aerators for the bathroom and kitchen, and pipe wrap.

[DISPLAY IF KIT_SIZE=MEDIUM]
We'd like to ask you about the energy and water saving items included in your kit. The kit contained two showerheads, faucet aerators for the bathroom and kitchen, and pipe wrap.

Q10. Have you or anyone else installed any of those items in your home, even if they were taken out later? [SINGLE RESPONSE]
[*Interviewer: Throughout interview, remind respondent as needed to report whether someone else in the home installed or uninstalled any items.*]
1. Yes
2. No [→ Q24a]
98. Don't know [→ TERMINATE]

[ASK IF Q10 = 1]
Q11. Which of the items did you install, even if they were taken out later?
[MULTIPLE RESPONSE]
[*Interviewer: Record each response, then prompt with the list items.*]

Item
a. Showerhead
b. Kitchen faucet aerator
c. Bathroom faucet aerator
d. Pipe wrap
e. I don't remember which items were installed [→ TERMINATE]

[ASK IF Q11A = 1 AND KIT_SIZE=MEDIUM]
Q12. Your kit contained two showerheads. Did you install one or both of the showerheads in the kit, even if one or both were taken out later?
[SINGLE RESPONSE]
1. I installed both
2. I only installed one showerhead
98. Don't know

[ASK IF Q11C = 1]
Q13. How many of the bathroom faucet aerators from the kit did you install in your home, even if one or more were taken out later?
[SINGLE RESPONSE]
1. One
2. Two
3. Three [*DISPLAY IF KIT_SIZE=MEDIUM*]
4. Four [*DISPLAY IF KIT_SIZE=MEDIUM*]
98. Don't know

[ASK IF Q11D = 1]
Q14. Did you install all of the pipe insulation that was included with the kit?
[SINGLE RESPONSE]
1. Yes
2. No
98. Don't know

[ASK IF Q14 IS DISPLAYED]
Q15. About how many feet of the pipe extruding from your water heater did you wrap with the insulation **that came in the kit**? Please go over to your water heater if you need to check. [SINGLE RESPONSE]
1. About three feet or less
2. About five feet
3. About ten feet
4. About fifteen feet or more
98. Don't know

[ASK IF ANY PART OF Q11 = 1]
Q16. Overall, how satisfied are you with the item[s] you installed?
[DISPLAY IF MODE=PHONE] Please use a 0 to 10 scale, where 0 is very dissatisfied and 10 is very satisfied. How satisfied are you with...

DISPLAY IF	Item	Rating
Q11a = 1	a. Showerhead	0-10 with DK
Q11b = 1	b. Kitchen faucet aerator	0-10 with DK
Q11c = 1	c. Bathroom faucet aerator	0-10 with DK
Q11d = 1	d. Pipe wrap	0-10 with DK

[ASK IF ANY ITEMS IN Q16<7]
Q16a. Can you please explain any dissatisfaction you had with [DISPLAY ALL ITEMS IN Q16 THAT ARE <7]?
[OPEN END: RECORD VERBATIM]

Q17. Overall, how satisfied are you with Duke Energy's Save Energy and Water Kit Program? [DISPLAY IF MODE=PHONE] [IF NEEDED: Please use that same 0 to 10 scale, where 0 is very dissatisfied and 10 is very satisfied.]

0.	0. Very dissatisfied
1.	1.
2.	2
3.	3
4.	4
5.	5.
6.	6.
7.	7.
8.	8.
9.	9.
10.	10. Very satisfied
98.	Don't Know

[ASK IF ANY PART OF Q11 = 1]

Q18. Have you (or anyone in your home) uninstalled any of the items from the kit that you had previously installed? [SINGLE RESPONSE]

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

[ASK IF Q18 = 1]

Q19. Which of the items did you uninstall?
[*Interviewer: Record the response, then prompt with the list items.*]
[MULTIPLE RESPONSE]

1. [DISPLAY IF Q11a = 1] Showerhead[s]
2. [DISPLAY IF Q11b = 1] Kitchen faucet aerator
3. [DISPLAY IF Q11c = 1] Bathroom faucet aerator[s]
4. [DISPLAY IF Q11d = 1] Pipe wrap
98. Don't know [*EXCLUSIVE ANSWER*]

[ASK IF Q19.1 = 1 AND Q12 = 1]

Q20. Did you uninstall one or both of the showerheads you had previously installed? [SINGLE RESPONSE]

1. I uninstalled both
2. I only uninstalled one of the showerheads
98. Don't know

[ASK IF Q19.3 = 1 AND Q13 = 2-4]

Q21. How many bathroom faucet aerators did you uninstall?
[SINGLE RESPONSE]

1. One [*DISPLAY IF Q13 = 1-4*]
2. Two [*DISPLAY IF Q13 = 2-4*]

3. Three [*DISPLAY IF Q13 = 3-4*]
4. Four [*DISPLAY IF Q13 = 4*]
98. Don't know

[CALCULATE SHOWERHEAD:
IF Q12 = 1, THEN SHOWERHEAD = 2;
IF Q12 = 2 OR (Q11_1 = 1 AND KIT_SIZE = SMALL), THEN SHOWERHEAD = 1;
ELSE SHOWERHEAD = 0]

[CALCULATE KITCHEN:
IF Q11_2 = 1, THEN KITCHEN = 1, ELSE KITCHEN=0]

[CALCULATE BATH:
IF Q13 = 2, THEN BATH = 2;
IF Q13 = 1, THEN BATH = 1;
ELSE BATH = 0]

[CALCULATE PIPEWRAP:
IF Q11_4 = 1, THEN PIPEWRAP = 1, ELSE PIPEWRAP=0]

[CALCULATE SHOWERHEAD_I:
IF SHOWERHEAD = 1 AND Q19_1 = 1, THEN SHOWERHEAD_I = 0;
IF Q19_1 = 1 AND (Q20 = 1 OR Q20 = 98), THEN SHOWERHEAD_I = 0;
IF Q19_1 = 1 AND Q20 = 2, THEN SHOWERHEAD_I = 1;
ELSE SHOWERHEAD_I = SHOWERHEAD]

[CALCULATE KITCHEN_I:
IF Q19_2 = 1, THEN KITCHEN_I = 0;
ELSE KITCHEN_I = KITCHEN]

