2022 Power Manager Winter-Focused BYOT Evaluation Report

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1 Executive Summary

This report presents the results and key findings of Resource Innovations' impact and process evaluations of the Winter 2022 BYOT Power Manager program in the Duke Energy Carolinas service territory for the event season spanning December 2021, through March 2022.

1.1 Background

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-focused 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. Participating BYOT customers are provided incentives in the form of e-gift cards upon successful enrollment and annually each year they remain on the program.

Power Manager has two components for participation. Customers may enroll in the traditional direct load control (DLC) option, which enables Duke Energy to cycle customers' central air conditioner's outdoor compressor and fan during summertime events. During normal shed events, a remote signal is sent to participating load control devices that reduce customers' air conditioner use. During emergency shed operations, all devices are initiated to quickly shed loads and deliver larger demand reductions. The second component, made available in late 2019, enables customers 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 (BYOT)), customers agree to let Duke Energy make brief, small adjustments to their thermostat during times of peak electric demand. Customers enrolled in the winter-focused option must also have wi-fi connected thermostat controlled central electric heating. Upon enrolling, customers received an initial incentive in the form of a $75 e-gift card, as well as a $25 e-gift card for each additional year of enrollment. To promote the kick-off of the winter-focused option, customers who enrolled from mid-November to year-end 2020, received a $90 enrollment incentive e-gift card.

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 degree setpoint adjustment and duration of a possible pre-heating period. During a pre-heating period, the setpoints of participating thermostats are automatically adjusted upward to raise 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 content of this report relates specifically to customers who participated in the Winter-Focused BYOT program option during the 2021-2022 winter event season (December 2021 through March 2022).

1.1.1 Impact Evaluation Key Findings

The BYOT impact analysis was performed using a randomized control trial (RCT) approach. Prior to the event season, Power Manager BYOT participants were randomly assigned to one of five groups. During each event, at least one group was withheld as the control group in order to provide an estimated load profile absent curtailment, i.e., the baseline. The average loads among control group customers are used to compare against the average event day loads of the treatment group to calculate the event impacts.

1.1.2 Bring-Your-Own-Thermostat Analysis Key Findings

Key findings of the Winter 2022 BYOT impact analysis include:

- The average load reduction across all winter-focused BYOT events in 2021-2022 was 1.24 kW (35%)
- The magnitude of load impacts tend to increase as temperature decreases
- Events where the temperature offset was 3°F produced greater impacts compared to events with 2°F offsets.

Table 1-1: Summary of 2021 BYOT Event Impacts

Pre-Heat	Event Offset	# of Events	Average Impact	Maximum Impact
120 min 3° Pre-Heat	3° Offset	6	1.31	1.55
60 min 2° Pre-Heat	2° Offset	8	1.14	1.40
60 min 3° Pre-Heat	3° Offset	8	1.31	1.66
90 min 3° Pre-Heat	3° Offset	7	1.27	1.48
90 min 3° Pre-Heat	4° Offset	5	1.24	1.59
No Pre-Heat	3° Offset	11	1.21	1.34
Average Event		**11**	**1.24**	**1.66**

1.2 Demand Reduction Capability

A key objective of the impact evaluation is to quantify the relationship between demand reductions, temperature, hour-of-day, and event settings. This objective is achieved by estimating loads under historical weather conditions and applying observed percent load reductions from the Winter 2021-

2022 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.

1.2.1 BYOT Demand Reduction Capability Key Findings

Key findings of the BYOT Time-Temperature Matrix tool include:

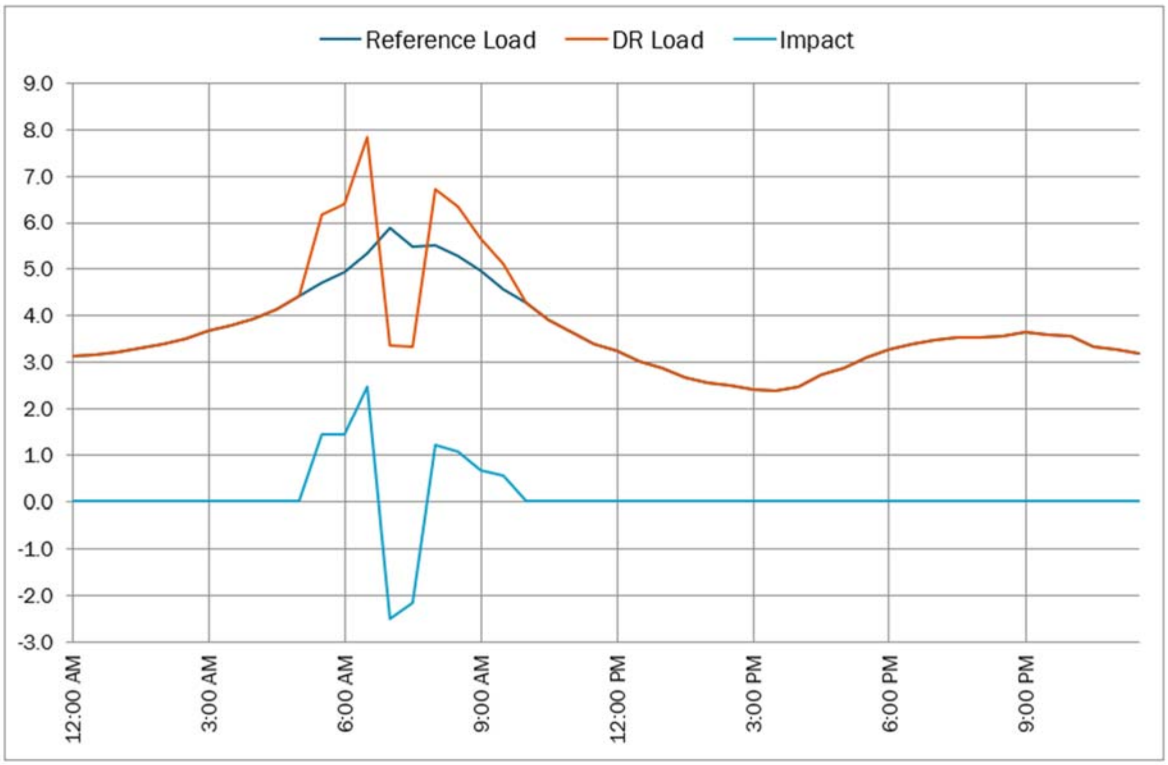
- Per household impacts grow larger as the event period temperature offset increases
- The duration and degree of the pre-heating did not significantly affect event impacts
- The Time-Temperature Matrix predicted that for a 1-hour event called at 7:00am under 12°F conditions, with a 90-minute 3°F pre-heat and a 4°F event offset, the average impact is -2.33[1] kW per household.

[1] Load reductions are presented as negative values for Duke Energy's ex ante reporting purposes. In all other sections of this report positive values are used to represent load reductions.

Figure 1-1: Load Reduction Capability for Extreme BYOT Event

INPUTS	
Event Start Time	7:00 AM ▼
Event Duration	2 ▼
Event Option	90 min 3 deg preheat / 4 deg offset ▼
Event Temperature	12 ▼
# Customers	15,000

OUTPUTS	
Reference Load	5.69 kW
Curtailed Load	3.35 kW
Impact per Customer	-2.33 kW
Program Impact	-35.0 MW
% Impact	-41.1 %



1.3 Process Evaluation Key Findings

The process evaluation is 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 of participants implemented after an event, and a nonevent survey of participants implemented on the same day as the post-event survey.

Key findings from the process evaluation include:

- Most respondents are pleased with the program and would recommend it to others.

- Power Manager events did not lead to statistically significant increases in reported thermal discomfort for BYOT participants during the winter.
- While some customers are aware of when events occur (28% correctly recognized that an event happened and identified the day it occurred on), the majority of customers (73%) do not change their behavior in response to events (real or perceived).
- Monetary incentives remain the strongest driver of participation in the program (56% of respondents said this was their most important reason for enrolling), and one of the most common requests from respondents is an increase in incentives.
- The most common suggestion from respondents (27% of all suggestions) is better communication from Duke Energy. Generally, respondents indicated they would like advanced notice of events, event notifications, and/or a summary of energy saved and benefits attributable to the program.
- While the percentage of respondents willing to recommend Power Manager following the winter BYOT survey (69%) was smaller compared to the Summer BYOT (79%) and DLC (79%) surveys, the majority of respondents still indicated that they would recommend the program to others.

1.4 Recommendations

The 2021-2022 Winter season Power Manager BYOT evaluation provided insights into program performance from both a load impact and a customer experience perspective for the Winter-Focused BYOT program offerings. The following recommendations have been developed based on the key findings from the evaluation.

- Continue to promote the Winter-Focused BYOT Power Manager program to DEC 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 to demand savings.

- Reserve the use of extreme pre-heat and offset scenarios for days with critical system conditions, as the impacts from large offsets may only be marginally greater, but there could be a higher risk of customer discomfort.

