Duke Energy Carolinas
2022 Power Manager Evaluation Report

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1. Executive Summary

This report presents the results of Resource Innovations' (RI) 2022 Power Manager program evaluation for the Duke Energy Carolinas (DEC) territory. Power Manager is a voluntary demand response program that offers incentives to residential customers who allow Duke Energy to reduce the home's electric load during days with high energy usage. Through the program, events may be called to help lessen electricity use during times of high demand. Summer demand response events are called by Duke Energy on hot summer days between May and September, and winter events are called during peak hours between December and March. Events are designed to reduce loads during times with the greatest system-wide energy demands.

Beginning in late 2019, Duke Energy introduced a new Power Manager offering to DEC customers that enables them to participate in demand response events through their home's qualifying smart thermostat. By enrolling their thermostats in the Smart Thermostat option (also referred to as Bring Your-Own-Thermostat or "BYOT"), customers agree to let Duke Energy make brief, small adjustments to their thermostat during times of peak electric demand. Participating customers are notified prior to events and provided incentives in the form of pre-paid gift cards. Events called under the BYOT option may vary by duration of the event period, the degree setpoint adjustment implemented during the event period, as well as the duration setpoint adjustment and duration of the pre-cooling period. During the pre-cooling period, the setpoints of participating thermostats are automatically adjusted downward to lower the interior temperature of the home during the period immediately prior to the event in order to help maintain comfort levels during the event period.

The 2022 Power Manager evaluation was completed as a desk review. A desk review is designed to quantify the load impacts achieved by the 2022 events and estimate expected load reductions that the program is capable of delivering under specified conditions. This process does not involve any primary data collection or in-depth analysis; instead, impacts are estimated using the forecasting tool (commonly referred to as the Time-Temperature Matrix) that was developed as part of the 2021 Power Manager evaluation. The 2021 DEC Power Manager evaluation involved comprehensive impact and process evaluations for both DLC and BYOT programs, allowing RI to estimate 2022 impacts for both options presented in this report. For more information on the 2021 evaluation and results, refer to the 2021 Power Manager Evaluation Report, dated November 22, 2022.

1.1. Summary of Results

During the 2022 summer event season, Duke Energy called two DLC events and two BYOT events. Events were called between the hours of 3:00 PM and 6:30 PM at temperatures ranging from 92°F to 96°F. A summary of the 2022 events is shown in Table 1-1.

Table 1-1: Summer 2022 DEC Events (DLC & BYOT)

Option	Date	Event Period	Event Type	System Temperature
DLC	6/2/2022	3:00 - 3:30 PM	Full shed test event	92°F
	6/15/2022	4:00 - 6:00 PM	50% cycling event	95°F
BYOT	5/20/2022	4:30 - 6:30 PM	90-min 2°F precool / 3°F offset	92°F
	6/15/2022	3:00 - 4:00 PM	60-min 1°F precool / 3°F offset	96°F

Impacts for the 2022 events were estimated using the most current versions of RI's forecasting tools, developed as part of the 2021 Summer DLC and BYOT Power Manager program evaluation for the Duke Carolinas jurisdiction. In 2021, forecasting tools were developed separately for the DLC and BYOT options. Both tools provide the same fundamental purpose, to predict per household and aggregate load reductions capable by the program under defined event conditions. However, the tools differ in specific ways due to programmatic differences and M&V objectives. For example, as of the timing of this report, Duke Energy's program team does not plan to call BYOT events lasting less than one hour, whereas DLC events may be 30 minutes in duration. With that in mind, RI designed the DLC forecasting tool to be capable of delivering load estimates at 30-minute intervals, while the BYOT forecasting tool is designed to estimate load reductions per hour and only allows for events to start and end at the top of the hour. As a result, RI and Duke Energy agreed to estimate impacts for the 5/20 BYOT event using a 4:00 PM to 6:00 PM event period.

Using the 2021 forecasting tool, the 2022 Power Manager DLC events were estimated to generate average per household load reductions of -1.19 kW and -0.89 kW, respectively. Assuming a program population of approximately 248,000 customers, the aggregate load reductions for the full program were estimated to be -295 MW and -214 MW, respectively.

Table 1-2: Estimated 2022 DLC Event Load Impacts

Event Date	Inputs					Event Outputs				
	Event Start	Event Duration	Event Type	Event Period Temp	# Total Homes	Ref Load	Event Load	Per Home Impact	Program Impact	% Impact
6/2/2022	3:00 PM	30 minutes	Full shed	92°F	248,000	3.32 kW	2.14 kW	-1.19 kW	-295 MW	-35.7%
6/15/2022	4:00 PM	2 hours	Normal	96°F	248,000	3.70 kW	2.80 kW	-0.89 kW	-222 MW	-24.2%

The two BYOT events called in 2022 were estimated to produce average per household load reductions of -1.51 kW and -1.48 kW, respectively. Assuming a BYOT program population of approximately 38,500 customers, the aggregate load reductions for the full program were estimated to be -58.2 MW and -57.1 MW, respectively.

