Guidehouse

EM&V Report for the EnergyWise Home Demand Response Program

Summer 2021

Prepared for:

Duke Energy Progress

DUKE ENERGY®

Submitted by:

Jeff Erickson
Director

Primary contributing authors:
Peter Steele-Mosey, Associate Director
Nicola Charles, Senior Consultant

Guidehouse Inc.

guidehouse.com
April 1, 2022

Table of Contents

Section **Page**

Included as Separate Documents

Appendix A: Output Summary

Filename: "*DEP EnergyWise 2021 Summer Mini Analysis Appendix A 2022-02-11.xlsx*"

Description: Includes summary results and snapback calculation.

List of Figures

Figure **Page**

List of Tables

Table **Page**

Evaluation Summary

The EnergyWise Home (EnergyWise) demand response (DR) program offers Duke Energy Progress (DEP) residential customers the opportunity to earn credits on their electricity bill by allowing DEP to remotely cycle and curtail air conditioners (A/C) during times of peak seasonal load in the summer months (available system wide) and space- and water-heating equipment in winter months (Western region customers only).

This report covers the evaluation, measurement, and verification (EM&V) activities for the summer of 2021. For this evaluation, Guidehouse evaluated program impacts using the regression-estimated DR coefficients (parameters) from the most recent metering study (2019 summer).

At the start of the summer 2021 DR season, the program had 189,275 participants eligible for summer curtailment in DEP's territory, representing approximately 242,427 controlled air conditioners.

This season was atypical for the program, since no program-wide DR events were called. Instead, events were called to test device responsiveness. DEP called 4 of these test events throughout the season that each applied only to the participants in one of the four regions: eastern, southern, western, and northern. These events were not coincident with system peak and therefore occurred at significantly lower temperatures when compared to typical summer events. Since summer air conditioner impacts are a function of temperature, this resulted in lower program impacts. Due to these factors, the impacts from this evaluation should not be used to inform program capability at system peak.

Table ES - 1, below summarizes the average impacts for each of the four test events called in the season.

Table ES - 1. Summary of Impacts

Event Date	Region	Avg. Event Temperature (F)	Impact Per Customer (kW)	Relative Precision (+/- %)	Number of Customers	Total Program Impact (MW)	Impact Per Appliance (kW)
2021-08-30	Eastern	81.6	0.77	19%	41,000	31.51	0.60
2021-08-30	Southern	80.9	0.76	19%	34,162	25.90	0.59
2021-08-30	Western	75.4	0.34	19%	18,113	6.07	0.26
2021-09-13	Northern	84.9	0.90	19%	96,000	86.79	0.71
Average		**80.7**	**0.69**	**10%**			**0.54**

Source: Guidehouse analysis

Evaluation Objectives

The key objectives of the impact analysis include:

1. **Estimating the average (kW) DR event load shed per participant household.** Guidehouse has estimated the average impact of curtailment per participant household, for every quarter-hour of each event to which EM&V participants were subject. Per-participant household impacts were converted to per-device impacts by scaling them according to the proportion of devices per participant reported by Duke.
2. **Estimating the average impact for each cycling strategy employed.** The EnergyWise program has historically deployed cycling strategies of 100%, 75%, 65%, and 50%. During the summer 2021 season, only a cycling strategy of 100% was deployed.

3. **Estimating the aggregate (MW) DR event load shed for entire program.** Guidehouse has estimated the aggregate impact of curtailment for the program for each event and on average across all regions by summing the estimated average per participant impacts by event to the total program population.
4. **Estimating Average hourly DR event snapback.** Guidehouse has estimated the average kW snapback impact for all events. Quarter-hourly impacts for all events are provided in the spreadsheet appendix.

Impact Evaluation Methods

Since Guidehouse (formerly Navigant)'s first evaluation of the EnergyWise program in 2011, Guidehouse has evaluated impacts using one of three approaches: a logger analysis, an AMI analysis, or a "mini" analysis. For the most recent *prior* summer program period (2019 summer), Guidehouse deployed data loggers at a representative sample of participant homes and used regression analysis to estimate event impacts and project program capability alongside an identical regression analysis done with Duke's Advanced Meter Infrastructure (AMI) data. The results showed no statistically significant difference in the results, confirming that AMI data is a reliable resource for impact results.