[CALCULATE BATH_I:
IF BATH = 1 AND Q19_3 = 1, THEN BATH_I = 0;
IF Q19_3 = 1 AND (Q21 = 2 OR Q21 = 98), THEN BATH_I = 0;
IF Q19_3 = 1 AND Q21 = 1, THEN BATH_I = 1;
ELSE BATH_I = BATH]

[CALCULATE PIPEWRAP_I:
IF Q19_4 = 1, THEN PIPEWRAP_I = 0;
ELSE PIPEWRAP_I = PIPEWRAP]

CALCULATE TOTAL_I:
[SHOWERHEAD_I + BATH_I + KITCHEN_I + PIPEWRAP_I]

[ASK IF ANY OF Q19.1-4 IS SELECTED]
Q22. Why were those items uninstalled?
[READ IF MODE=PHONE] Let's start with…
[*Interviewer: Read each item*]
[MULTIPLE RESPONSE]

DISPLAY ONLY THOSE 1-6 ITEMS THAT WERE SELECTED IN Q19	Item	Reason
	a. Showerhead	1. It was broken 2. I didn't like how it worked 3. I didn't like how it looked, or 96. Some other reason (specify: ______) 98. Don't know
	b. Kitchen faucet aerator	Repeat reason options
	c. Bathroom faucet aerator	Repeat reason options
	d. Pipe wrap	Repeat reason options

Q24a. Customers that need additional assistance with their items can call a toll-free customer care hotline. Did you call the customer care hotline to seek assistance in installing any of your items?
1. Yes
2. No
98. Don't know

[ASK IF Q24a = 1]
Q24b. Did you call the customer care hotline to seek assistance in installing your kitchen faucet aerator?
1. Yes
2. No
98. Don't know

[ASK IF Q24b = 1]
Q24c. Did the customer care hotline offer to send you an adapter for the kitchen faucet aerator?
1. Yes
2. No
98. Don't know

[ASK IF Q24a = 1]
Q24d. Did you call the customer care hotline to seek assistance in installing your bathroom faucet aerator?
1. Yes
2. No
98. Don't know

[ASK IF Q24d = 1]
Q24e. Did the customer care hotline offer to send you an adapter for the bathroom faucet aerator?

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

[ASK IF Q11a = 1 AND AT LEAST ONE SHOWERHEAD STILL INSTALLED]
Q29. On average, what is the typical shower length in your household?

1. One minute or less
2. Two to four minutes
3. Five to eight minutes
4. Nine to twelve minutes
5. Thirteen to fifteen minutes
6. Sixteen to twenty minutes
7. Twenty-one to thirty minutes
8. More than thirty minutes
98. Don't know

[ASK IF AT LEAST ONE SHOWERHEAD STILL INSTALLED]
Q30. [DISPLAY IF TWO SHOWERHEADS STILL INSTALLED: Thinking of the efficient showerhead you installed that gets the most usage…]
[DISPLAY IF ONE SHOWERHEAD STILL INSTALLED: Thinking of the efficient showerhead currently installed in your home…]
On average, how many showers per day are taken in this shower?

1. Less than one
2. One
3. Two
4. Three
5. Four
6. Five
7. Six
8. Seven
9. Eight or more
98. Don't know

[ASK IF TWO SHOWERHEADS STILL INSTALLED]

Q31. Thinking of the other efficient showerhead you installed…
On average, how many showers per day are taken in this shower?

1. Less than one
2. One
3. Two
4. Three
5. Four
6. Five
7. Six
8. Seven
9. Eight or more

98. Don't know

Q32. [This question was moved to demographics section – but not renumbered for programming purposes]

NTG

[IF TOTAL_I = 0, SKIP TO Q40]

Q33. If you had not received the free efficiency items in the kit, would you have purchased and installed any of these same items within the next year?

1. Yes
2. No

98. Don't know

[ASK IF Q33 = 1]

Q34. What items would you have purchased and installed within the next year?
[MULTIPLE RESPONSES]

Q34_1. [IF SHOWERHEAD_I > 0] Energy-efficient showerhead[s]
Q34_2. [IF KITCHEN_I > 0] Energy-efficient kitchen faucet aerator
Q34_3. [IF BATH_I > 0] Energy-efficient bathroom faucet aerator[s]
Q34_4. [IF PIPEWRAP_I > 0] Pipe wrap
Q34_7. Don't know [EXCLUSIVE ANSWER]

[ASK IF Q34_1 = 1 AND SHOWERHEAD_I = 2]

Q35. If you had not received them in your free kit, how many energy-efficient showerheads would you have purchased and installed within the next year?

1. One
2. Two

98. Don't know

[ASK Q34.3=1 AND IF MORE THAN ONE BATHROOM AERATOR IS STILL INSTALLED]

Q36. If you had not received them in your free kit, how many energy-efficient bathroom aerators would you have purchased and installed within the next year?

1. One
2. Two
98. Don't know

Q37. Now, thinking about the energy and water savings items that were provided in the kit - using a scale from 0 to 10, where 0 means "not at all influential" and 10 means "extremely influential," how influential were the following factors on your decision to install the items from the kit? How influential was…

[*Interviewer: If respondent says, "Not applicable - I didn't get/use that," then follow up with: "So would you say it was "not at all influential?" and probe to code.*]

[MATRIX QUESTION: SCALE]

Elements	Responses
The fact that the items were free	0-10 scale with DK
The fact that the items were mailed to your house	0-10 scale with DK
Information provided by Duke Energy about how the items would save energy and water	0-10 scale with DK
Other information or advertisements from Duke Energy, including its website	0-10 scale with DK

Q40. Since receiving your kit from Duke Energy, have you purchased and installed any other products or made any improvements to your home to help save energy?
1. Yes
2. No
98. Don't know

[ASK IF Q40 = 1]

Q41. What products have you purchased and installed to help save energy in your home? [*Do not read list. After each response, ask, "Anything else?"*] [MULTIPLE RESPONSE]