Table 1-3: Estimated 2022 BYOT Event Load Impacts

Event Date	Inputs				Event Outputs					
	Event Start	Event Duration	Event Type	Event Period Temp	# Total Homes	Ref Load	Event Load	Per Home Impact	Program Impact	% Impact
5/20/2022	4:00 PM	2 hours	90-min 2°F precool 3°F offset	92°F	38,500	3.81 kW	2.29 kW	-1.51 kW	-58.2 MW	-39.7%
6/15/2022	3:00 PM	1 hour	60-min 1°F precool 3°F offset	96°F	38,500	3.78 kW	2.29 kW	-1.48 kW	-57.1 MW	-39.3%

1.2. Key Findings

- The average estimated event impact for the DLC events was 1.04 kW per household;
- The average estimated event impact for the BYOT events was 1.50 kW per household;
- If 100% emergency shed becomes necessary on a 98°F day, Power Manager DLC can deliver 1.79 kW of demand reductions per household, or 445 MW of aggregate load reduction through a 1-hour event at 4:00 PM; assuming approximately 1.22 devices per customer, the per device impact is 1.47 kW per device.
- A one-hour BYOT event beginning at 4:00 PM at 98°F with a 90-minute 2°F event period offset can deliver 1.79 kW per household, or approximately 63 MW of aggregate load reduction; assuming approximately 1.45 devices per household, the per device impact is 1.23 kW per device.

2. Introduction

This report presents the results of the 2022 Power Manager evaluation for the Duke Energy Carolinas (DEC) territory. Power Manager is a voluntary demand response program that provides incentives to residential customers who allow Duke Energy to reduce their household cooling loads during summer days with high energy usage. The DEC operations team schedules and calls Power Manager events for testing, economic, or system emergency purposes.

Beginning in 2019, Duke Energy offers customers two options within the Power Manager program: the legacy direct load control (DLC) option, which involves customers allowing Duke Energy to cycle their outdoor AC compressors through a remote switch installed on the unit, and the smart thermostat (BYOT) option, which involves customers allowing Duke Energy to remotely adjust the setpoints of their smart thermostats to reduce cooling consumption.

During the 2022 summer event season, Duke Energy called two DLC events and two BYOT events.

2.1. Key Research Questions

The study analysis was designed to leverage the prior year's study to answer a few key questions related to the load reduction capability of the program:

- What demand reductions were achieved during the event called in 2022?
- What demand reduction is the program capable of delivering under emergency conditions?

To answer these questions, RI used the outcomes of the 2021 impact evaluation to estimate the load impacts that were delivered during 2022 events, as well as the program's total load reduction capability under extreme conditions.

2.2. Program Description

Upon enrolling in the program, all Power Manager DLC participants agree to have a load control device installed on the outdoor unit of their qualifying air conditioner. If customers have more than one air conditioner, all units must be equipped with a load control device. The device enables the customer's air conditioner compressor to be cycled off and on to reduce load when a Power Manager event is called (or turned off completely in the case of a grid emergency). Duke Energy initiates DLC events by sending a signal to participating devices through the Duke Energy paging network, which instructs the DLC devices to reduce air conditioner runtime during events.

All customers participating in the BYOT option must have a qualifying smart thermostat installed in their home. Duke Energy initiates summer BYOT events by remotely adjusting the setpoint of participating thermostats upward, thereby reducing the cooling load required. To help maintain comfort levels during the event period, BYOT events may also involve a pre-cooling period, when

thermostats are remotely adjusted downward during the period immediately preceding the event, lowering the interior temperature of the home before the event begins.

Power Manager events occur from May through September in the DEC territory. DLC participants receive financial incentives for their participation in the form of $8 credits applied to their electric bills. BYOT participants receive financial incentives for their participation in the form of pre-paid gift cards.

In DEC territory, Duke Energy uses a cycling algorithm known as TrueCycle to reduce DLC customers' system runtimes during events. The algorithm uses stored data on the air conditioner's runtime to calculate the off and on cycle times to achieve a specific percentage of reduced runtime during each event. In general, DLC events fall into two categories: regular shed events, during which customers are cycled at 64% or the less frequently used 50%, and emergency full-shed events, during which customers are shed at 100%. For purposes of regulatory reporting, emergency full shed is used to estimate program capability.

During BYOT events, Duke Energy may remotely adjust customers' home thermostats by up to 4°F for up to four hours. Event pre-cooling ranges from 0°F to 2°F for up to 90 minutes. Duke Energy may apply different combinations of pre-cooling and event period offsets that may result in varying changes in load demanded during each phase of the event. For purposes of regulatory reporting, a 90-minute pre-cool of 2°F, followed by a 4°F offset for one hour is used to estimate program capability.

2.3. Participant Characteristics

Duke Energy serves approximately 2.25 million residential customers in its DEC service territory, which spans a large portion of the western half of North Carolina and northwestern South Carolina. During the 2022 summer season, approximately 248,000 customers were enrolled in the DLC option of Power Manager and approximately 38,500 customers were enrolled in the BYOT option.