For the current evaluation (2021 summer), Guidehouse completed a "mini" analysis. For this program year, Guidehouse estimated impacts using:

(1) the regression-estimated DR coefficients (parameters) from the most recent metering study (2019 summer);

(2) the reported DR event dates and durations for 2021 summer; and

(3) the actual temperature values observed during 2021 summer events. These are used to deliver the equivalent of an ex ante impact, or prediction, based on previously estimated impact/temperature relationships.

Findings and Conclusions

The principal EM&V impact findings and conclusions regarding the summer event demand impacts for 2021 are as follows:

1. **The estimated average (kW) DR event load shed per participant household was 0.69 kW.** This is the average of the estimated impacts across the four 100% cycling test events taking place at various half hour intervals between 12pm and 3:30pm.
2. **The estimated average program impact of the events deployed in the summer of 2021 was approximately 150.27 MW.** This is the sum of the estimated impact of all four test events that occurred throughout the season, which each only covered one of DEP's regions. These impacts are slightly lower than 2019 summer, which can be ascribed to the lower average event temperature observed in the summer of 2021.
3. **The average snapback** impact during the first full hour beginning 15 minutes after the end of the event was 0.34 kW.

1.0 Introduction

The EnergyWise program provides residential customers the opportunity to earn credits on their electricity bill by allowing DEP to remotely cycle air conditioning (in the summer) and curtail water heater and heat pump auxiliary heating strips (in the winter, Western region customers only) during times of seasonal peak load. This report covers the evaluation, measurement, and verification (EM&V) activities for the summer of 2021. At the start of the summer 2021 DR season, the program had 189,275 participants eligible for summer curtailment, representing approximately 242,427 controlled air conditioners.

EM&V refers generally to the assessment and quantification of the energy and peak demand impacts of an energy efficiency or DR program. For DR, estimating reductions in peak demand is the primary objective, as energy impacts are generally negligible. EM&V can also encompass an evaluation of program processes and customer feedback typically conducted through participant surveys. The summer 2021 EM&V cycle did not include a process evaluation.

1.1 Objectives of the Evaluation

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

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

5. **Estimating the average (kW) DR event load shed per participant household.** Guidehouse has estimated the average impact of curtailment per participant household, for every quarter-hour of each event to which EM&V participants are subject. Per-participant household impacts were converted to per-device impacts by scaling them according to the proportion of devices per participant reported by Duke.
6. **Estimating the average impact for each cycling strategy employed.** The EnergyWise program has historically deployed cycling strategies of 100%, 75%, 65%, and 50%. During the summer 2021 season, only a cycling strategy of 100% was deployed.
7. **Estimating the aggregate (MW) DR event load shed for entire program.** Guidehouse has estimated the aggregate impact of curtailment for the program for each event by applying the average estimated impact per participant to the total number of participants.
8. **Estimating Average hourly DR event snapback.** Guidehouse has estimated the average kW snapback impact for all events. Quarter-hourly impacts for all events are provided in the spreadsheet appendix.

1.2 Program Overview

The EnergyWise program was developed in response to DEP's determination that a curtailable load program would be a valuable resource for the company and that it would provide an opportunity to engage directly with customers to help reduce costly seasonal peak demand. The program seeks to attract DR by incenting residential customers to allow DEP to remotely control the most important driver of summer peak demand typically found in the home: central air conditioning.

The program offers an annual bill credit of $25 (per appliance type controlled) to customers that choose to allow DEP to cycle their central air conditioners (summer only), electric auxiliary heat strips, and/or water heaters (winter only).

Eligibility. To be eligible for participation in the summer component of the EnergyWise program, a household must meet the following criteria:

- Participants must occupy the residence where the controls are installed. Renters must complete a Tenant Authorization Form and the landlord/property owner must approve.
- Residential electricity service must be in the name of the participant.
- Participants must be in an area that can receive the EnergyWise Home paging signal.
- Participation also requires that participants have electric central air conditioning or a centrally ducted heat pump.

Incentives. Each participant receives a $25 yearly bill credit upon joining the summer program, and then an additional $25 bill credit every 12 months they remain on the program.