Q41_4. Bought energy efficient appliances
Q41_5. Moved into an ENERGY STAR home
Q41_6. Bought efficient heating or cooling equipment
Q41_7. Bought efficient windows
Q41_8. Added insulation
Q41_9. Sealed air leaks in windows, walls, or doors
Q41_10. Sealed or insulated ducts
Q41_11. Bought LEDs
Q41_12. Bought CFLs
Q41_13. Installed an energy efficient water heater
Q41_14. None – no other actions taken [EXCLUSIVE ANSWER]
Q41_15. Other, please specify: ____________________
Q41_16. Don't know [EXCLUSIVE ANSWER]

[ASK IF Q41_5 = 1]

Q42. Is Duke Energy still your gas or electricity utility?
1. Yes

2. No
98. Don't know

[ASK IF ANY ITEM IN Q41 WAS SELECTED]
Q46. On a scale of 0 to 10, where 0 means "not at all influential" and 10 means "extremely influential", how much influence did the Duke Energy Save Energy and Water Kit Program have on your decision to…
[MATRIX QUESTION: SCALE]

[LOGIC] ITEM	Response
[IF Q41_4 IS SELECTED] Q46_4 Buy energy efficient appliances	0-10 scale with DK
[IF Q41_5 IS SELECTED] Q46_5 Move into an ENERGY STAR home	0-10 scale with DK
[IF Q41_6 IS SELECTED] Q46_6 Buy efficient heating or cooling equipment	0-10 scale with DK
[IF Q41_7 IS SELECTED] Q46_7 Buy efficient windows	0-10 scale with DK
[IF Q41_8 IS SELECTED] Q46_8 Add insulation	0-10 scale with DK
[IF Q41_9 IS SELECTED] Q46_9 Seal air leaks in windows, walls, or doors	0-10 scale with DK
[IF Q41_10 IS SELECTED] Q46_10 Seal or insulate ducts	0-10 scale with DK
[IF Q41_11 IS SELECTED] Q46_11 Buy LEDs	0-10 scale with DK
[IF Q41_12 IS SELECTED] Q46_12 Buy CFLs	0-10 scale with DK
[IF Q41_13 IS SELECTED] Q46_13 Install an energy efficient water heater	0-10 scale with DK
[IF Q41_15 IS SELECTED] Q46_15 Other, please specify	0-10 scale with DK

[ASK IF Q41_1 IS SELECTED AND Q46_1 <> 0]
Q47. What kinds of appliance(s) did you buy?
[*Do not read list*] [MULTIPLE RESPONSE]
Q47_4 Refrigerator
Q47_5 Stand-alone Freezer
Q47_6 Dishwasher
Q47_7 Clothes washer
Q47_8 Clothes dryer
Q47_9 Oven
Q47_10 Microwave
Q47_11 Other, please specify: ____________
Q47_12 Don't know

[ASK IF Q47 = 4, 5, 6, 7, 8, 10, OR 11]
Q48. Was the [INSERT Q47 RESPONSE] an ENERGY STAR or high-efficiency model?
1. Yes
2. No
98. Don't know
99. Refused
[REPEAT THIS QUESTION FOR EACH ITEM MENTIONED IN Q47]

[ASK IF Q47 = 8]
Q49. Does the new clothes dryer use natural gas?

1. Yes - it uses natural gas
2. No – does not use natural gas
98. Don't know
99. Refused

[ASK IF Q41 = 6 AND Q46_6 > 0]
Q50. What type of heating or cooling equipment did you buy?
[*Do not read list*] [MULTIPLE RESPONSE]
Q50_4 Central air conditioner
Q50_5 Window/room air conditioner unit
Q50_6 Wall air conditioner unit
Q50_7 Air source heat pump
Q50_8 Geothermal heat pump
Q50_9 Boiler
Q50_10 Furnace
Q50_11 Wifi
Q50_12 Other, please specify: _______________
Q50_13 Don't know

[ASK IF Q50 = 9 OR 10]
Q51. Does the new [INSERT Q50 RESPONSE] use natural gas?
1. Yes – it uses natural gas
2. No – does not use natural gas
98. Don't know
99. Refused

[ASK IF Q50= 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, OR 12]
Q52. Was the [INSERT Q50 RESPONSE] an ENERGY STAR or high-efficiency model? [SINGLE RESPONSE]
1. Yes
2. No
98. Don't know
99. Refused
[REPEAT THIS QUESTION FOR EACH ITEM MENTIONED IN Q50, EXCLUDING WIFI THERMOSTAT]

[ASK IF Q41 = 7 AND Q46_7 > 0]
Q53. Do you know how many windows you installed??
1. Yes (please specify how many you installed) [NUMERIC OPEN END]
2. No

[ASK IF Q41=8 AND Q46_8 > 0]

Q54. Please let us know what spaces you added insulation to. Also, let us know the proportion of each space you added insulation to (for example, if you added insulation that covered your entire attic space, you would type in 100%).

	Check here for each space you added insulation to	Use these boxes to type in the approximate proportion of each space you added insulation to
1. Attic		[NUMERIC 0-100] %
2. Walls		[NUMERIC 0-100] %
3. Below the floor		[NUMERIC 0-100] %

[ASK IF Q41= 11 AND Q46_11 > 0]
Q55. Do you know how many LEDs you installed at your property?
1. Yes (please specify how many you installed) [NUMERIC OPEN END]
2. No

[ASK IF Q41 = 12 AND Q46_12 > 0]
Q56. Do you know how many CFLs you installed at your property?
1. Yes (please specify how many you installed) [NUMERIC OPEN END]
2. No

[ASK IF Q41 = 13 AND Q46_13 > 0]
Q57. Does the new water heater use natural gas?
1. Yes – it uses natural gas
2. No – does not use natural gas
98. Don't know

[ASK IF Q41 = 13 AND Q46_13 > 0]
Q58. Which of the following water heaters did you purchase?
1. A traditional water heater with a large tank that holds the hot water
2. A tankless water heater that provides hot water on demand
3. A solar water heater
4. Other, please specify: _______________
98. Don't know

[ASK IF Q41= 13 AND Q46_13 > 0]
Q59. Is the new water heater an ENERGY STAR model?
[SINGLE RESPONSE]
1. Yes
2. No
98. Don't know

Demographics

Lastly, we have some basic demographic questions for you. Please be assured that your responses are confidential and are for statistical purposes only.

Q60. Which of the following types of housing units would you say best describes your home? It is...?