- Continue to prioritize participant comfort and satisfaction during curtailment events.

- Continue to prioritize practices that are focused on maximizing customer satisfaction in the design and implementation of the Power Manager program.

- Evaluate Power Manager's participant communication approach – before, during, and after load control seasons – and consider ways to communicate with participants more, even if only through opt-in communications that interested participants can elect to receive. Increased program communication is the most-requested program improvement mentioned in participant surveys. Improved communication could improve customer satisfaction and increase positive word-of-mouth awareness.

2 Introduction

This report presents the results the Winter 2021-2022 Power Manager BYOT program impact and process evaluations for the Duke Energy Carolinas (DEC) jurisdiction. Power Manager is a voluntary demand response program that provides incentives to residential customers who allow Duke Energy to reduce their electricity usage on summer or winter days with high energy usage. The DEC Power Manager program includes two offerings: traditional direct load control (DLC) and a newer option for homes with qualifying smart thermostats. Participants in the thermostat option – referred to as the Bring Your Own Thermostat or "BYOT" option – allow Duke Energy to remotely adjust their thermostat setpoints during and prior to events in order to reduce household cooling or heating loads. Customers participating in the Winter-Focused option of BYOT experience morning events on cold days between December and March.

Because Duke Energy has full deployment of smart meters in DEC territory and has access to Power Manager customers' interval meter data, the impact evaluation is predominantly based on a randomized control trial involving the random assignment of customers into five different groups prior to the 2021-2022 event season. During each event, at least one of the groups is withheld to serve as a control group and to provide an estimate of customer's load usage profiles absent a Power Manager event. The randomized control trial approach was applied to all Power Manager operations where a valid control group was available, as well as to test events designed to address a set of specific research questions.

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

The process evaluation uses survey data from both treatment and control customers, as assigned for impact analysis, gathered during a non-emergency event and similar nonevent day for control customers. As in the impact analysis, responses from control group customers served as a baseline from which treatment effects on the customer experience may be measured. In addition, the evaluation uses interview data and analyses of program documentation and the program database to offer analytic context for evaluating survey results, as well as to offer insight into program operations.

2.1 Key Research Questions

The data collection and analysis activities are designed to address the following research questions and objectives.

2.1.1 Impact Evaluation Research Questions

- What demand reductions were achieved during each event called during the 2021-2022 season?
- Do impacts vary based on the hours of dispatch?
- Do impacts vary based on temperature conditions?
- Do event conditions, such as pre-heating duration, pre-heating offset, event period offset, result in different impacts?
- 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, program incentives, and other key program features?
- What is the participant experience during events, particularly relating to thermal comfort?
- What actions do participants take in response to events?
- What are the motivations and potential barriers for participation?
- What are the processes associated with operations and program delivery?
- What are the program's 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 cooling and/or heating energy use on days with high energy usage.

During the 2021-2022 winter season, approximately 5,000 customers were enrolled in the Winter-Focused BYOT option. All customers participating in the BYOT option must have a qualifying internet connected smart thermostat installed in their home. Duke Energy initiates winter BYOT events by remotely adjusting participating thermostats downward, thereby reducing the heating load required. To help maintain comfort levels during the event period, winter BYOT events may also involve a pre-heating period, when thermostats are remotely adjusted upward during the period immediately preceding the event, raising the interior temperature of the home before the event begins.

Winter BYOT events typically occur from December through March in DEC territory but are not limited to these months. BYOT participants receive financial incentives for their participation in the form of pre-paid gift cards.

During BYOT events, Duke Energy may remotely adjust customers' home thermostats by up to 4°F for up to four hours. Event pre-heating ranges from 0°F to 3°F for up to 120 minutes. Duke Energy may apply different combinations of pre-heating 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-heat of 3°F, followed by a 4°F offset for one hour is used to estimate program capability.

2.3 Event Characteristics

BYOT Power Manager events were called on eleven days in the 2022 winter season – five days held events from 6 AM – 8 AM, three from 6 AM – 9 AM, and three from 7 AM – 9 AM. Five different combinations of pre-event heating and event period temperature offsets were available for use across event days: 120-minute 3° pre-heat 3° offset, 60-minute 2° preheat 2° offset, 60-minute 3° preheat 3° offset, 90-minute 3° preheat 3° offset, 90-minute 3° preheat 4° offset, and no preheat 3° offset. BYOT events occurred during system temperatures ranging from 24.5°F to 39.5°F. With the exception of the first event day, four of the five combinations were dispatched with different pre-heat and offset configurations during a given event to test the efficacy of each, with one group providing a control for the others.

The table below summarizes BYOT event conditions for the Winter 2022 season.

Table 2-1: Summary of 2021 BYOT Events

Event Date	Start	End	Pre-Heat	Offset	Dispatch Group(s)	Control Group	System Temp °F
1/18/2022	6	8	No Pre-Heat	3° Offset	A+B+C+D+E	None	24.5
1/24/2022	6	8	90 min 3° Pre-Heat	3° Offset	E	A	29.5
			No Pre-Heat	3° Offset	B		
			60 min 3° Pre-Heat	3° Offset	D		
			60 min 2° Pre-Heat	2° Offset	C		
1/27/2022	6	9	60 min 3° Pre-Heat	3° Offset	B	C	26.3
			60 min 2° Pre-Heat	2° Offset	A		
			120 min 3° Pre-Heat	3° Offset	E		
			90 min 3° Pre-Heat	3° Offset	D		
2/1/2022	6	8	90 min 3° Pre-Heat	3° Offset	B	D	30.5
			120 min 3° Pre-Heat	3° Offset	C		
			60 min 2° Pre-Heat	2° Offset	E		
			60 min 3° Pre-Heat	3° Offset	A		
2/7/2022	7	9	90 min 3° Pre-Heat	3° Offset	D	B	32.5
			No Pre-Heat	3° Offset	E		
			60 min 2° Pre-Heat	2° Offset	A		
			60 min 3° Pre-Heat	3° Offset	C		
2/9/2022	7	9	60 min 3° Pre-Heat	3° Offset	A	E	34.0
			No Pre-Heat	3° Offset	D		

Event Date	Start	End	Pre-Heat	Offset	Dispatch Group(s)	Control Group	System Temp °F
			90 min 3° Pre-Heat	3° Offset	C		
			120 min 3° Pre-Heat	3° Offset	B		
2/14/2022	6	9	60 min 2° Pre-Heat	2° Offset	C	A	30.3
			120 min 3° Pre-Heat	3° Offset	D		
			90 min 3° Pre-Heat	4° Offset	B		
			No Pre-Heat	3° Offset	E		
2/15/2022	6	8	60 min 3° Pre-Heat	3° Offset	E	A	31.0
			No Pre-Heat	3° Offset	C		
			90 min 3° Pre-Heat	4° Offset	B		
			60 min 2° Pre-Heat	2° Offset	D		
2/28/2022	6	8	90 min 3° Pre-Heat	4° Offset	D	E	34.5
			60 min 3° Pre-Heat	3° Offset	C		
			120 min 3° Pre-Heat	3° Offset	A		
			60 min 2° Pre-Heat	2° Offset	B		
3/14/2022	6	9	90 min 3° Pre-Heat	3° Offset	B	D	36.7
			60 min 3° Pre-Heat	3° Offset	A		
			60 min 2° Pre-Heat	2° Offset	E		
			90 min 3° Pre-Heat	4° Offset	C		
3/28/2022	7	9	120 min 3° Pre-Heat	3° Offset	D	C	39.5
			No Pre-Heat	3° Offset	B		
			90 min 3° Pre-Heat	4° Offset	E		
			90 min 3° Pre-Heat	3° Offset	A		

3 Methodology and Data Sources

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

3.1 Data Sources

3.1.1 Impact Evaluation Data Sources

The impact analysis relied on four primary datasets:

- Participant data identifying customer account numbers and group assignments
- Premise-level AMI data in 30-minute intervals for all participants spanning December 2021 through March 2022
- Event tracking data for all DEC BYOT Power Manager events called in the Winter 2022 season, including treatment and control group assignments, event scenarios, start/end times for each event
- Hourly weather data for the full event season, used to inform proxy day selection for the within-subjects analysis, as well as to establish relationships between impacts and weather conditions

All primary datasets were provided by Duke Energy following the Winter 2022 Power Manager BYOT event season. All subsequent datasets used by RI for analysis were compiled from a combination of these primary datasets.

3.1.2 Process Evaluation Data Sources

The process analysis relied on four primary datasets:

- Program tracking and documentation database
- In-depth interviews with key program stakeholders
- Post-event program participant surveys
- Nonevent program participant surveys

3.2 Data Management and Validation

All data sets were thoroughly cleaned and validated to ensure that impacts were estimated using reliable observations from customers who were properly dispatched on event days. The analysis benefitted from a full population-based approach, allowing RI to logically exclude customers who were found to have incomplete or questionable load data, while still maintaining large enough group sizes to produce precise estimates.