3. Event Impacts

The 2022 summer program evaluation was implemented as a desk review. This methodology involves a streamlined approach to evaluating event performance, whereby load impacts are estimated by a predictive tool (commonly referred to as the Time-Temperature Matrix) that was developed during the prior year's evaluation, completed in 2021. No primary data collection or detailed analysis is performed as part of the desk review. Using the actual 2022 event conditions as inputs, the tool estimates impacts based on the performance of the 2021 summer events.

3.1. DLC Event Impacts

Duke Energy called two DLC events during the 2022 summer event season, shown in Table 3-1.

Table 3-1: 2022 Summer DLC Events

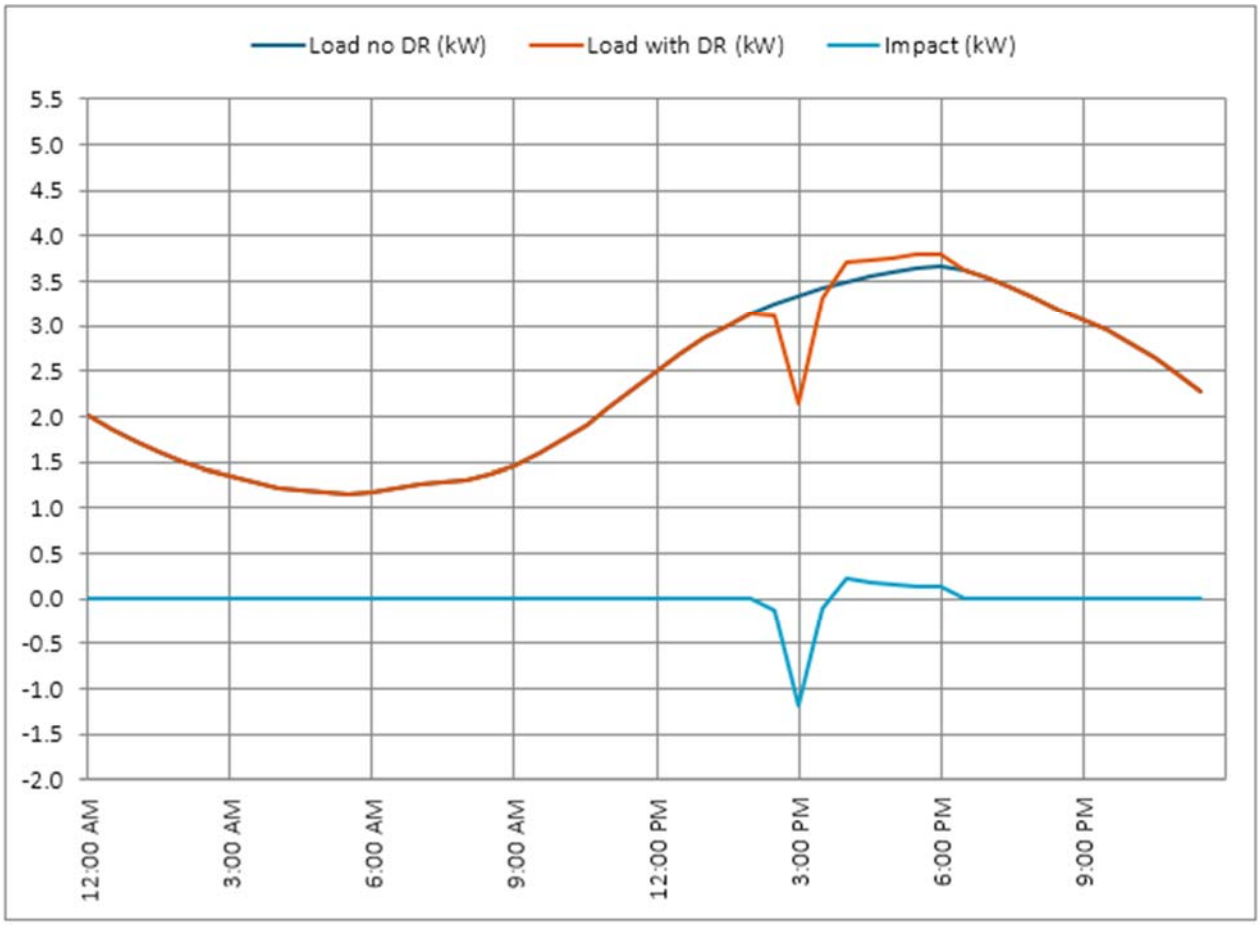
Date	Event Period	Event Type	System Temperature
6/2/2022	3:00 - 3:30 PM	Full shed test event	92°F
6/15/2022	4:00 - 6:00 PM	50% cycling event	95°F

Using the event scenario inputs shown in Table 3-1, the 6/2 event was estimated to generate per household load impacts of 1.19 kW, or a 35.7% load reduction. Assuming a total program population of roughly 240,800 homes at the time of the event, the aggregate load reduction capability of the program was approximately 286 MW. Figure 3-1 presents estimated per household loads and event period impacts for the 6/2 event.