1. Single-family detached house
2. Single-family attached home (such as a townhouse or condo)
3. Duplex, triplex or four-plex
4. Apartment or condominium with 5 units or more
5. Manufactured or mobile home
6. Other ______________
98. Don't know
99. Prefer not to say

Q61. How many showers are in your home? Please include both stand-up showers and bathtubs with showerheads.

1. One
2. Two
3. Three
4. Four
5. Five or more
98. Don't know

Q62. How many bathroom sink faucets are in your home? (Keep in mind that some bathrooms may have multiple bathroom sink faucets in them)

1. One
2. Two
3. Three
4. Four
5. Five
6. Six
7. Seven
8. Eight or more
98. Don't know

Q63. How many kitchen faucets are in your home?

1. One
2. Two
3. Three
4. Four or more
98. Don't know

Q63a. [ASK IF [Q63=2,3,4] You mentioned that you have more than one kitchen faucet. Where is/are your other kitchen faucet(s) located in your home?
[OPEN-ENDED: RECORD VERBATIM RESPONSE]

Q32. What fuel type does your water heater use?
1. Electric
2. Natural Gas
3. Other, please specify: [OPEN-ENDED RESPONSE]
4. Don't know

Q64. How many square feet of living space are there in your residence, including bathrooms, foyers and hallways (exclude garages, unfinished basements, and unheated porches)?
1. Less than 500 square feet
2. 500 to under 1,000 square feet
3. 1,000 to under 1,500 square feet
4. 1,500 to under 2,000 square feet
5. 2,000 to under 2,500 square feet
6. 2,500 to under 3,000 square feet
7. Greater than 3,000 square feet
98. Don't know
99. Prefer not to say

Q65. Do you or members of your household own your home, or do you rent it?
1. Own / buying
2. Rent / lease
3. Occupy rent-free
98. Don't know
99. Prefer not to say

Q66. Including yourself, how many people currently live in your home year-round?
1. I live by myself
2. Two people
3. Three people
4. Four people
5. Five people
6. Six people
7. Seven people
8. Eight or more people
98. Don't know
99. Prefer not to say

Q67. What was your total annual household income for 2019, before taxes?
1. Under $20,000
2. 20 to under $30,000

3. 30 to under $40,000
4. 40 to under $50,000
5. 50 to under $60,000
6. 60 to under $75,000
7. 75 to under $100,000
8. 100 to under $150,000
9. 150 to under $200,000
10. $200,000 or more
98. Don't know
99. Prefer not to say

Q68. What is the highest level of education achieved among those living in your household?

1. Less than high school
2. Some high school
3. High school graduate or equivalent (such as GED)
4. Trade or technical school
5. Some college (including Associate degree)
6. College degree (Bachelor's degree)
7. Some graduate school
8. Graduate degree, professional degree
9. Doctorate
98. Don't know
99. Prefer not to say

Q69. Finally, what is your year of birth?

[Scroll box with years 1900-2010, and Prefer not to say]

Appendix E DEK Participant Survey Results

This section reports the results from each question in the DEK participant survey. Since the results reported in this appendix represent the “raw” data (that is, none of the open-ended responses have been coded and none of the scale questions have been binned), some values may be different from those reported in the Process Evaluation Findings chapter (particularly: percentages in tables with “Other” categories and scale response questions). Only respondents who completed the survey are included in the following results.

Q1. [Read if mode = phone] Hi, I’m _______, calling on behalf of Duke Energy. We are calling about the Save Energy and Water Kit you got from Duke Energy.

This kit included faucet aerators, one or two showerheads, and pipe wrap that can help you save water and energy in your home. Do you recall receiving this kit?

Response Option	Percent (n=39)
Yes	100%
No	0%
Don’t know	0%

Q2. [Display if mode = web] We are conducting surveys about the Save Energy and Water Kit you got from Duke Energy. This kit included faucet aerators, one or two showerheads, and pipe wrap that can help you save water and energy in your home.

Do you recall receiving this kit?

Response Option	Percent (n=136)
Yes	100%
No	0
Don’t know	0

Q4. Did you read the included instructions on how to install the items that came in the kit?

Response Option	Percent (n=174)
Yes	77%
No	15%
Don't remember	7%

Q5. [Ask if Q4 = YES] On a scale from 0 to 10, where 0 is not at all helpful and 10 is very helpful, how helpful were the instructions on how to install the items that came in the kit?

Response Option	Percent (n=135)
Not at all helpful	0%
1	0%
2	1%
3	0%
4	1%
5	6%
6	4%
7	7%
8	23%
9	10%
10 - Very helpful	42%
Don't Know	7%

Q6. [Ask if Q5<7] What might have made the instructions more helpful?

Verbatim Response	Count (n=15)
we already knew how	1
The instructions were fine, I just didn't need them. I can change an aerator or shower head without instructions	1
Pictures	1
picssss	1
Nothing really. I already knew how to install the showerhead.	1
Nothing I can think opf	1
More visuals	1
More photos	1
More examples or photos included.	1
More details	1
Less steps.	1
It's that I have a hard time with written directions and find them complicated	1
I need some one to install them.	1
I don't think tou could have made them more helpful	1
easier terminology	1

Q10. Have you or anyone else installed any of those items in your home, even if they were taken out later?

Response Option	Percent (n=174)
Yes	72%
No	28%
Don't Know	0%

Q11. [Ask if Q10 = YES] Which of the items did you install, even if they were taken out later?

Response Option	Percent (n=174)*
Showerhead	50%
Kitchen faucet aerator	33%
Bathroom faucet aerator	42%
Pipe wrap	30%
I don't remember	0%

* Multiple responses were allowed for this question

Q12. [Ask if Q11 = SHOWERHEAD AND KIT_SIZE= MEDIUM] Your kit contained two showerheads. Did you install one or both of the showerheads in the kit, even if one or both were taken out later?

Response Option	Percent (n=30)
I installed both	33%
I only installed one showerhead	63%
Don't know	3%

Q13. [Ask if Q11 = BATHROOM FAUCET AERATOR] How many of the bathroom faucet aerators from the kit did you install in your home, even if one or more were taken out later?

Response Option	Percent (n=74)
One	59%
Two	34%
Don't know	7%

Q14. [Ask if Q11 = PIPEWRAP] Did you install all of the pipe insulation that was included with the kit?