Resource Innovations was deliberate to carefully monitor individual group responses to each event, and to adapt analysis techniques wherever necessary to ensure accurate results. For example, during a majority of events in which groups were dispatched with no pre-heat, RI observed that some pre-heating had taken place among customers who were designated as no pre-heating. After investigating, RI confirmed that Eco+ customers with Ecobee thermostats did experience pre-heating during the 30 minutes prior to a no pre-heat event.[2] Otherwise, there were no known instances of widespread device failure, signaling deficiency, or other technical problems that jeopardized the reliability of results.

3.3 RCT Analysis Design

A randomized control trial (RCT) study design is well-recognized as the gold standard for obtaining accurate impact estimates. RCTs have several advantages over other hypothesis testing methods, including:

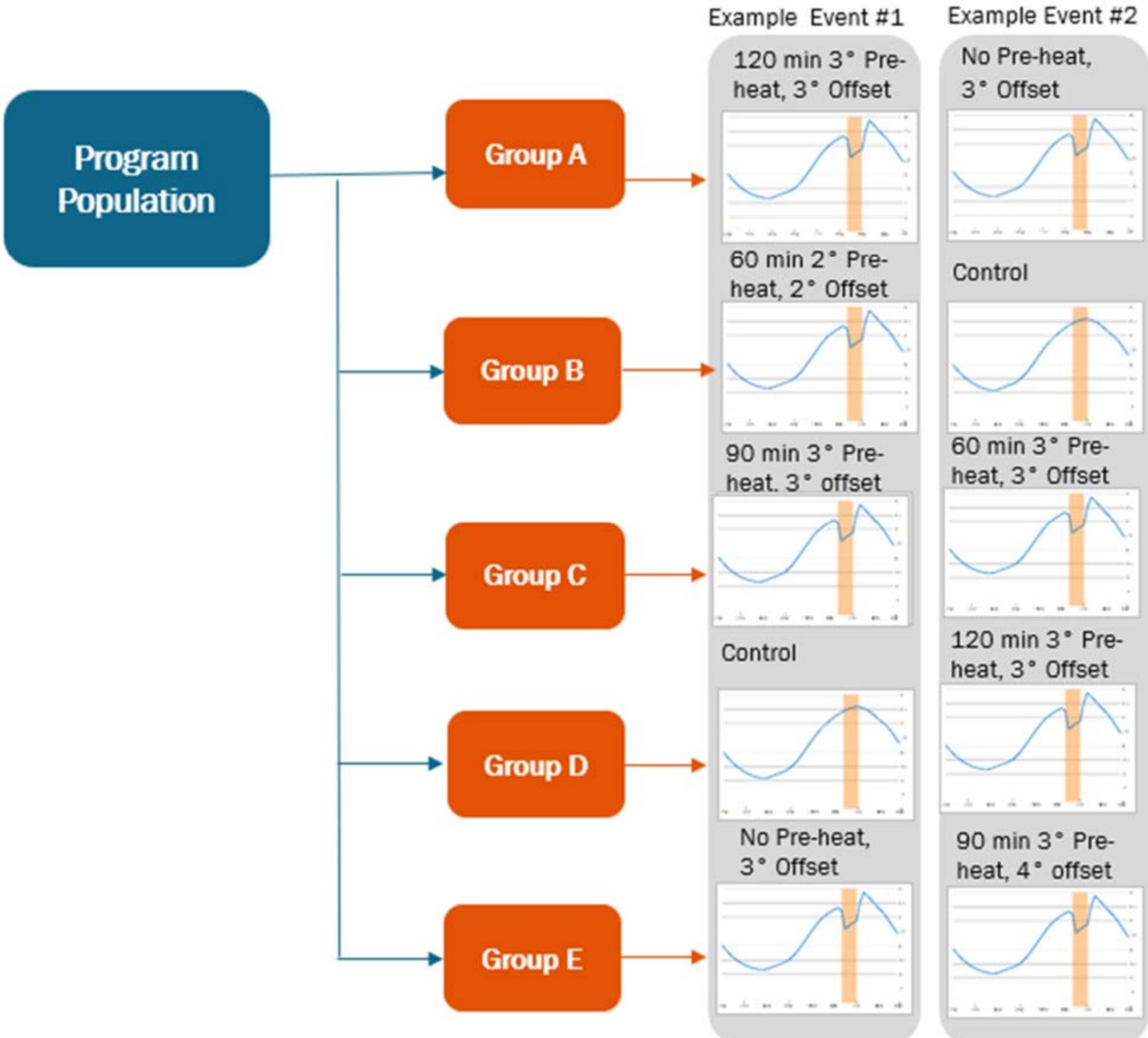
- They require fewer assumptions than engineering-based calculations
- They allow for simpler modeling procedures that are immune to sampling bias
- They are guaranteed to produce accurate and precise estimates, provided proper randomization and large sample sizes

RI randomly assigned customers from the Power Manager BYOT population into five equally sized research groups (Groups A, B, C, D, and E). For each event, load curtailment was withheld from one group to act a control group for the other four groups, while the other groups were dispatched with different dispatch scenarios. 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. 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.

The figure below shows the conceptual framework of the random group assignment.

[2] Specific manufacturers may have proprietary programming in their thermostats that dictate preheating functionality independent of Duke's signaling.

Figure 3-1: Randomized Control Trial Design Framework



All customers who were enrolled in the program and had the required equipment installed at their homes by the start of the 2021-2022 winter were randomly assigned into one of five groups. The table below summarizes the number of households assigned to each research group.

Table 3-1: Approximate Group Sizes

Group	Approximate # BYOT Accounts
Group A	1,186
Group B	1,186
Group C	1,186
Group D	1,186
Group E	1,186

The purpose of creating five distinct randomly assigned groups was twofold. First, it allowed for side-by-side testing of cycling strategies, event start times, or other operational aspects to help optimize the program. Second, it allowed 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.

For each event, at least one of the 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 a 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 alternative heating sources to compensate for the temperature setpoint adjustments.

Additional statistical metrics, such as standard error, are calculated 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 90% confidence bands, which are additional measures used to describe the statistical accuracy of the impact estimate.

Equation 3-1: Calculation of Standard Error

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

Where:

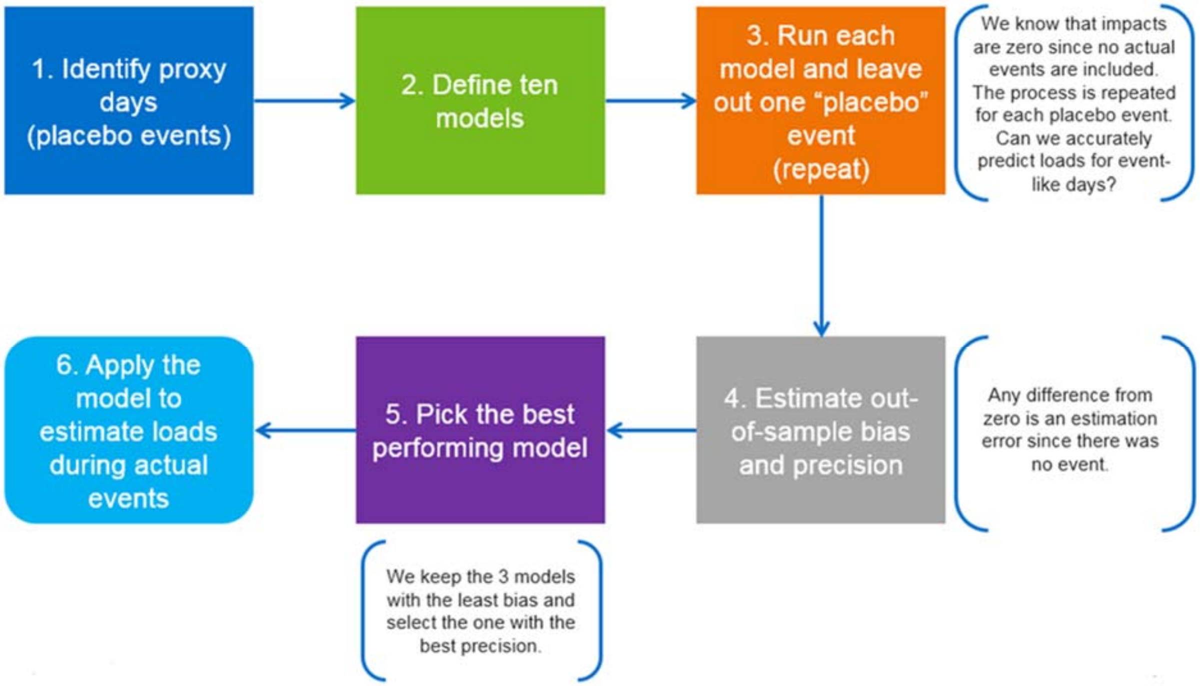
sd = standard deviation
n = sample size
t = indicator for treatment group
c = indicator for control group
i = individual time intervals

3.4 Within-Subjects Analysis Design

Although an RCT approach has many implicit advantages that make it the preferred method for estimating impacts, it is not available for events with no valid control group to establish the counterfactual. In these cases, when events were called absent a control group, a within-subjects approach is used, whereby customer loads observed on similar nonevent days are used to establish the counterfactual against which to compare treatment loads. This approach works by allowing comparison of load patterns within the same group on days on event and non-event days.