Figure 3-1: Estimated DLC Load Impacts for June 2 Event

Inputs	
Dispatch Type	Emergency Dispatch
Event Start Time	3:00 PM
Event Duration	0.5 hours
Event Period Max Temp	92
# Customers	240,800

Event Window Average Impacts		
Load without DR	3.32	kW per customer
Load with DR	2.14	kW per customer
Impact per Customer	-1.19	kW per customer
Program Impact	-286.0	MW
% Impact	-35.7	%

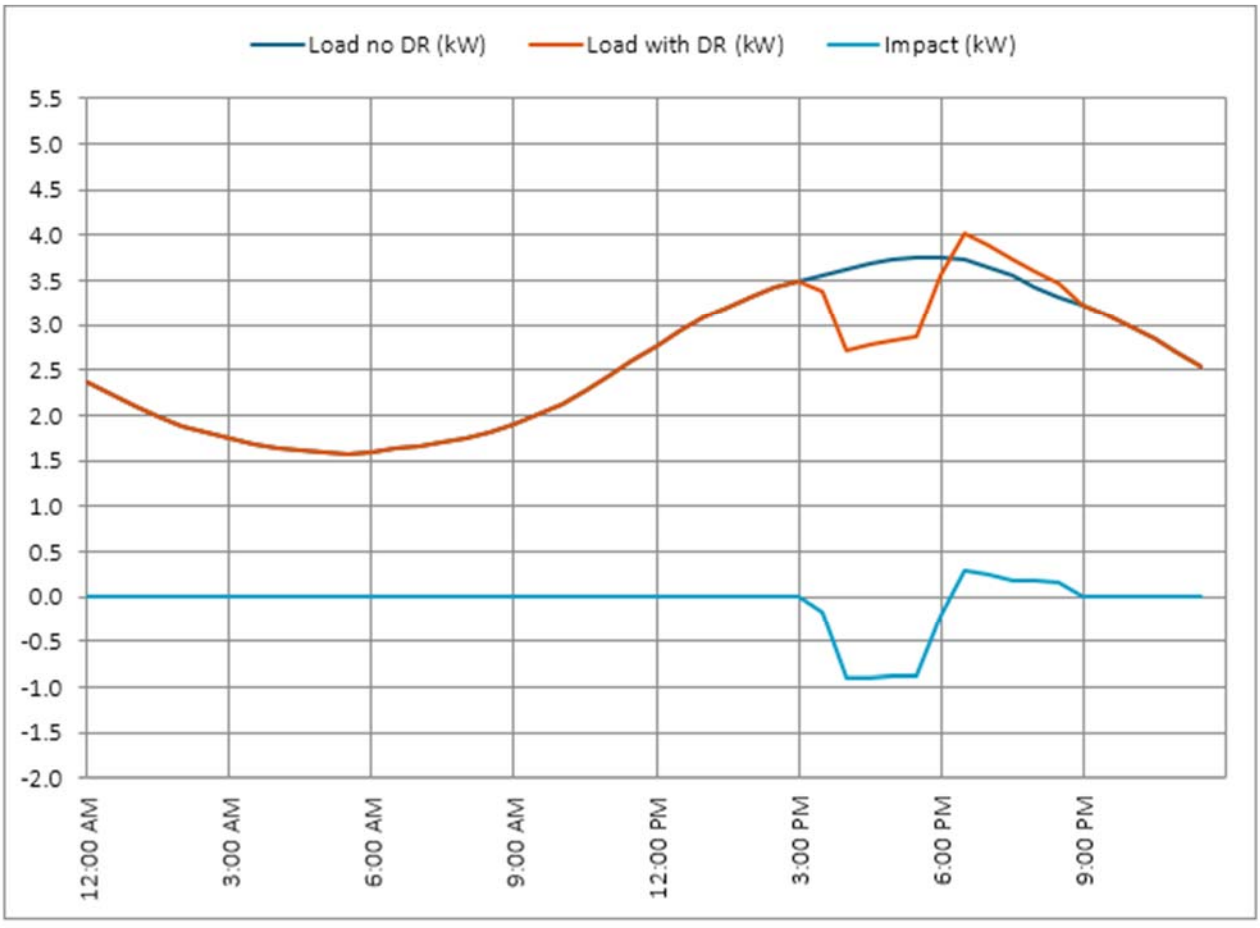


The 6/15 event was estimated to generate per household load impacts of 0.89 kW, or a 24.2% load reduction. The aggregate load reduction capability of the program was approximately 215 MW. Figure 3-2 presents estimated per household loads and event period impacts for the 6/15 event.

Figure 3-2: Estimated DLC Load Impacts for June 15 Event

Inputs	
Dispatch Type	Normal Dispatch
Event Start Time	4:00 PM
Event Duration	2 hours
Event Period Max Temp	96
# Customers	240,800

Event Window Average Impacts		
Load without DR	3.70	kW per customer
Load with DR	2.80	kW per customer
Impact per Customer	-0.89	kW per customer
Program Impact	-215.2	MW
% Impact	-24.2	%



3.2. BYOT Event Impacts

Duke Energy called two BYOT events during the 2022 summer event season, shown in Table 3-1.