Response Option	Percent (n=52)
Yes	67%
No	25%
Don't know	8%

Q15. [Ask if Q14 is displayed] About how many feet of the pipe extruding from your water heater did you wrap with the insulation **that came in the kit**? Please go over to your water heater if you need to check.

Response Option	Percent (n=52)
About three feet or less	38%
About four to five feet	36%
About six feet or more	10%
Don't know	15%

Q16. [Ask if any part of Q11 = YES] Overall, how satisfied are you with the item[s] you installed?

Showerhead

Response Option	Percent (n=87)
0 - Very dissatisfied	1%
1	0%
2	1%
3	3%
4	1%
5	1%
6	2%
7	12%
8	15%
9	16%
10 - Very satisfied	45%
Don't know	2%

Kitchen Faucet Aerator

Response Option	Percent (n=58)
0 – Very dissatisfied	1%
1	0%
2	0%
3	0%
4	4%
5	10%
6	3%
7	9%
8	14%
9	10%

Response Option	Percent (n=58)
10 - Very satisfied	46%
Don't know	3%

Bathroom Faucet Aerator

Response Option	Percent (n=74)
0 – Very dissatisfied	0%
1	0%
2	1%
3	1%
4	3%
5	7%
6	4%
7	7%
8	12%
9	15%
10 - Very satisfied	50%
Don't know	0%

Pipe Wrap

Response Option	Percent (n=52)
0 – Very dissatisfied	2%
1	2%
2	0%
3	0%
4	0%
5	4%
6	4%
7	2%
8	10%
9	20%
10 - Very satisfied	57%
Don't know	2%

Q16a. Can you please explain any dissatisfaction you had with [DISPLAY ALL ITEMS IN Q16 THAT ARE <7]?

Showerhead

Verbatim Response	Count (n=9)
We use a removable shower head wand more than a stationary head. Besides that it was a good head. Good pressure	1
too small	1
The water pressure expelled from the shower head was too low for my liking.	1
the flow was too light	1
Not enough flow for ys	1
It seemed cheap and leaked no matter what i tried	1
It leaked	1
It doesn't have as much pressure as the old one but I realize it is to save water.	1
I like my rain shower head better	1

Kitchen Faucet Aerator

Verbatim Response	Count (n=11)
Water pressure was very low with these	1
Wasn't as much pressure	1
Slow running water	1
Reduced water flow.	1
Not being used to an aerator, it made the water pressure much lower therefore not being useful for a kitchen faucet as that is typically used to rinse plates and bowls which needs a higher pressure. Easy to install.	1
It will spray water everywhere and it gets in the way when cleaning large items	1
It was to slow not enough pressure, we live in the country and the pressure is already slow as it is.	1
it made the faucet head too low and made doing dishes and filling up pitchers tough. Also the switching from spray to stream needed more force then should be necessary.	1
It hangs lower than what I'm used to.	1
Didn't like the pressure	1
Didn't fit my faucet used parts from it	1

Bathroom Faucet Aerator

Verbatim Response	Count (n=13)
Water pressure very low	1
water flow too low	1
There wasn't enough water pressure	1
slow running water	1
Reduced water flow	1
None other than water pressure being significantly reduced.	1
None	1
It reduces the flow of water too much.	1
Hangs too low into the sink	1
Didn't work for very long.	1
Decreasing water flow to the extent the aerator did made it more difficult to keep the sink clean.	1
chrome discolored	1
After I installed this aerator the faucet would sometimes leak out of it.	1

Pipe wrap

Verbatim Response	Count (n=6)
The adhesive isn't sticky enough.	3
None, just needed more	1
None	1
I did not use for the pipe. I cut it and stuck on door side to fill the space in between a door and the frame. The pipe wrap doesn't seem to be a good quality product.	1
Didn't seem to be practical.	1
Did little to no insulating had to use tape to secure ends	1

Q17. Overall, how satisfied are you with Duke Energy's Save Energy and Water Kit Program?

Response Options	Percent (n=126)
0 - Very dissatisfied	0%
1	0%
2	1%
3	2%
4	0%
5	3%
6	3%
7	7%

8	14%
9	16%
10 - Very satisfied	53%
Don't know	1%

Q18. [Ask if any part of Q11 = YES] Have you (or anyone in your home) uninstalled any of the items from the kit that you had previously installed?

Response Option	Percent (n=126)
Yes	17%
No	82%
Don't know	1%

Q19. [Ask if Q18 = YES] Which of the items did you uninstall?

Response Option	Count (n= 21)*
Showerhead	10
Kitchen faucet aerator	9
Bathroom faucet aerator	7
Pipe wrap	0
Don't know	0

* Multiple responses were allowed for this question

Q20. [Ask if Q19 = SHOWERHEAD and Q12 = INSTALLED BOTH] Did you uninstall one or both of the showerheads you had previously installed?

Response Option	Percent (n=2)
I only uninstalled one of the showerheads	100%
Don't know	0%

Q21. [Ask if Q19 = BATHROOM FAUCET AERATOR and Q13 = 2-4] How many bathroom faucet aerators did you uninstall?

Response Option	Percent (n=2)
One	50%
Two	50%
Don't know	0%

Q22. [Ask if any item of Q19 is selected] Why were those items uninstalled?

Showerhead

Response Option	Percent (n=10)*
It was broken	10%

Didn't like how it worked	50%
Didn't like how it looked	0%
Other	50%
Don't know	0%

* Multiple responses were allowed for this question

Verbatim Other Responses	Count (n=5)
I reinstalled my hand held sprayer. I found I needed it.	1
I'm remodeling that bathroom.	1
It leaked	1
Not enough flow for us	1
Remodeled bathroom	1

Kitchen faucet aerator

Response Options	Percent (n=9)*
It was broken	0%
Didn't like how it worked	56%
Didn't like how it looked	11%
Other	44%
Don't know	0%

* Multiple responses were allowed for this question

Verbatim Other Response	Count (n=4)
Bought new faucet and it had an aerator in it.	1
Bought new kitchen faucet	1
It didn't fit right, so we took it out.	1
Too slow, not enough pressure.	1

Bathroom faucet aerator

Response Options	Percent (n=7)*
It was broken	0%
Didn't like how it worked	43%
Didn't like how it looked	29%
Other	43%
Don't know	0%

* Multiple responses were allowed for this question

Verbatim Other Responses	Count (n=3)
Got clogged	1
I bought a completely new faucet	1
Remodeling bathroom and have torn out all sinks and showers.	1

Pipe wrap

Response Options	Percent (n=0)*
It was broken	0%
Didn't like how it worked	0%
Didn't like how it looked	0%
Other	0%
Don’t know	0%

* Multiple responses were allowed for this question

Q24a. Customers that need additional assistance with their items can call a toll-free customer care hotline. Did you call the customer care hotline to seek assistance in installing any of your items?