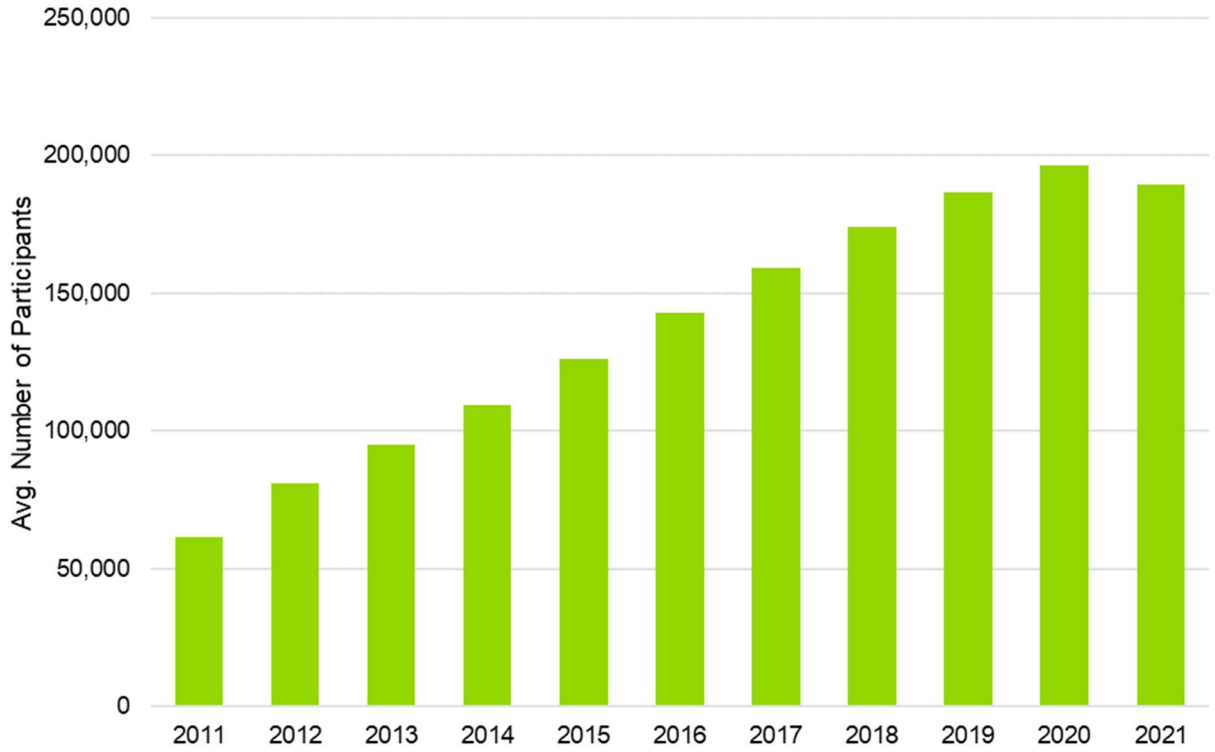
Marketing. DEP is responsible for all marketing of the EnergyWise program. Participant enrollments are generated through a mix of direct mail, bill inserts, email, outbound calling, and door-to-door canvassing.

1.3 Reported Program Participation

This section reports the overall program participation for the summer EnergyWise program in the summer of 2021. In total, at the beginning of the DR season, approximately 189,275 customers were enrolled in the program and eligible for curtailment.

Since the summer of 2011, up until the summer of 2019 program growth has been strong. In recent years it appears to have tapered off (see Figure 1-1).

Figure 1-1. Historical EnergyWise Summer Participation[1]



Source: DEP

Altogether the 189,275 participants have a total of nearly 242,427 central air-conditioning units enrolled, or approximately 1.28 per participant. This ratio is from the summer 2019 evaluation and has not changed meaningfully over time – in the first year Guidehouse (formerly Navigant) evaluated this program there were approximately 1.3 enrolled central air conditioners enrolled for each participant – a statistically identical value to that in summer 2019.

1.4 Prior Year Evaluations

Guidehouse (formerly Navigant)'s full econometric evaluations[2] of the EnergyWise Home program for prior years are available online and can provide valuable context for the current evaluation. The locations of these evaluations are provided below.

- Summer 2011

  https://starw1.ncuc.net/NCUC/ViewFile.aspx?Id=7529baa9-3d22-4735-b0dc-9fe363b0219d

- Summer 2013

[1] The summer of 2020 was not evaluated so participant numbers are not available.