A key consideration of the within-subjects design is how to select a model that generates the most precise and accurate counterfactual. In many cases, multiple counterfactuals may be plausible, but result in varying estimations of impacts. Using nonevent 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. To identify the regression model that best predicts the counterfactual, a rigorous model selection process is 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. The figure below summarizes the regression model selection process.

Figure 3-2: Within-Subjects Regression Model Selection Process



Bias metrics measure the tendency of different approaches to over or under predict and are measured over multiple out-of-sample days. The mean percent error (MPE) describes the relative magnitude and direction of the bias. A negative value indicates a tendency to under predict, and a positive value indicates a tendency to over predict. The precision metrics describe the magnitude of errors for individual event days and are always positive. The closer they are to zero, the more precise the model prediction. The absolute value of the mean percentage error is used to select the three model candidates with the lowest bias. The coefficient of variation of the root mean square error, or CV(RMSE), metric is used to identify the most precise model from the three models with the least bias.

Equation 3-2: Measures of Bias and Precision

Type of Metric	Metric	Description	Mathematical Expression
Bias	Average Error	Absolute error, on average	$AE = \frac{1}{n}\sum_{i=1}^{n}(\hat{y}_i - y_i)$
	Mean Percentage Error (MPE)	Indicates the percentage by which the measurement, on average, over or underestimates the true demand reduction	$MPE = \frac{\frac{1}{n}\sum_{i=1}^{n}(\hat{y}_i - y_i)}{\bar{y}}$
Precision	Root Mean Squared Error	Measures how close the results are to the actual answer in absolute terms, penalizes large errors more heavily	$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(\hat{y}_i - y_i)^2}$
	CV(RMSE)	Measures the relative magnitude of errors across event days, regardless of positive or negative direction (typical error)	$CV(RMSE) = \frac{RMSE}{\bar{y}}$

3.5 Process Evaluation Methodology

The following table summarizes the primary data collection tasks and analysis objectives included in the process evaluation.

Table 3-2: Data Collection Techniques and Sample Size by Technology

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 and weaknesses, and provide a foundation for understanding the customer experience.	4	NA
Post-event surveys	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. For the winter-focused BYOT evaluation, the post event surveys were sent to two groups, one who experienced a short-duration and short intensity offset event, and one who experienced a longer and more intense offset.	300 (two groups of 150)	90/7
Nonevent survey	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	150	90/7

	awareness, satisfaction, customer experience and comfort during events, and motivations for participation. In the case of this winter-focused BYOT evaluation, the nonevent survey was sent to a pre-assigned control group the same day as the post-event surveys were sent to the treatment groups.

3.5.1 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 or incentives are communicated and applied or delivered. 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, Resource Innovations requested copies of internal program manuals or guidelines as well as copies of marketing materials. The program database analysis consisted of an examination of program tenure, load curtailed per household, and other variables that inform indications of program progress.

3.5.2 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 confirmed the evaluation team's understanding of key program components.

Goals of the interviews include:

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

3.5.3 Post-event surveys

Guided by information obtained from stakeholder interviews and a review of program guidance documents (including any notification protocols), Resource Innovations developed a survey for participating customers that was deployed immediately following a BYOT Power Manager 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 surveys were deployed the afternoon following a morning curtailment event were closed within two days. 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 HVAC or thermostat settings, using other equipment (including portable heaters) to mitigate thermal discomfort? Were participants home during the event? Are they usually home during that time period?
- Satisfaction with the BYOT Power Manager program, the participation incentives earned, and the number of events called;
- Expectations and motivations for enrolling: What did participants expect to gain from enrollment? To what extent are they motivated to earn incentives 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 and the impact evaluation team, Resource Innovations 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. Participants selected into the survey sample received an email invitation with a link to the survey URL. Survey respondents received a $20 Amazon e-gift card after completing the post-event survey.

3.5.4 Nonevent program surveys

In addition to the post-event survey, the evaluation team prepared a survey to be deployed at the same time as the post-event survey, but delivered to a sample of BYOT option participants that did not experience the curtailment event. This nonevent survey was identical to the post-event survey to facilitate comparison with the results of the post-event survey. Like the post-event survey, the nonevent survey was developed, approved, and programmed prior to the demand response season to enable immediate deployment. Similar to the post-event survey, a survey link was sent via email to participants selected into the survey sample. Survey respondents received a $20 Amazon e-gift card after completing the nonevent survey.

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. This section presents overall program results for all event days, including all variations of event start time, duration pre-heating, and offset scenarios. The section also details the results of the research events and investigates weather sensitivity of impacts for Winter 2021-2022 BYOT RCT events.

4.1 BYOT Program Results

4.1.1 Event Impacts

The load impact estimates resulting from the RCT analysis for the Winter 2022 BYOT events are presented in the table below. The load impacts presented for each event are the average per household changes in load during the indicated dispatch windows. The first event of the season on January 18, 2022 was called program-wide without a control group and was analyzed via within-subjects approach described in Section 3.4.

Table 4-1: Bring Your Own Thermostat Event Impacts

Event Date	Start	End	Pre-Heat	Offset	Load w/o DR	Load w/ DR	Impact (kW)	Percent Impact	Event Temp °F
1/18/2022	6	8	No Pre-Heat	3° Offset	4.06	2.74	1.32	32.5%	24.5
1/24/2022	6	8	90 min 3° Pre-Heat	3° Offset	3.65	2.32	1.34	36.6%	29.5
1/24/2022	6	8	No Pre-Heat	3° Offset	3.65	2.41	1.24	34.0%	29.5
1/24/2022	6	8	60 min 3° Pre-Heat	3° Offset	3.65	2.32	1.33	36.4%	29.5
1/24/2022	6	8	60 min 2° Pre-Heat	2° Offset	3.65	2.45	1.20	32.9%	29.5
1/27/2022	6	9	60 min 3° Pre-Heat	3° Offset	4.24	2.85	1.39	32.9%	26.3
1/27/2022	6	9	60 min 2° Pre-Heat	2° Offset	4.24	2.84	1.40	32.9%	26.3
1/27/2022	6	9	120 min 3° Pre-Heat	3° Offset	4.24	2.81	1.43	33.8%	26.3
1/27/2022	6	9	90 min 3° Pre-Heat	3° Offset	4.24	2.76	1.48	34.8%	26.3
2/1/2022	6	8	90 min 3° Pre-Heat	3° Offset	3.48	2.09	1.39	39.9%	30.5
2/1/2022	6	8	120 min 3° Pre-Heat	3° Offset	3.48	2.24	1.24	35.6%	30.5

Event Date	Start	End	Pre-Heat	Offset	Load w/o DR	Load w/ DR	Impact (kW)	Percent Impact	Event Temp °F
2/1/2022	6	8	60 min 2° Pre-Heat	2° Offset	3.48	2.33	1.15	33.1%	30.5
2/1/2022	6	8	60 min 3° Pre-Heat	3° Offset	3.48	2.17	1.31	37.7%	30.5
2/7/2022	7	9	90 min 3° Pre-Heat	3° Offset	3.17	2.05	1.13	35.5%	32.5
2/7/2022	7	9	No Pre-Heat	3° Offset	3.17	2.17	1.00	31.6%	32.5
2/7/2022	7	9	60 min 2° Pre-Heat	2° Offset	3.17	2.11	1.06	33.5%	32.5
2/7/2022	7	9	60 min 3° Pre-Heat	3° Offset	3.17	2.11	1.06	33.4%	32.5
2/9/2022	7	9	60 min 3° Pre-Heat	3° Offset	3.74	2.08	1.66	44.4%	34.0
2/9/2022	7	9	No Pre-Heat	3° Offset	3.74	2.41	1.34	35.7%	34.0
2/9/2022	7	9	90 min 3° Pre-Heat	3° Offset	3.74	2.30	1.44	38.5%	34.0
2/9/2022	7	9	120 min 3° Pre-Heat	3° Offset	3.74	2.19	1.55	41.5%	34.0
2/14/2022	6	9	60 min 2° Pre-Heat	2° Offset	3.77	2.73	1.03	27.4%	30.3
2/14/2022	6	9	120 min 3° Pre-Heat	3° Offset	3.77	2.43	1.33	35.4%	30.3
2/14/2022	6	9	90 min 3° Pre-Heat	4° Offset	3.77	2.46	1.31	34.8%	30.3
2/14/2022	6	9	No Pre-Heat	3° Offset	3.77	2.75	1.02	27.0%	30.3
2/15/2022	6	8	60 min 3° Pre-Heat	3° Offset	3.94	2.55	1.40	35.4%	31.0
2/15/2022	6	8	No Pre-Heat	3° Offset	3.94	2.73	1.21	30.8%	31.0
2/15/2022	6	8	90 min 3° Pre-Heat	4° Offset	3.94	2.35	1.59	40.3%	31.0
2/15/2022	6	8	60 min 2° Pre-Heat	2° Offset	3.94	2.66	1.29	32.6%	31.0
2/28/2022	6	8	90 min 3° Pre-Heat	4° Offset	3.33	1.98	1.35	40.6%	34.5
2/28/2022	6	8	60 min 3° Pre-Heat	3° Offset	3.33	2.06	1.27	38.1%	34.5
2/28/2022	6	8	120 min 3° Pre-Heat	3° Offset	3.33	1.86	1.47	44.2%	34.5
2/28/2022	6	8	60 min 2° Pre-Heat	2° Offset	3.33	2.11	1.21	36.5%	34.5