Response Option	Percent (n=174)
Yes	1%
No	98%
Don’t know	1%

Q24b. [ASK IF Q24a = YES] Did you call the customer care hotline to seek assistance in installing your kitchen faucet aerator?

Response Option	Percent (n=1)
Yes	0%
No	100%
Don’t know	0%

Q24c. [ASK IF Q24b = YES] Did the customer care hotline offer to send you an adapter for the kitchen faucet aerator?

Response Option	Percent (n=0)
Yes	0%
No	0%
Don’t know	0%

Q24d. [ASK IF Q24a = YES] Did you call the customer care hotline to seek assistance in installing your bathroom faucet aerator?

Response Option	Percent (n=1)
Yes	0%
No	100%
Don't know	0%

Q24e. [ASK IF Q24d = YES] Did the customer care hotline offer to send you an adapter for the bathroom faucet aerator?

Response Option	Percent (n=0)
Yes	0%
No	0%
Don't know	0%

Q29. [Ask if Q11 = SHOWERHEAD and at least one showerhead is still installed] On average, what is the typical shower length in your household?

Response Option	Percent (n=78)
One minute or less	0%
Two to four minutes	5%
Five to eight minutes	35%
Nine to twelve minutes	33%
Thirteen to fifteen minutes	17%
Sixteen to twenty minutes	8%
Twenty-one to thirty minutes	0%
More than thirty minutes	0%
Don't know	3%

Q30. [DISPLAY IF TWO SHOWERHEADS STILL INSTALLED: Thinking of the efficient showerhead you installed that gets the most usage…]

[DISPLAY IF ONE SHOWERHEAD STILL INSTALLED: Thinking of the efficient showerhead currently installed in your home…]

On average, how many showers per day are taken in this shower?

Response Option	Percent (n=78)
Less than one	14%
One	32%
Two	28%
Three	14%

Four	8%
Six	3%
Seven	0%
Eight or more	0%
Don't know	0%

Q31. [Ask if two showerheads still installed] Thinking of the other efficient showerhead you installed…

On average, how many showers per day are taken in this shower?

Response Option	Percent (n=8)
Less than one	38%
One	25%
Two	25%
Three	12%
Four	0%
Five	0%
Six	0%
Seven	0%
Eight or more	0%
Don't know	0%

Q32. What fuel type does your water heater use?

Response Option	Percent (n=174)
Electric	89%
Natural gas	5%
Other (please specify in the box below)	5%
Don't know	2%

Verbatim Other Response	Count (n=8)
Propane	6
Oil	1
Propaine	1

Q33. [IF CALCTOTAL1 = 0, SKIP TO Q40] If you had not received the free efficiency items in the kit, would you have purchased and installed any of these same items within the next year?

Response Option	Percent (n=121)
Yes	25%
No	56%
Don't know	19%

Q34. [Ask if Q33 = YES] What items would you have purchased and installed within the next year?

Response Option	Count (n=30)*
Showerhead	21
Kitchen faucet aerator	5
Bathroom faucet aerator	6
Pipe wrap	6
Don't know	1

*Multiple responses were allowed for this question

Q35. [Ask if Q34 = SHOWERHEAD and two showerheads are still installed] If you had not received them in your free kit, how many energy-efficient showerheads would you have purchased and installed within the next year?

Response Option	Percent (n=2)
One	50%
Two	50%
Don't know	0%

Q36. [Ask if Q34 = BATHROOM FAUCET AERATOR and if more than one bathroom aerator is still installed] If you had not received them in your free kit, how many energy-efficient bathroom aerators would you have purchased and installed within the next year?

Response Option	Percent (n=2)
One	0%
Two	100%
Don't know	0%

Q37. [If Q33 was displayed] Now, thinking about the energy and water-savings items that were provided in the kit - using a scale from 0 to 10, where 0 means “not at all influential” and 10 means “extremely influential,” how influential were the following factors on your decision to install the items from the kit? How influential was…

The fact that the items were free

Response Option	Percent (n=121)
Not at all influential	3%
1	0%
2	0%
3	0%
4	0%
5	2%
6	2%
7	6%
8	12%
9	8%
10 - Extremely influential	66%
Don't know	0%

The fact that the items were mailed to your home

Response Option	Percent (n=121)
0- Not at all influential	1%
1	0%
2	0%
3	0%
4	0%
5	0%
6	2%
7	6%
8	12%
9	10%
10 - Extremely influential	70%
Don't know	0%

Information provided by Duke Energy about how the items would save energy and water

Response Option	Percent (n=121)
0- Not at all influential	5%
1	0%
2	0%
3	1%
4	0%
5	4%

6	6%
7	7%
8	15%
9	9%
10 - Extremely influential	53%
Don't know	0%

Other information or advertisements from Duke Energy, including its website

Response Option	Percent (n=121)
0- Not at all influential	16%
1	1%
2	1%
3	1%
4	3%
5	12%
6	3%
7	8%
8	10%
9	8%
10 - Extremely influential	31%
Don't know	6%

Q40. Since receiving your kit from Duke Energy, have you purchased and installed any other **products** or made any improvements to your home to help save energy?

Response Option	Percent (n=174)
Yes	41%
No	57%
Don't know	3%

Q41. [If Q40 = YES] What **products** have you purchased and installed to help save energy in your home?