[2] Historically evaluations have alternated between full econometric evaluations, in which impacts are estimated by applying regression analysis to demand data collected from participants, and smaller scale evaluations that have applied the regression parameters estimated in the most recent prior evaluation to the event conditions observed in the given year.

https://starw1.ncuc.net/NCUC/ViewFile.aspx?Id=1b413a77-e26f-4fad-8e38-041a737d179d

- Summer 2016

  https://starw1.ncuc.net/NCUC/ViewFile.aspx?Id=e7c07401-f53e-48f3-bf82-80ab05a4c617

- Summer 2019

  https://starw1.ncuc.gov/NCUC/ViewFile.aspx?Id=05f7230c-8782-47cc-b63c-79ae0ead7f77

2.0 Evaluation Methods

This section of the EM&V report describes the approach used to estimate the DR and snapback impacts of the EnergyWise program for summer 2021.

Since Guidehouse (formerly Navigant)'s first evaluation of the EnergyWise program in 2011, Guidehouse has evaluated impacts using one of three approaches: a logger analysis, an AMI analysis, or a "mini" analysis.

- For **a logger analysis** (for example the completed evaluation of the EnergyWise program for the summer of 2019), data loggers are deployed to a representative sample of participant homes and regression analysis is used to estimate event impacts and project program capability.
- For **an AMI analysis** (for example, the recently completed evaluation of the EnergyWise program for the winter of 2020/2021), AMI data is collected for a representative sample of participant homes and regression analysis is used to estimate event impacts and project program capability.
- For **a "mini" analysis**, Guidehouse applies the regression-estimated DR coefficients (parameters) to the actually observed temperature values. This delivers the equivalent of an ex ante impact, or prediction, based on previously estimated impact/temperature relationships.

No data loggers were deployed to participating homes in the summer of 2021, nor was AMI data collected. The most recent summer program year in which regression analysis was completed was the summer of 2019. In the summer of 2019, both a logger analysis and an AMI analysis were carried out side-by-side to determine the accuracy and consistency of using AMI data. The results from this study showed no statistically significant difference between the impacts estimated by the two approaches. For 2021 summer, Guidehouse completed a "mini" analysis using:

- The regression-estimated DR coefficients (parameters) estimated for the EM&V sample using AMI data from the 2019 summer study
- The reported event dates and durations for 2021 summer
- The actual observed temperature values from the 2021 summer events.

Full details of the 2019 summer logger and AMI study and regression approach can be found in the EMV Report for DEP EnergyWise Summer 2019[3].

2.1 Data Sources

Table 2 lists the data sources used for the 2021 "mini" analysis. Duke Energy provided Guidehouse with the schedule of called events. Guidehouse obtained hourly weather data, including average hourly dry-bulb temperature, from the National Oceanic and Atmospheric Administration (NOAA). Guidehouse also used results from the 2019 summer evaluation, specifically:

[3] EM&V Report for the EnergyWise Home Demand Response Program Summer 2019, DEP. Available: *https://starw1.ncuc.gov/NCUC/ViewFile.aspx?Id=05f7230c-8782-47cc-b63c-79ae0ead7f77*

- Regression Parameter Estimates – the coefficients estimated as part of the regression analysis used to estimate impacts for both heat strips and water heaters
- Device Responsiveness and Functionality – the percentages of devices found to be not connected, not in use, or not responsive.

Table 2. Data Sources Used for the 2021 Summer Evaluation

Data	Source
2021 Summer Event Schedule	Provided by Duke Energy
2021 EnergyWise Program Populations	
Hourly Weather Data (2021)	National Oceanic and Atmospheric Administration
Regression Parameter Estimates	2019 Summer Evaluation Results
Device Responsiveness and Functionality	
Number of appliances per participant	

Source: Guidehouse Analysis

2.2 Demand Response and Snapback Impact Estimation

Guidehouse estimated impacts for air conditioning units as follows:

1. **Obtain average per-participant impacts**

   Guidehouse gathered hourly temperature data from the National Oceanic and Atmospheric Administration (NOAA) for each event day for four weather stations collocated with population centers of each of the four regions. See Table 3 for the weather stations used. It should be noted that while region specific weather data was used in this "mini" analysis, the regression parameter estimates developed in 2019 were based on one set of weather data, a weighted average of weather across the regions.

Table 3: Region to Weather Station Map

Region	City	NOAA Weather Station
Eastern	Fayetteville	72303593740
Southern	Florence[4]	72310613744
Western	Asheville	7231503812
Northern	Raleigh	72306013722

Source: DEP and the National Oceanic and Atmospheric Administration (NOAA)

Guidehouse applied this temperature data to the regression-estimated parameters from 2019 to estimate average per-participant impacts.