Table 3-2: 2022 Summer BYOT Events

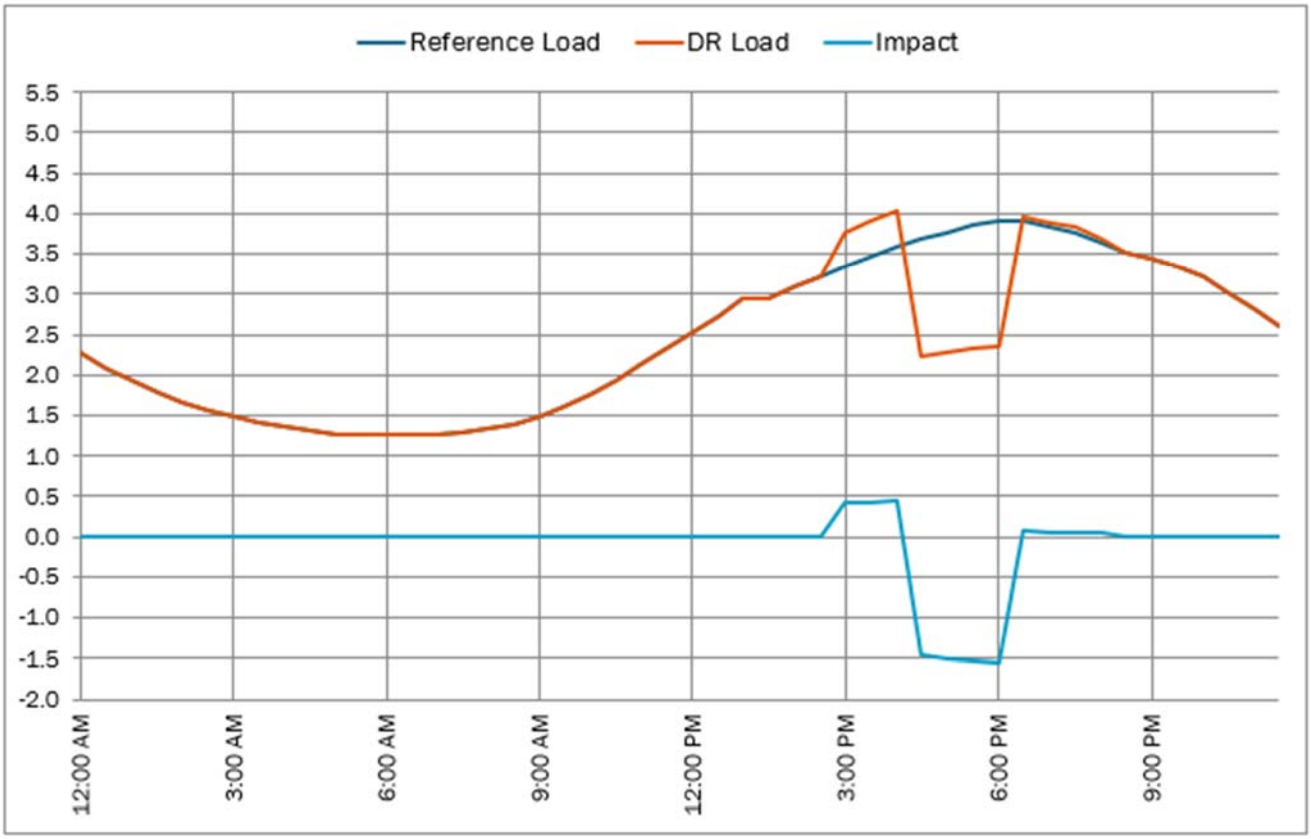
Date	Event Period	Event Type	System Temperature
5/20/2022	4:30 - 6:30 PM	90-min 2°F precool / 3°F offset	92°F
6/15/2022	3:00 - 4:00 PM	60-min 1°F precool / 3°F offset	96°F

Due to the tool's limitations, the 5/20 event was estimated based on a 4:00 PM to 6:00 PM event period, rather than 4:30 PM to 6:30 PM. The event was estimated to generate per household load impacts of 1.51 kW, or a 39.7% load reduction. Assuming a program population of roughly 37,000 at the time of the event, the aggregate load reduction capability of the program was approximately 56 MW. Figure 3-3 presents estimated loads and event impacts for the 5/20 event.