Response Option	Percent (n=174)*
Bought energy efficient appliances	15%
Moved into an ENERGY STAR home	0%
Bought efficient heating or cooling equipment	11%
Bought efficient windows	5%
Added insulation	5%
Sealed air leaks in windows, walls, or doors	8%
Sealed or insulated ducts	1%

Response Option	Percent (n=174)*
Bought LEDs	29%
Bought CFLs	5%
Installed an energy efficient water heater	7%
None – no other actions taken	0%
Other	3%
Don't know	1%

* Multiple responses were allowed for this question

Verbatim Other Responses	Count (n=6)
Light bulbs but I don't know what kind. They came in the mail.	1
Installed energy efficient vstorm doors	1
Installed an awning to shield from heat and cold. Cut my energy bill by 30%+	1
Bought new storm door	1
air filters that fit our furnace!, others didn't fit very well.	1
A storm door	1

Q42. [If Q41 = MOVED INTO AN ENERGY STAR HOME] Is Duke Energy still your gas or electricity utility?

Response Option	Count (n=0)
Yes	0%
No	0%
Don’t know	0%

Q46. [Ask if any item in Q41 was selected] On a scale of 0 to 10, where 0 means “not at all influential” and 10 means “extremely influential”, how much influence did the Duke Energy Save Energy and Water Kit Program have on your decision to…

Response Option	0	1	2	3	4	5	6	7	8	9	10	Don’t know	n
Buy energy efficient appliances	31%	0%	8%	0%	8%	0%	0%	4%	8%	15%	27%	3%	26
Move into an ENERGY STAR home	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0
Buy efficient heating or cooling equipment	35%	0%	0%	0%	5%	5%	0%	5%	20%	5%	20%	5%	20
Buy efficient windows	33%	0%	0%	0%	11%	11%	0%	11%	11%	0%	22%	0%	9
Add insulation	22%	0%	0%	11%	0%	11%	0%	22%	11%	0%	11%	11%	9
Seal air leaks	14%	0%	0%	0%	7%	0%	14%	14%	0%	0%	50%	0%	14
Seal ducts	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%	0%	2
Buy LEDs	16%	0%	0%	4%	4%	4%	6%	10%	8%	6%	39%	2%	49
Buy CFLs	0%	0%	12%	0%	12%	12%	12%	12%	0%	0%	25%	12%	8
Install an energy efficient water heater	8%	8%	8%	0%	8%	8%	0%	17%	8%	0%	17%	17%	12
Other	0%	0%	17%	0%	17%	0%	17%	0%	0%	33%	0%	17%	6

Q47. [Ask if Q41 = BOUGHT ENERGY EFFICIENT APPLIANCES and Q46_BUY ENERGY EFFICIENT APPLIANCES <> 0] What kinds of appliance(s) did you buy?

Response Option	Percent (n=18)*
Refrigerator	61%
Stand-alone freezer	17%
Dishwasher	33%
Clothes washer	44%
Clothes dryer	39%
Oven	17%
Microwave	22%
Other	11%
Don't know	0%
Refused	0%

* Multiple responses were allowed for this question

Verbatim Other Responses	Count (n = 2)
Water heater	1
HVAC System	1

Q48. [Ask if Q47 <> DON'T KNOW] Was the [INSERT Q47 RESPONSE] an ENERGY STAR or high-efficiency model?

Response Option	Microwave	Refrigerator	Stand-alone Freezer	Dishwasher	Clothes washer	Clothes dryer	Other
Yes	3	9	3	5	6	5	2
No	0	0	0	0	0	0	0
Don't know	1	2	0	1	2	2	0
Total	4	11	3	6	8	7	2

Q49. [Ask if Q47 = CLOTHES DRYER] Does the new clothes dryer use natural gas?

Response Option	Percent (n=7)
Yes	0%
No	100%
Don't know	0%
Refused	0%

Q50. [Ask if Q41 = BOUGHT EFFICIENT HEATING OR COOLING EQUIPMENT and Q46_BUY EFFICIENT HEATING OR COOLING EQUIPMENT > 0] What type of heating or cooling equipment did you buy?

Response Option	Percent (n=13)*
Central air conditioner	62%
Window/room air conditioner unit	0%
Wall air conditioner unit	8%
Air source heat pump	15%
Geothermal heat pump	0%
Boiler	0%
Furnace	54%
Wifi thermostat	15%
Other	8%
Don't know	0%
Refused	0%

* Multiple responses were allowed for this question

Verbatim Other Responses	Count (n = 1)
Furnace filter	1

Q51. [Ask if Q50 = BOILER OR FURNACE] Does the new [INSERT Q50 RESPONSE] use natural gas?

Response Option	Percent (n=7)
Yes - it uses natural gas	43%
No – does not use natural gas	57%
Don't know	0%

Q52. [Ask if Q50 <> WIFI-ENABLED THERMOSTAT, DON'T KNOW, OR REFUSED] Was the [INSERT Q50 RESPONSE] an ENERGY STAR or high-efficiency model?

Response Option	Other	Central air conditioner	Window / room air conditioner unit	Wall air conditioner unit	Air source heat pump	Geothermal heat pump	Boiler	Furnace
Yes	1	6	0	1	2	0	0	0
No	0	2	0	0	0	0	0	0
Don't know	0	0	0	0	0	0	0	0
Total	1	8	0	1	2	0	0	0

Q53. [Ask if Q41= BOUGHT EFFICIENT WINDOWS and Q46_BUY EFFICIENT WINDOWS >0] Do you know how many windows you installed?

Response Option	Percent (n=6)
Yes [please specify how many you installed in the box below]	100%
No	0%

Verbatim Responses	Percent (n=6)
6	2
10	1
13	2
Sic	1

Q54. [Ask if Q41 = ADDED INSULATION and Q46_ADD INSULATION > 0] Please let us know what spaces you added insulation to. Also, let us know the proportion of each space you added insulation to (for example, if you added insulation that covered your entire attic space, you would type in 100%).

Response Option	Percent (n=7)*
Attic	57%
Walls	57%
Below the floor	29%

* Multiple responses were allowed for this question

Attic

Verbatim Response	Count (n=4)
About 16" deep entire attic	1
45×60	1
100%	2

Walls

Verbatim Response	Count (n=4)
Put on walls	1
100%	1
10×12 room and 10×10 room	1
??	1

Below the floor

Verbatim Response	Count (n=2)
On water pipes	1
??	1

Q55. [Ask if Q41 = BOUGHT LEDS and Q46_BUY LEDS > 0] Do you know how many LEDs you installed at your property?