Event Date	Start	End	Pre-Heat	Offset	Load w/o DR	Load w/ DR	Impact (kW)	Percent Impact	Event Temp °F
3/14/2022	6	9	90 min 3° Pre-Heat	3° Offset	3.01	1.92	1.09	36.3%	36.7
3/14/2022	6	9	60 min 3° Pre-Heat	3° Offset	3.01	1.96	1.06	35.1%	36.7
3/14/2022	6	9	60 min 2° Pre-Heat	2° Offset	3.01	2.23	0.78	26.0%	36.7
3/14/2022	6	9	90 min 3° Pre-Heat	4° Offset	3.01	1.99	1.02	33.9%	36.7
3/28/2022	7	9	120 min 3° Pre-Heat	3° Offset	2.57	1.71	0.85	33.2%	39.5
3/28/2022	7	9	No Pre-Heat	3° Offset	2.57	1.67	0.90	35.1%	39.5
3/28/2022	7	9	90 min 3° Pre-Heat	4° Offset	2.57	1.66	0.91	35.5%	39.5
3/28/2022	7	9	90 min 3° Pre-Heat	3° Offset	2.57	1.57	1.00	38.9%	39.5
Average Event					3.55	2.31	1.24	35.0%	31.6

Overall ex post load impacts for the average BYOT customer were 1.24 kW. No direct comparison between the six pre-heat/offset configurations is available, as temperature and reference load play a large part in the impacts achieved. Although the 11 event days provided variation in pre-heat and offset configurations across the five dispatch groups, comparison across configurations must take into account weather conditions on each event day. On average, 120 min 3° Pre-Heat, 3° Offset and 60 min 3° Pre-Heat, 3° Offset provided the largest hourly impacts at 1.31 kW per customer. The 60 min 3° Pre-Heat, 3° Offset configuration also provided the largest single event hourly impact during the Winter 2021-2022 event season, 1.66 kW. Counterintuitively, average impacts during 90 min 3° Pre-Heat, 4° Offset events on average provided lower impacts than the 90 min 3° Pre-Heat, 3° Offset events. Though, this outcome is at least partially driven by warmer temperatures on some of the 4° Offset event days.

Table 4-2: Summary of BYOT Event Impacts by Type

Pre-Heat	Event Offset	# of Events	Average Impact kW	Maximum Impact kW
120 min 3° Pre-Heat	3° Offset	6	1.31	1.55
60 min 2° Pre-Heat	2° Offset	8	1.14	1.40
60 min 3° Pre-Heat	3° Offset	8	1.31	1.66
90 min 3° Pre-Heat	3° Offset	7	1.27	1.48
90 min 3° Pre-Heat	4° Offset	5	1.24	1.59
No Pre-Heat	3° Offset	7	1.21	1.34
Average Event		**11**	**1.24**	**1.66**

Event impacts are displayed graphically in the series of figures that follow, with the average customer load profiles shown for the treatment and control groups. In each of the graphs, the darker blue line represents the average load from control group customers, while the other solid colored lines represent the average loads from the various treatment groups dispatched on that day. All of the events show a clear drop in treatment group loads during the event dispatch period. The figures also clearly depict the increase in load during the pre-heating phase immediately preceding the event period, as well as the load increase during the post-event snapback period.

Figure 4-1: Per Household BYOT Event Performance, January 24 and January 27

Event Date	1/24/2022				1/27/2022			
Start Time	6:00 AM				6:00 AM			
End Time	8:00 AM				9:00 AM			
System Temperature	29.5°F				26.3°F			
Pre-heat	90 min 3°F	No pre-heat	60 min 3°F	60 min 2°F	60 min 3°F	60 min 2°F	120 min 3°F	90 min 3°F
Offset	3°F	3°F	3°F	2°F	3°F	2°F	3°F	3°F
Event Impact	1.34 kW	1.24 kW	1.33 kW	1.20 kW	1.39 kW	1.40 kW	1.43 kW	1.39 kW

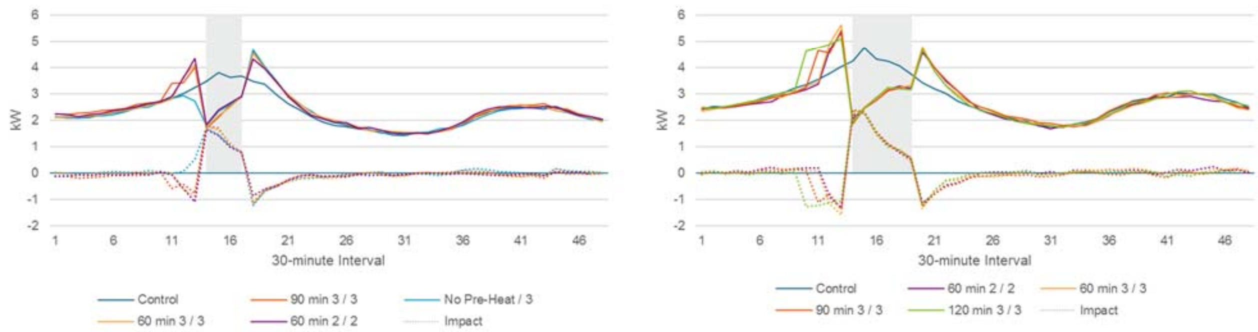


Figure 4-2: Per Household BYOT Event Performance, February 1 and February 7

Event Date	2/1/2022				2/7/2022			
Start Time	6:00 AM				7:00 AM			
End Time	8:00 AM				9:00 AM			
System Temperature	30.5°F				32.5°F			
Pre-heat	90 min 3°F	120 min 3°F	60 min 2°F	60 min 3°F	90 min 3°F	No pre-heat	60 min 2°F	60 min 3°F
Offset	3°F	3°F	2°F	3°F	3°F	3°F	2°F	3°F
Event Impact	1.39 kW	1.24 kW	1.15 kW	1.31 kW	1.13 kW	1.00 kW	1.06 kW	1.06 kW

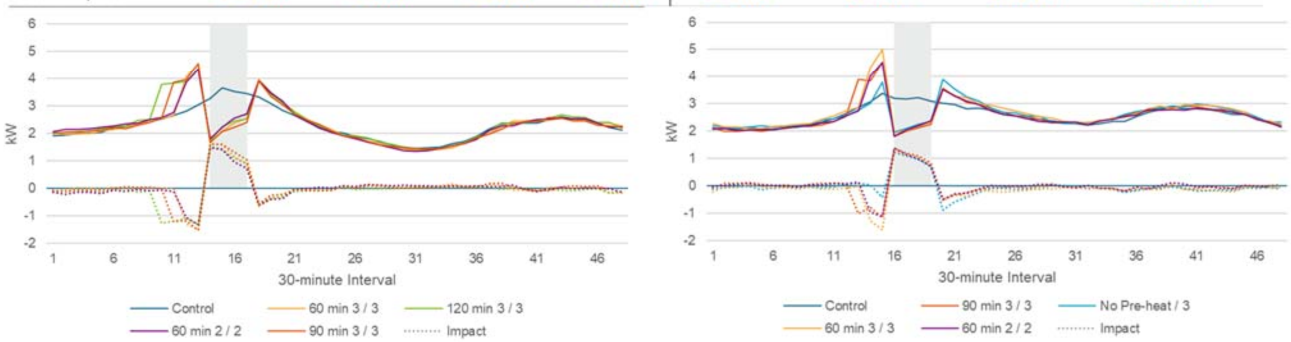


Figure 4-3: Per Household BYOT Event Performance, February 9 and February 14

Event Date	2/9/2022				2/14/2022			
Start Time	7:00 AM				6:00 AM			
End Time	9:00 AM				9:00 AM			
System Temperature	34.0°F				30.3°F			
Pre-heat	60 min 3°F	No pre-heat	90 min 3°F	120 min 3°F	60 min 2°F	120 min 3°F	90 min 3°F	No pre-heat
Offset	3°F	3°F	3°F	3°F	2°F	3°F	4°F	3°F
Event Impact	1.66 kW	1.34 kW	1.44 kW	1.55 kW	1.03 kW	1.33 kW	1.31 kW	1.02 kW