[4] Note that a representative population center was not provided by DEP for the Southern region, so Guidehouse assumed Florence, SC.

2. **Adjust for devices not connected, non-responsive, or not in use**

   The average impact per appliance was multiplied by 89%, the inverse of the 11% disconnection rate from summer 2019. The proportion of devices that were disconnected in 2021 was assumed to be the same as the overall season average from 2019.

3. **Estimate aggregate program impact and per device impacts**

   To estimate per-customer population impacts for each event, the adjusted per-participant EM&V sample impacts were multiplied by the ratio of average number of appliances per household in the population to the average number of appliances per household in the EM&V sample observed during the 2019 summer study. Guidehouse estimated per-appliance impacts by dividing the per-customer impacts by the average number of appliances per customer observed during the 2019 summer study.

   To estimate aggregate program impacts, the per-customer impacts were multiplied by the number of participants in each regional event. These impacts were then summed over each event to arrive at the total program impact.

4. **Estimate snapback impacts**

   Snapback is defined as the increase in demand observed in the period following a DR event. During a DR event A/C cycling limits the run time of the A/C compressor. This results in the indoor temperature rising above the thermostat set-point. When cycling ceases, the compressor needs to run for longer than it normally would in order to restore the indoor temperature to the thermostat set-point.

   The 15-minute gap between the end of the event and the beginning of the period in which snapback is reported is to accommodate appliance ramping (some appliances may still be curtailing during this period as they await a signal to release curtailment). Therefore, snapback is reported over one hour, starting 15 minutes after the end of an event.

   The mechanics of the snapback approach are clearly laid out in the Appendix A workbook (see the “Snapback Calculation” tab).

3.0 Impact Findings

This section provides the estimated demand reduction and snapback impacts for the EnergyWise program for the summer of 2021. Section 2.0 details how these impacts were estimated.

For each summer 2021 event, Table 4 lists the estimated average impact for each appliance and the total program impact. Estimated regional program impacts for individual 2021 summer events ranged from 6.07 to 88.79 MW, driven by the participant population by region, and the temperature at the time of the event.

Table 4. Average Demand Reduction Impact by Event

Event Date	Region	Avg. Event Temperature (F)	Impact Per Customer (kW)	Relative Precision (+/- %)	Number of Customers	Total Program Impact (MW)	Impact Per Appliance (kW)
2021-08-30	Eastern	81.6	0.77	19%	41,000	31.51	0.60
2021-08-30	Southern	80.9	0.76	19%	34,162	25.90	0.59
2021-08-30	Western	75.4	0.34	19%	18,113	6.07	0.26
2021-09-13	Northern	84.9	0.90	19%	96,000	86.79	0.71
Average		**80.7**	**0.69**	**10%**			**0.54**

Source: Guidehouse analysis

Figure 2 and Figure 3 present the DR capability for air conditioners that were operating during DR events and responded to curtailment signals.[5]

As shown in Figure 2, the grey line (ex ante) shows the average projected capability of all responsive devices from 75°F to 104°F as estimated in the summer 2019 study. Estimated event impacts are represented on this chart as a series of "X"s (2019 summer events) and colored circles (2021 summer events). Whiskers represent the 90% confidence interval around each estimate.[6]

These impacts are noticeably lower than the impacts and DR capability that were estimated for the 2019 summer study. This is because the four test events called in 2021 occurred at significantly lower temperatures than the events in 2019. The hottest test event in 2021 was approximately two degrees cooler than the mildest event in 2019. It can also be observed that the summer 2021 event impacts fall below the ex ante line in the figure below.