Figure 3-3: Estimated BYOT Event Impacts for May 20 Event

INPUTS	
Event Start Time	4 PM ▼
Event Duration	2 hours ▼
Event Option	90 min 2 deg precool / 3 deg offset ▼
Event Temperature	92 ▼
# Customers	37,000

OUTPUTS	
Reference Load	3.81 kW
Curtailed Load	2.29 kW
Impact per Customer	-1.51 kW
Program Impact	-55.9 MW
% Impact	-39.7 %

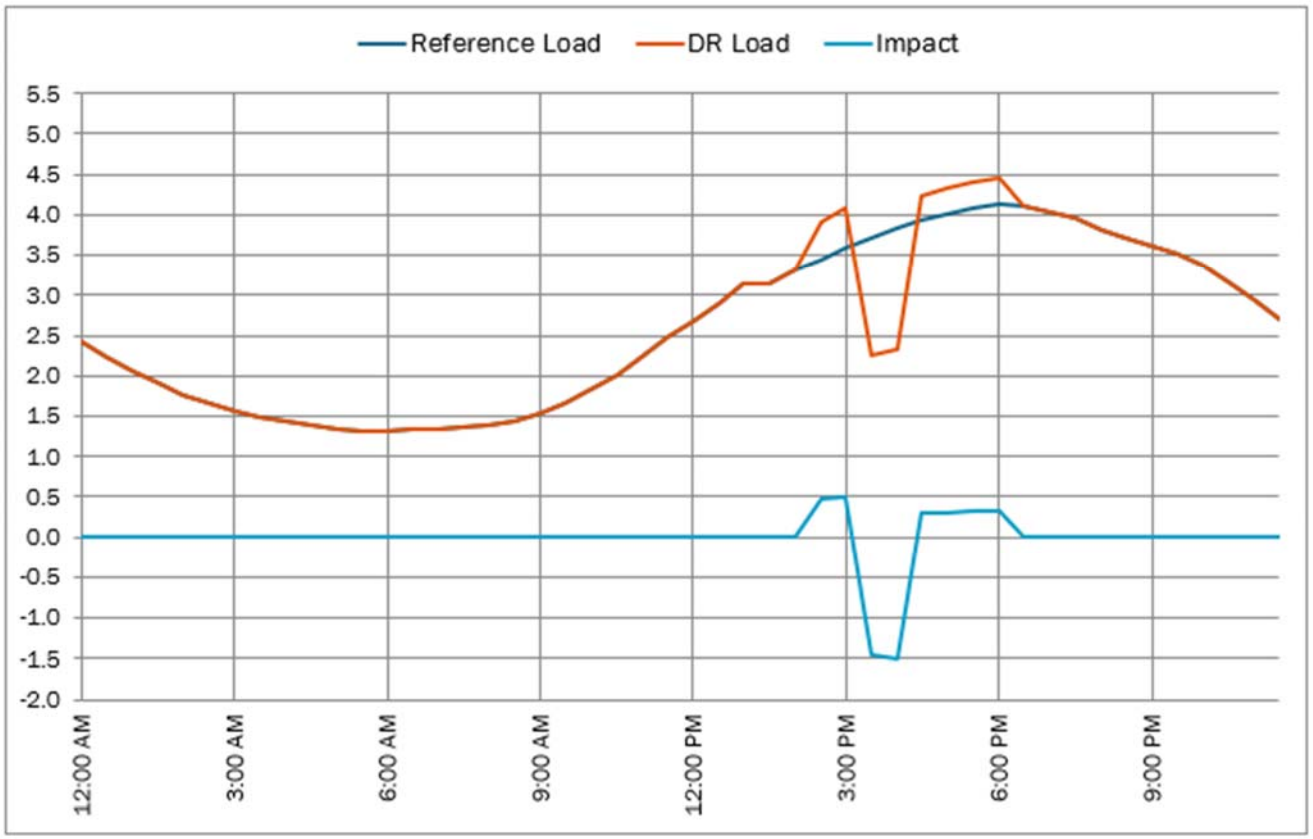


The 6/15 event was estimated to generate per household load impacts of 1.48 kW, or a 39.3% load reduction. With a program population of approximately 38,000 households at the time of the event, the aggregate load reduction capability of the program was approximately 56 MW. Figure 3-4 presents estimated pre household loads and event period impacts for the 6/15 event.

Figure 3-4: Estimated BYOT Event Impacts for June 15 Event

INPUTS	
Event Start Time	3 PM ▼
Event Duration	1 hour ▼
Event Option	60 min 1 deg precool / 3 deg offset ▼
Event Temperature	96 ▼
# Customers	38,000

OUTPUTS	
Reference Load	3.78 kW
Curtailed Load	2.29 kW
Impact per Customer	-1.48 kW
Program Impact	-56.4 MW
% Impact	-39.3 %



4. Load Reduction Capability

While Power Manager is typically dispatched for economic or research purposes, its primary purpose is to deliver demand relief during extreme conditions when demand is high, and capacity is constrained. Extreme temperature conditions can trigger Power Manager emergency operation where all devices are dispatched to instantaneously shed loads and deliver larger demand reductions. While these scenarios are rare and ideally avoided, they represent the full load reduction capability of the program. To estimate the expected load reduction capability of Power Manager under extreme conditions, Duke Energy selected severe, yet realistic event scenarios for predicting a reportable maximum load reduction for regulatory purposes.