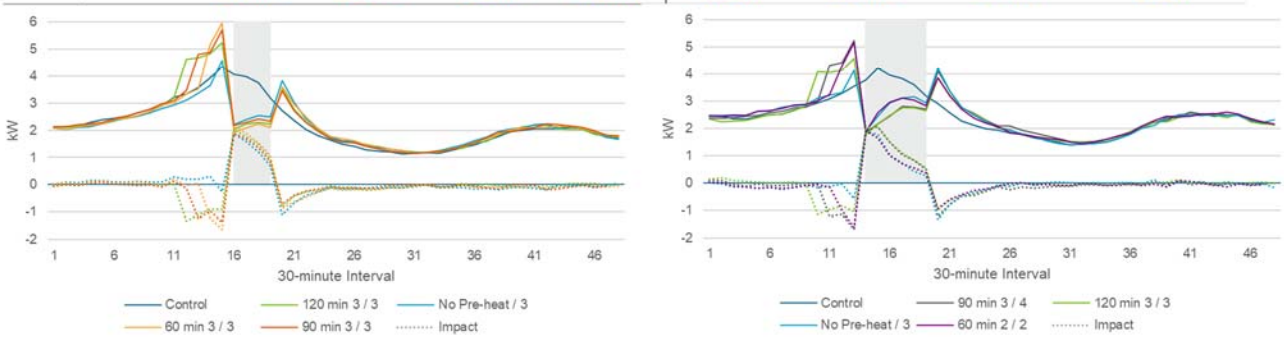


Figure 4-4: Per Household BYOT Event Performance, February 15 and February 28

Event Date	2/15/2022				2/28/2022			
Start Time	6:00 AM				6:00 AM			
End Time	8:00 AM				8:00 AM			
System Temperature	31.0°F				34.5°F			
Pre-heat	60 min 3°F	No pre-heat	90 min 3°F	60 min 2°F	90 min 3°F	60 min 3°F	120 min 3°F	60 min 2°F
Offset	3°F	3°F	4°F	2°F	4°F	3°F	3°F	2°F
Event Impact	1.40 kW	1.21 kW	1.59 kW	1.29 kW	1.35 kW	1.27 kW	1.47 kW	1.21 kW

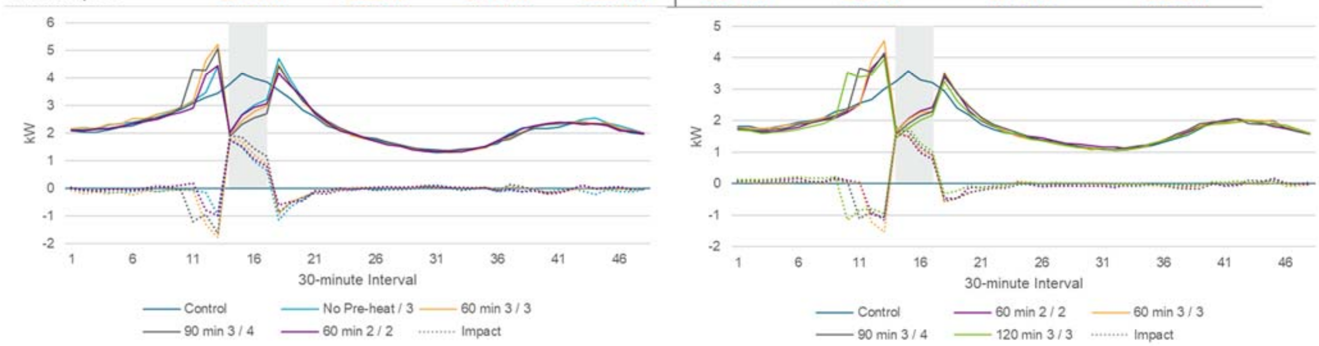
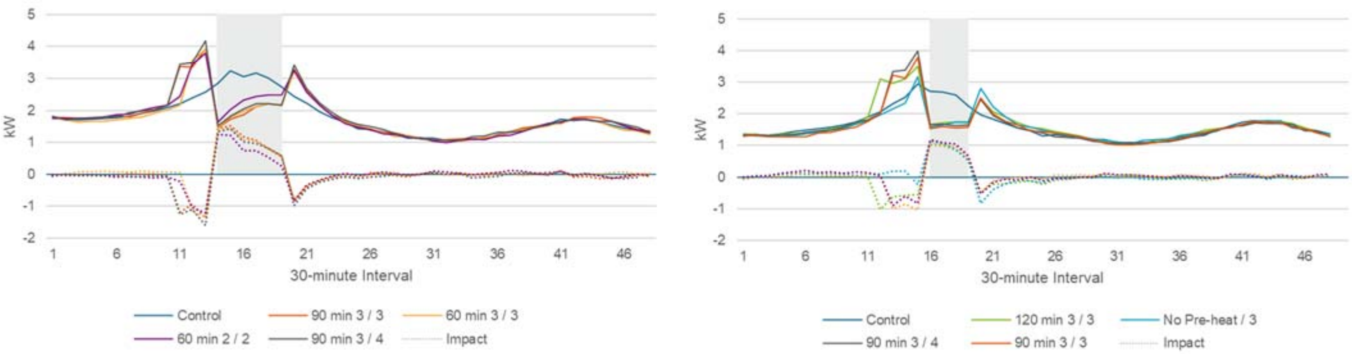


Figure 4-5: Per Household BYOT Event Performance, March 14 and March 28

Event Date	3/14/2022				3/28/2022			
Start Time	6:00 AM				7:00 AM			
End Time	9:00 AM				9:00 AM			
System Temperature	36.7°F				39.5°F			
Pre-heat	90 min 3°F	60 min 3°F	60 min 2°F	90 min 3°F	120 min 3°F	No pre-heat	90 min 3°F	90 min 3°F
Offset	3°F	3°F	2°F	4°F	3°F	3°F	4°F	3°F
Event Impact	1.09 kW	1.06 kW	0.78 kW	1.02 kW	0.85 kW	0.90 kW	0.91 kW	1.00 kW



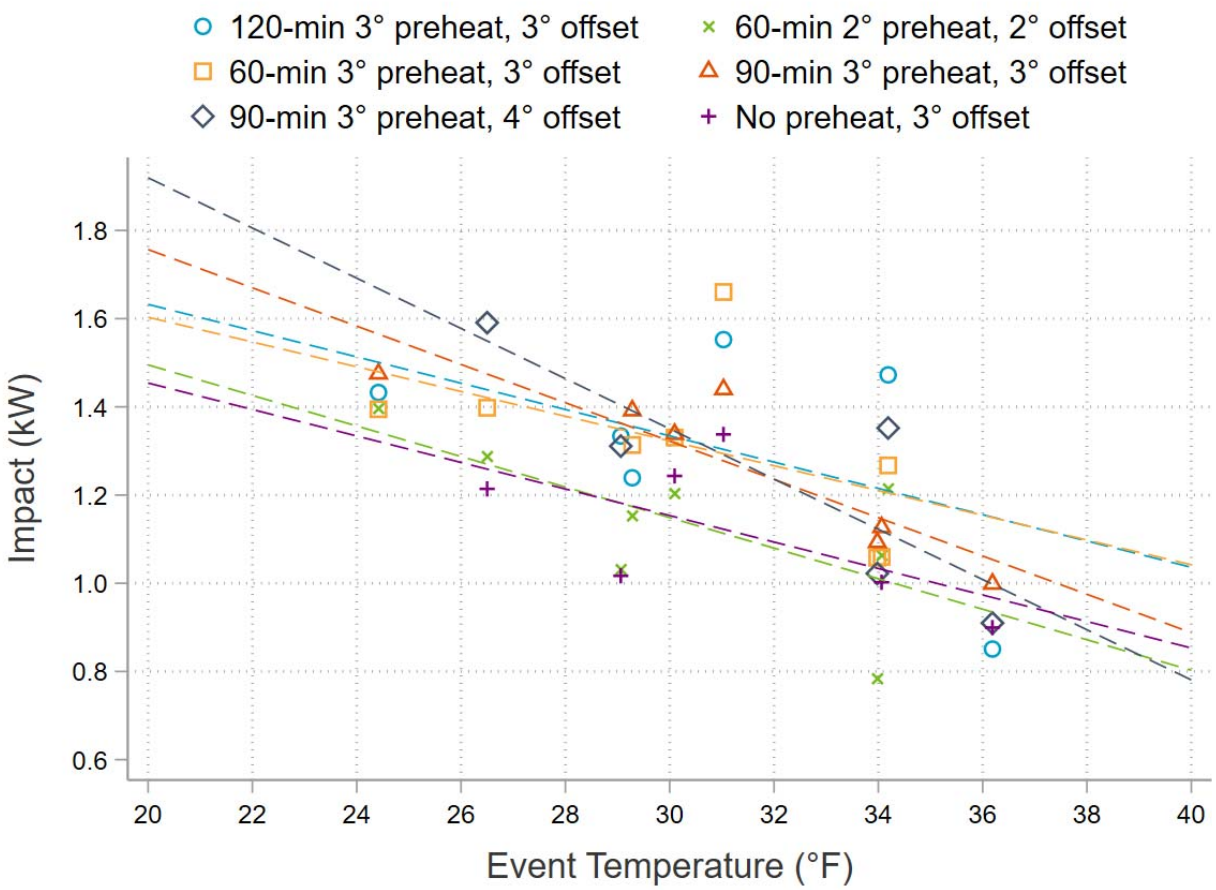
4.1.2 Weather Sensitivity

There is a clear correlation between the magnitude of BYOT event impacts and temperature. Table 4-3 summarizes average kW impacts, percent impacts and temperatures for each event day called during the 2021-2022 winter season. Figure 4-6 shows the trend with weather: impacts increase at lower temperatures.