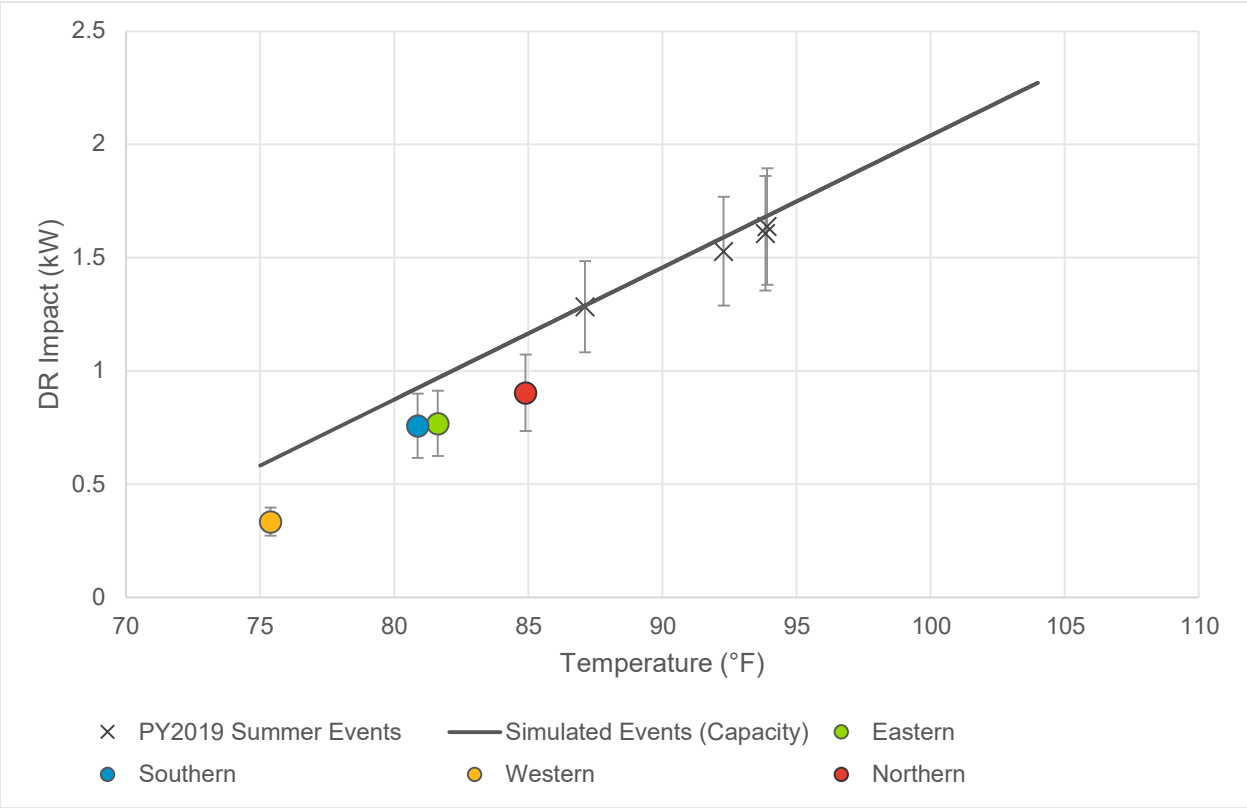
This is because the ex ante projections assume that the temperature leading up to an event is equal to the temperature during the event. This assumption provides a reasonable two-dimensional approximation of the estimated relationship for events in the mid- to late-afternoon, but is less accurate for test events occurring in the middle of the day.

Since the three hours leading up to the events were materially cooler than the event hour, the estimated impacts are slightly lower than the projected line which approximates the ex ante relationship between weather and demand impacts.

[5] The results shown in these figures represent the DR capability of the devices prior to accounting for the portion of customer equipment that were not connected, not in use, or not responsive during DR events.

[6] The values underlying this plot may be found in Appendix A, the Excel spreadsheet that accompanies this report.