Response Option	Percent (n=41)
Yes	76%
No	24%

[Please specify how many you installed in the box below:]

Verbatim Response	Count (n=31)
10	5
10?	1
15	3
18	1
2	1
20	2
26	1
30	1
30+	1
35	1
4	2
5	2
5 or 6	1
6	1
6 to 10	1
7	2
8	2
About 30	1
All lights	1
approx. 8	1

Q56. [Ask if Q41 = BOUGHT CFLS and Q46_BUY CFLS > 0] Do you know how many CFLs you installed at your property?

Response Option	Percent (n=8)
Yes	63%

No	37%

[Please specify how many you installed in the box below:]

Verbatim Response	Count (n=5)
9	1
7	1
6	1
5	1
3	1

Q57. [Ask if Q41 = INSTALLED AN ENERGY EFFICIENT WATER HEATER and Q46_INSTALL AN ENERGY EFFICIENT WATER HEATER > 0] Does the new water heater use natural gas?

Response Option	Percent (n=11)
Yes	18%
No	82%
Don't know	0%

Q58. [Ask if Q41 = INSTALLED AN ENERGY EFFICIENT WATER HEATER and Q46_INSTALL AN ENERGY EFFICIENT WATER HEATER > 0] Which of the following water heaters did you purchase?

Response Option	Percent (n=11)
A traditional water heater with a large tank that holds the hot water	73%
A tankless water heater that provides hot water on demand	0%
A solar water heater	0%
Other	18%
Don’t know	9%

Verbatim Other Responses	Count (n=2)
Propane	1
Hybrid electric heat pump	1

Q59. [Ask if Q41 = INSTALLED AN ENERGY EFFICIENT WATER HEATER and Q46_INSTALL AN ENERGY EFFICIENT WATER HEATER > 0] Is the new water heater an ENERGY STAR model?

Response Option	Percent (n=11)
Yes	91%
No	9%
Don't know	0%

Q60. Which of the following types of housing units would you say best describes your home? It is . . .?

Response Option	Percent (n=174)
Single-family detached house	74%
Single-family attached home (such as a townhouse or condo)	12%
Duplex, triplex or four-plex	1%
Apartment or condo with 5 units or more	8%
Manufactured or mobile home	5%
Other	1%
Prefer not to say	0%
Don't know	0%

Verbatim Other Response	Count (n=1)
Brick single family home.	1

Q61. How many showers are in your home? Please include both stand-up showers and bathtubs with showerheads.

Response Option	Percent (n=174)
One	26%
Two	61%
Three	13%
Four	1%
Five or more	0%
Don’t know	0%

Q62. How many bathroom sink faucets are in your home? (Keep in mind that some bathrooms may have multiple bathroom sink faucets in them)

Response Option	Percent (n=174)
One	13%
Two	35%
Three	28%
Four	19%
Five	4%

Six	2%
Seven	0%
Eight or more	0%
Don't know	0%

Q63. How many kitchen faucets are in your home?

Response Option	Percent (n=174)
One	93%
Two	6%
Three	0%
Four or more	1%
Don't know	0%

Q63A. [IF Q63 > 1] You mentioned that you have more than one kitchen faucet. Where is/are your other kitchen faucet(s) located in your home?

Verbatim Other Response	Count (n=12)
Upstairs and downstairs	1
Laundry room.	1
Kitchenette	1
It's on the bar or counter top of the kitchen.	1
in the garage	1
in my second kitchen, we have a kitchen both upstairs and down stairs	1
family room in basement	1
Basement kitchen	1
Basement	2
Badement	1
5	1

Q64. How many square feet of living space are there in your residence, including bathrooms, foyers and hallways (exclude garages, unfinished basements, and unheated porches)?

Response Option	Percent (n=174)
Less than 500 square feet	0%
500 to under 1,000 square feet	9%
1,000 to under 1,500 square feet	25%
1,500 to under 2,000 square feet	22%
2,000 to under 2,500 square feet	13%
2,500 to under 3,000 square feet	6%
Greater than 3,000 square feet	5%

Prefer not to say	1%
Don't know	20%

Q65. Do you or members of your household own your home, or do you rent it?

Response Option	Percent (n=174)
Own / buying	93%
Rent / lease	5%
Occupy rent-free	0%
Prefer not to say	2%
Don't know	1%

Q66. Including yourself, how many people currently live in your home year-round?

Response Option	Percent (n=174)
I live by myself	23%
Two people	34%
Three people	15%
Four people	13%
Five people	7%
Six people	2%
Seven people	1%
Eight or more people	1%
Prefer not to say	3%
Don't know	0%

Q67. What was your total annual household income for 2018, before taxes?

Response Option	Percent (n=174)
Under $20,000	3%
$20,000 to under $30,000	7%
$30,000 to under $40,000	7%
$40,000 to under $50,000	4%
$50,000 to under $60,000	13%
$60,000 to under $75,000	9%
$75,000 to under $100,000	12%
$100,000 to under $150,000	9%
$150,000 to under $200,000	5%
$200,000 or more	1%
Prefer not to say	25%
Don't know	5%

Q68. What is the highest level of education achieved among those living in your household?

Response Option	Percent (n=174)
Less than high school	1%
Some high school	2%
High school graduate or equivalent (such as GED)	15%
Trade or technical school	5%
Some college (including Associate degree)	23%
College degree (Bachelor's degree)	29%
Some graduate school	1%
Graduate degree, professional degree	14%
Doctorate	4%
Prefer not to say	7%
Don't know	0%

Q69. Finally, what is your year of birth?

Verbatim Response	Count (n=174)
1933	1
1934	1
1937	2
1938	1
1939	1
1941	1
1942	1
1944	1
1945	2
1946	1
1947	2
1948	3
1949	5
1950	4
1951	5
1952	3
1953	2
1954	1
1955	2
1956	5
1957	2
1958	4

1959	3
1960	4
1961	4
1962	2
1963	3
1964	3
1965	2
1966	4
1967	4
1969	2
1970	1
1971	4
1972	3
1973	1
1974	1
1975	2
1976	4
1977	1
1978	3
1979	4
1980	1
1981	7
1982	5
1983	6
1984	1
1985	3
1987	1
1988	4
1989	4
1990	5
1991	1
1993	2
1994	1
Prefer not to say	29