Table 4-3: Average Per Household Event Day Impacts

Event Date	Start	End	Load w/o DR	Load w/ DR	Impact (kW)	Percent Impact	Event Temp °F
1/18/2022	6:00 AM	8:00 AM	4.06	2.74	1.32	32.5%	24.5
1/24/2022	6:00 AM	8:00 AM	3.65	2.38	1.28	35.0%	29.5
1/27/2022	6:00 AM	9:00 AM	4.24	2.82	1.42	33.6%	26.3
2/1/2022	6:00 AM	8:00 AM	3.48	2.21	1.27	36.6%	30.5
2/7/2022	7:00 AM	9:00 AM	3.17	2.11	1.06	33.5%	32.5
2/9/2022	7:00 AM	9:00 AM	3.74	2.25	1.50	40.0%	34.0
2/14/2022	6:00 AM	9:00 AM	3.77	2.59	1.17	31.2%	30.3
2/15/2022	6:00 AM	8:00 AM	3.94	2.57	1.37	34.8%	31.0
2/28/2022	6:00 AM	8:00 AM	3.33	2.00	1.33	39.8%	34.5
3/14/2022	6:00 AM	9:00 AM	3.01	2.03	0.99	32.8%	36.7
3/28/2022	7:00 AM	9:00 AM	2.57	1.65	0.91	35.7%	39.5
Average Event			**3.55**	**2.31**	**1.24**	**35.0%**	**31.6**

Figure 4-6: Weather Sensitivity of BYOT Event Impacts



4.2 Key Findings

- The average BYOT load reduction across all events in was 1.24 kW
- The magnitude of baseline loads and load impacts tend to increase with lower temperatures
- BYOT event impacts are larger for events with temperature setpoint offsets of 3 °F or more compared to events with 2 °F offsets
- There does not appear to be any significant difference in BYOT event performance due to pre-heating levels

5 Within-Subjects Results

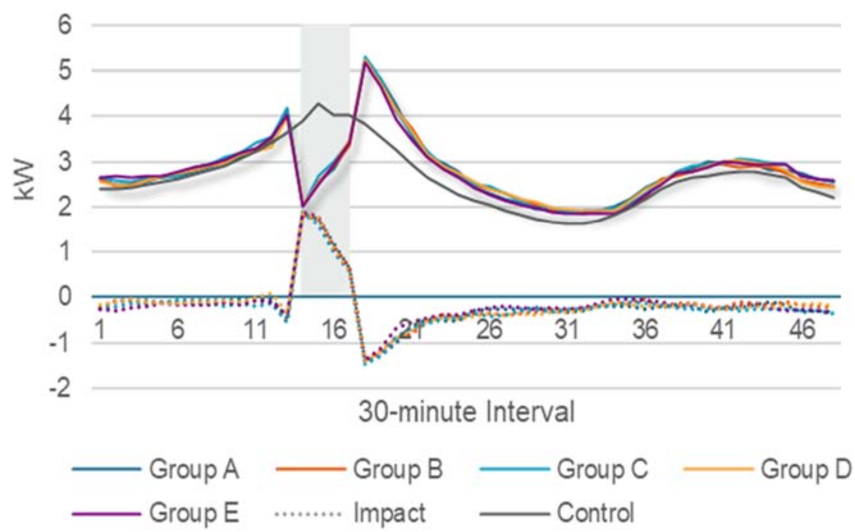
In addition to the events described in the previous section, one event called in Winter 2021-2022 could not be estimated using RCT approach because it was called for the full program population and did not withhold a control group. Load impacts for this event were estimated using the within-subjects approach described in Section 3.4.

5.1 BYOT Within-Subjects Results

One BYOT event was called population-wide in 2021-2022 and did not involve a control group. For this event, a set of non-event proxy days were used to construct a baseline against which to compare event day loads. The event was called on January 18, 2022 and involved a 3°F offset that lasted for two hours (6:00 AM to 8:00 AM) with no pre-heat. Event day loads and impacts for the event are shown in Figure 5-1.

Figure 5-1: Within-Subjects BYOT Event Performance, January 18

Event Date	1/18/2022
Start Time	6:00 AM
End Time	8:00 AM
Pre-heat	No pre-heat
Offset	3°F
System Temperature	24.5°F
Event Impact	1.32 kW



5.1.1 Key Findings

- Per household event impacts for the population-wide BYOT event called on January 18 were 1.32 kW
- The initial (first event interval) load drop was significant and tapered off during the 2-hour event window

6 Demand Reduction Capability

A key objective of the Winter 2021-2022 impact evaluation was to quantify the relationship between demand reductions, temperature, and hour of day. This was accomplished by estimating loads under historical weather conditions and applying observed percent load reductions from the 2021-2022 winter 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 temperatures and event conditions.

6.1 BYOT Time-Temperature Matrix

Among the key factors that go into producing a reliable and accurate time-temperature matrix are the number of events called and the variety of event conditions observed during those events. In order to predict load impacts under a wide range of conditions, a similarly wide range of conditions ideally would be observed during the actual events. With a narrower range of event scenarios, the tool is less informed in predicting impacts at the extremes, resulting in misleading and/or imprecise estimates. During the 2021-2022 winter event season, BYOT events occurred on 11 distinct days, under six different combinations of pre-heating and event period offsets. Event period temperatures ranged from 24°F to 39°F. The timing of this report submission allows for 2022-2023 winter events also to be included in the forecasting tool. Two events were called at extremely low temperatures during the 2022-2023 winter season, which gives the tool more predictive power at the extreme scenarios.

6.1.1 Methodology

The first step involved modeling reference loads for a wide range of temperature conditions by applying the observed AMI data from the 2021-2022 and 2022-2023 event seasons to 10-year historical weather data. From there, average percent reductions observed for each type of event were applied to the modeled referend loads for each of the various combinations of event start times, minimum temperatures, event durations, and event types.[3] In this way, event impacts, as well as pre- and post-event load increases, are purely a function of the reference loads and are not subject to the modeling error observed in the original approach. Table 6-1 shows the average percent impacts for each period of the six event types.

[3] The term "event type" is used to reflect the four different scenarios, combining pre-heating duration, pre-heat temperature offset, event period duration, and event period temperature offset, used in 2021-2022.

Table 6-1: Average Percent Impacts by Period and Event Type

Event Type	# Events Called	Period	Average % Impact
No Pre-heat / 3°F Event Offset	6	Pre-Event	-2.8%
		Event	32.0%
		Post-Event	-21.1%
60-minute 2°F Pre-heat / 3°F Event Offset	9	Pre-Event	-17.0%
		Event	31.1%
		Post-Event	-11.2%
60-minute 3°F Pre-heat / 3°F Event Offset	9	Pre-Event	-20.3%
		Event	36.1%
		Post-Event	-13.0%
90-minute 3°F Pre-heat / 3°F Event Offset	8	Pre-Event	-25.0%
		Event	36.7%
		Post-Event	-11.5%
90-minute 3°F Pre-heat / 4°F Event Offset	3	Pre-Event	-31.5%
		Event	36.2%
		Post-Event	-14.2%
120-minute 3°F Pre-heat / 3°F Event Offset	6	Pre-Event	-33.6%
		Event	36.4%
		Post-Event	-12.4%

6.1.2 Demand Reduction Capability for BYOT Events

Like DLC events, the primary purpose of BYOT is to relieve (or shift, if pre-heating) load demand during times of system peak demand. To maintain customers' comfort, the most extreme BYOT events (i.e., those with the largest temperature offsets) are ideally used sparingly and only when needed. Collectively, the 2021-2022 events show that per household load impacts are correlated with the event period temperature offset. Put simply, larger offsets generate greater impacts. Therefore, the most extreme event type is used for estimating the program's load reduction capability.