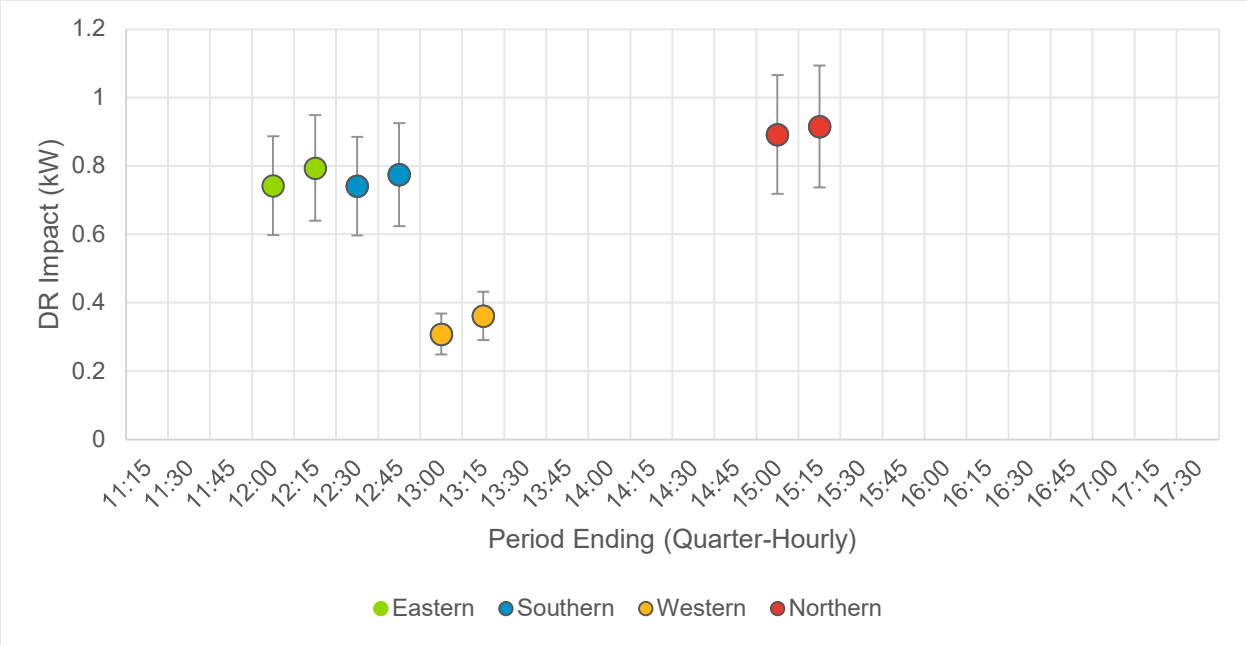
Figure 2. Estimated Impacts and Projected Average DR Capability



Source: Guidehouse Analysis

Figure 3 shows the average estimated quarter-hourly impacts for 2021 summer. The impacts are generally consistent throughout events, with the exception of the Western region which experienced significantly lower event temperatures.

Figure 3. Average Quarter-Hourly Impacts



Source: Guidehouse Analysis

4.0 Findings and Conclusions

The principal EM&V impact findings and conclusions regarding the summer event demand impacts for 2021 are as follows:

1. **The estimated average (kW) DR event load shed per participant household was 0.69 kW.** This is the average of the estimated impacts across the four 100% cycling test events taking place at various half hour intervals between 12pm and 3:30pm.
2. **The estimated average program impact of the events deployed in the summer of 2021 was approximately 150.27 MW.** This is the sum of the estimated impact of all four test events that occurred throughout the season, which each only covered one of DEP's regions. These impacts are slightly lower than 2019 summer, which can be ascribed to the lower average event temperature observed in the summer of 2021.
3. **The average snapback** impact during the first full hour beginning 15 minutes after the end of the event was 0.34 kW.

5.0 Summary Form

EnergyWise Home
Summer 2021
Completed EMV Fact Sheet

Description of Program

Duke Energy's EnergyWise program is a DR program offered to residential customers in the DEP territory.

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

This report evaluates the capability of the program as of the summer of 2021. In summer 2021, no events were called for the entire program population, but 4 test events were called, each for one DEP region (Eastern, Southern, Western, and Northern).

Date:	2021-12-22
Region:	DEP
Evaluation Period	Summer 2021
DR Event Impacts per Device (kW)	
Central Air Conditioner	0.54
DR Program Event Impact (MW)	
Central Air Conditioner	150.27
Net-to-Gross Ratio	1

Evaluation Methods

Guidehouse estimated DR impacts for central air conditioners using: (1) the regression-estimated DR coefficients (parameters) from the most recent metering study (2019 summer); (2) the reported event dates and durations for 2021 summer; and (3) the actual observed temperature values observed during 2021 summer events. This delivers the equivalent of an ex ante impact, or prediction, based on previously estimated impact/temperature relationships.

Impact Evaluation Details

- **The estimated average (kW) DR event load shed per participant household was 0.69 kW.** This is the average of the estimated impacts across the four 100% cycling test events taking place at various half hour intervals between 12pm and 3:30pm.
- **The estimated average program impact of the events deployed in the summer of 2021 was approximately 150.27 MW.** This is the sum of the estimated impact of all four test events that occurred throughout the season, which each only covered one of DEP's regions. These impacts are slightly lower than 2019 summer, which can be ascribed to the lower average event temperature observed in the summer of 2021, as well as shorter event windows.
- **The average snapback** impact during the first full hour beginning 15 minutes after the end of the event was 0.34 kW.
- Note that **Guidehouse's estimate of program capability has not changed** since the 2019 summer evaluation since program capability can only be estimated using individual customer meter data (either AMI or logger).