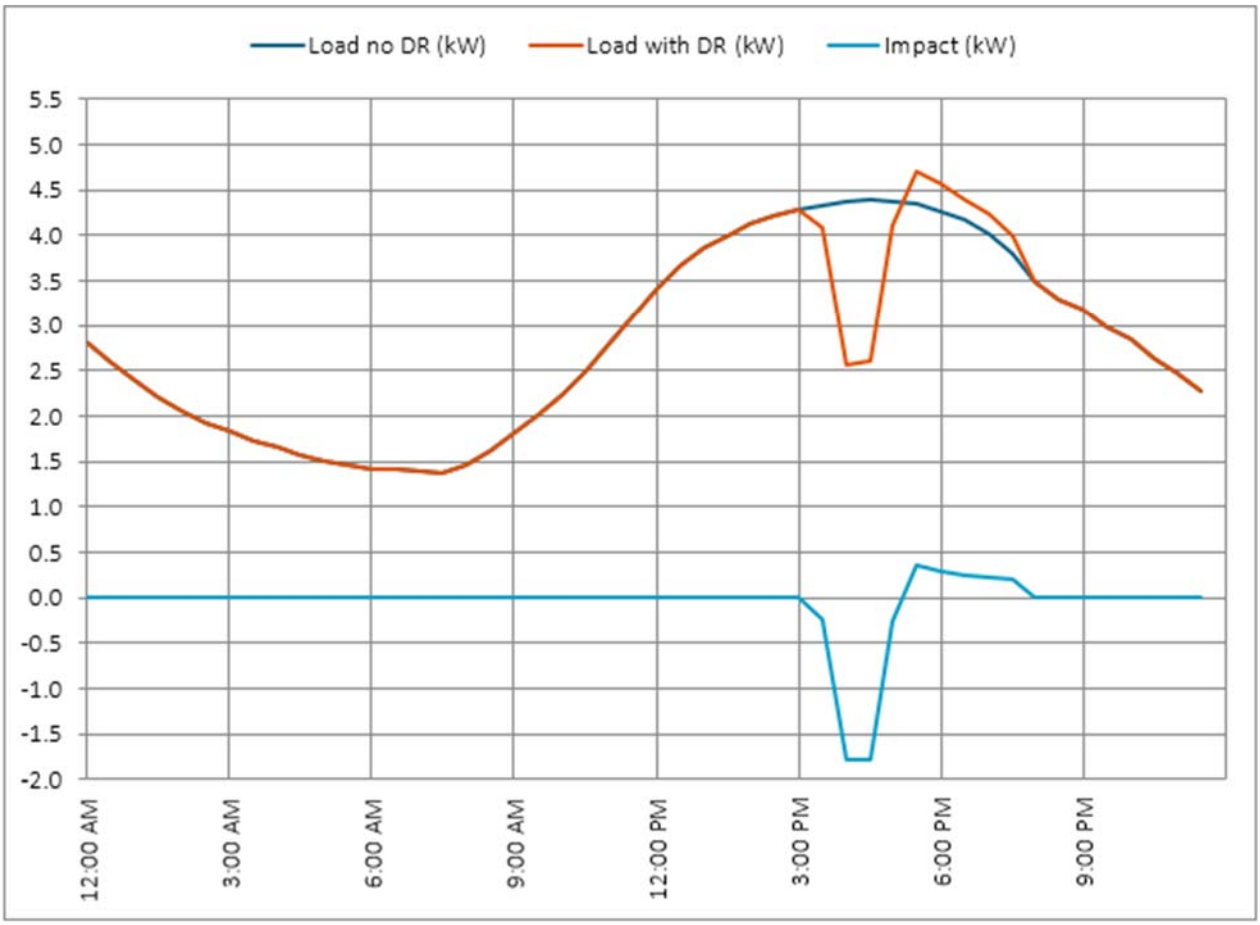
4.1. DLC Demand Reduction Capability

To estimate the expected load reduction of the DLC program under extreme conditions, RI again relied on the Time-Temperature Matrix developed through the 2021 program evaluation. A one-hour emergency full shed event beginning at 4:00 PM at 98°F was used for the extreme case. Figure 4-1 presents the predicted loads and event period impacts under these extreme conditions. The Time-Temperature Matrix estimates that the average per household load impacts would be -1.79 kW, or approximately 443 MW of aggregate load reduction for the DEC jurisdiction.

Figure 4-1: Load Reduction Capability for Extreme DLC Event

Inputs	
Dispatch Type	Emergency Dispatch
Event Start Time	4:00 PM
Event Duration	1 hour
Event Period Max Temp	98
# Customers	248,000

Event Window Average Impacts		
Load without DR	4.38	kW per customer
Load with DR	2.59	kW per customer
Impact per Customer	-1.79	kW per customer
Program Impact	-442.7	MW
% Impact	-40.8	%



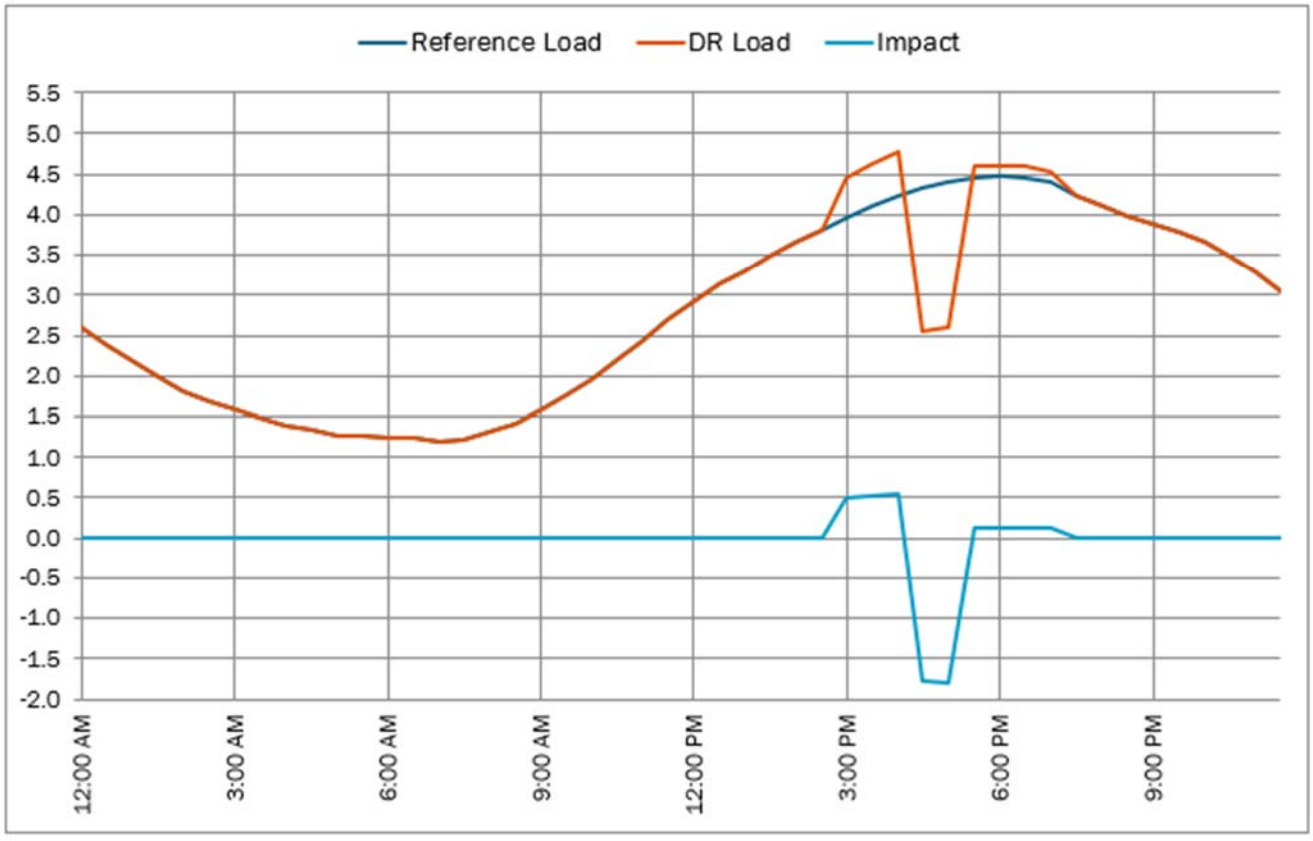
4.2. BYOT Demand Reduction Capability

For BYOT Power Manager events, the extreme case was defined as a one-hour event beginning at 4:00 PM at 98°F with a 90-minute 2°F precool and a 4°F event period offset. Figure 4-2Figure 4-1 presents the predicted loads and event period impacts under these extreme conditions. The Time-Temperature Matrix estimates that the average per household load impacts would be -1.79 kW, or approximately 69 MW of aggregate load reduction for the DEC jurisdiction.

Figure 4-2: Load Reduction Capability for Extreme BYOT Event

INPUTS	
Event Start Time	4 PM ▼
Event Duration	1 hour ▼
Event Option	90 min 2 deg precool / 4 deg offset ▼
Event Temperature	98 ▼
# Customers	38,500

OUTPUTS	
Reference Load	4.38 kW
Curtailed Load	2.58 kW
Impact per Customer	-1.79 kW
Program Impact	-69.1 MW
% Impact	-41.0 %



5. Conclusions and Recommendations

Conclusion: Overall, both Power Manager program options - DLC and BYOT - produce significant reductions in peak load for DEC's residential customers. The average estimated event impact for the DLC events was 1.04 kW per household. The average estimated event impact for the BYOT events was 1.50 kW per household.

> **Recommendation:** Continue to promote the Power Manager program to DEC residential customers. On average, customers enrolled in DLC were estimated to reduce their electric load by 30% during 2022 events. Customers enrolled in BYOT reduced their electric load by 37% during events.

Conclusion: Using timing and temperature inputs conforming to Duke Energy's "extreme" scenario (4:00 PM start time, 1-hour duration, event temperature of 98°F), both program options deliver similar per household impacts. The average estimated event impacts for an "extreme" event under both options were 1.79 kW per household. The aggregate program system capability for DLC Power Manager is 430 MW; the BYOT program capability is 63 MW.

> **Recommendation:** Explore the costs associated with each program offering (DLC and BYOT) to determine whether one should be prioritized over the other in terms of recruitment and participation.