Figure 6-1: Load Reduction Capability for Extreme BYOT Event

INPUTS	
Event Start Time	7:00 AM ▼
Event Duration	2 ▼
Event Option	90 min 3 deg preheat / 4 deg offset ▼
Event Temperature	12 ▼
# Customers	15,000

OUTPUTS		
Reference Load	5.69	kW
Curtailed Load	3.35	kW
Impact per Customer	-2.33	kW
Program Impact	-35.0	MW
% Impact	-41.1	%

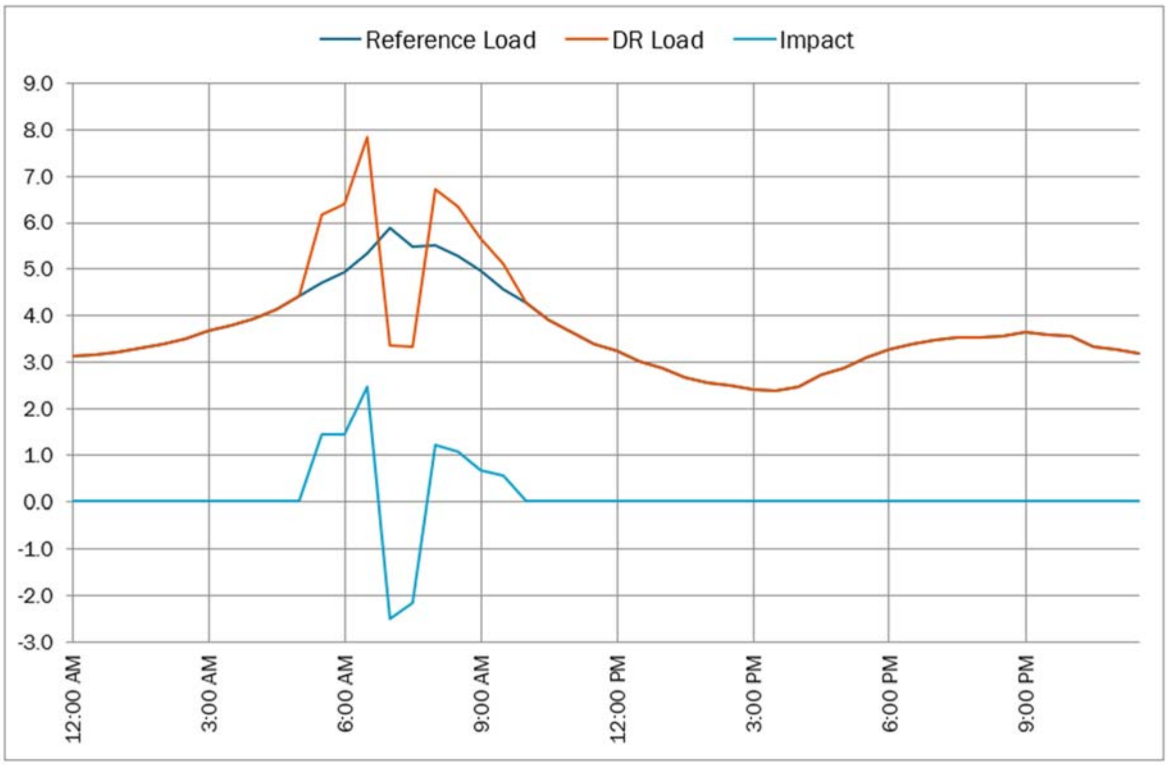


Figure 6-1 shows load impact predictions for an extreme BYOT event. Specifically, a 1-hour BYOT event beginning at 7:00 AM at 12°F that involves a 4°F offset, preceded by a 90-minute 3°F pre-heat, is expected to generate impacts of -2.33 kW per household. Assuming a program population of 15,000 accounts, this translates to approximately 35 MW of system load reduction.

6.1.3 Key Findings

Key takeaways from the BYOT Time-Temperature Matrix include:

- Impacts, which are applied as a percentage of the reference load, are correlated to temperature. As temperatures rise, both reference loads and impacts increase.
- Under the most extreme event scenario implemented – namely a 4°F offset with a 3°F pre-heat – a 1-hour event beginning at 7:00 AM at 12°F is expected to produce a per household impact of -2.33 kW.
- Similar to what was found during the development of the DLC TTM, events called under a relatively narrow range of event and weather conditions led to significant challenges in modeling impacts for extreme scenarios, ultimately persuading Resource Innovations to modify the methodology used to develop the BYOT TTM.

7 Process Evaluation

A process 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. This is particularly true when combined with the insight obtained from impact evaluation. The primary objectives for the process evaluation component of the evaluation include:

- Assessing the extent to which particpants are aware of events, incentives, and other key program features
- Understanding the participant experience during events, including comfort, occupancy, thermostat adjustments, and strategies employed to mitigate cold weather
- Identify 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
- Identify program strengths and potential areas for improvement

7.1 Survey Disposition

Resource Innovations developed a survey for customers participating in the Power Manager BYOT option that was deployed immediately following a Power Manager event on February 28, 2022. The event on this day occurred in the morning from 6 AM to 8 AM and the survey was launched the same afternoon. For this event, customers were randomly assigned to five groups; four treatment groups exposed to differing pre-heat and offset scenarios, and one control group, who did not experience an event on this day (see Table 2-1Table 1-1). For the purposes of the process evaluation, respondents from two of these treatment groups and the one control group were surveyed.

The two treatment groups that received post-event survey invitations experienced different pre-heating and setpoint offset strategies. The first treatment group experienced a 60-minute 3°pre-heat before the event start and a 3°setpoint offset during the event. For example, if the thermostat was originally set to 68°, during the hour before the event started the thermostat would be turned up to 71°. Then the thermostat would be turned down to 65° during the event hours. The second treatment group had a longer pre-heating period of 90 minutes at 3° and a higher offset during the event hours of 4°. In this section the two treatment groups are referred to as the small offset and large offset groups, respectively.

Table 6-1 provides a description of the event groups surveyed and the individual response rates by group. The survey was administered online beginning the day of the event and remained open for the three days following the event until 150 responses from each group (450 respondents total) had been collected. The overall response rate was 15.7%.

Table 7-1: Survey Summary

Group	Event Date	Event Start Time	Event Finish Time	Event Description	Survey Start Date	Survey End Date	Number of Responses	Valid Response Rate
Small Offset	2/28/2022	6:00 AM	8:00 AM	60-minute, 3-degree preheat and 3-degree offset	2/28/2022	3/3/2022	150	15.8%
Large Offset	2/28/2022	6:00 AM	8:00 AM	90-minute, 3-degree preheat and 4-degree offset	2/28/2022	3/3/2022	150	15.7%
Control	-	-	-	-	2/28/2022	3/3/2022	150	15.7%

The survey addressed the following topics:

- Awareness of the specific event day, including reasons for event day awareness (e.g., increased or decreased temperature in the home, etc.)
- Any actions taken during a Power Manager event: Do participants report changing thermostat settings, using other heating equipment, or taking other actions to be more comfortable. Were participants home during the event? Are they usually home during that time period? Respondents were also asked about their existing HVAC equipment and heating/cooling patterns.
- Respondent Comfort: Do respondents who experienced an event report differing levels of thermal discomfort compared to control customers?
- Satisfaction with the Power Manager program and its attributes: Are participants pleased with the ease of enrollment, communication, incentives provided, and the number of Power Manager events?
- 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 reducing the environmental effects of energy production?
- Retention and Referral: Do participants expect to remain enrolled in the program in future years? Would they recommend it to others?
- Demographics and Behavior of Respondents: Household size, age, level of education, and income.

Since event awareness and thermal comfort are primary areas of inquiry for the survey, the held-back control group provides the opportunity to net out any propensity for thermal discomfort or belief that a Power Manager event is occurring that would have happened on the day of the event regardless of whether a Power Manager event actually occurred. 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.

Respondents were first asked a series of questions about their existing HVAC systems and heating use during the winter months. Respondents in the two treatment groups did not vary significantly from the control group in the number of thermostats and heaters they owned and how often they typically used heating during the winter. The demographics, including household size, age, level of education, and income of the two treatment groups and the control customers also did not significantly differ. This provides evidence that making comparison between to two treatment groups and control is valid because the underlying populations have similar characteristics.

7.2 Program and Event Awareness

The customer surveys were designed with the key objective of evaluating participants' awareness of Power Manager events. 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 (88.2% of all respondents), reported that they are familiar with the Power Manager program.

Of the 450 responses received, 42.4% believed that a BYOT Power Manager event had occurred in the past few days. Of the treatment respondents, 54.7% of the small offset and 47.0% of the large offset customers correctly believed that an event had occurred, whereas 25.5% of the control group believed that an event had taken place. The difference in proportions between both treatment groups and the control group was statistically significant. The response frequencies are by group are shown in Table 7-2. The number of respondents from each group who answered the question is displayed next to "n=". This notation is consistent with the rest of the tables and figures in the section.

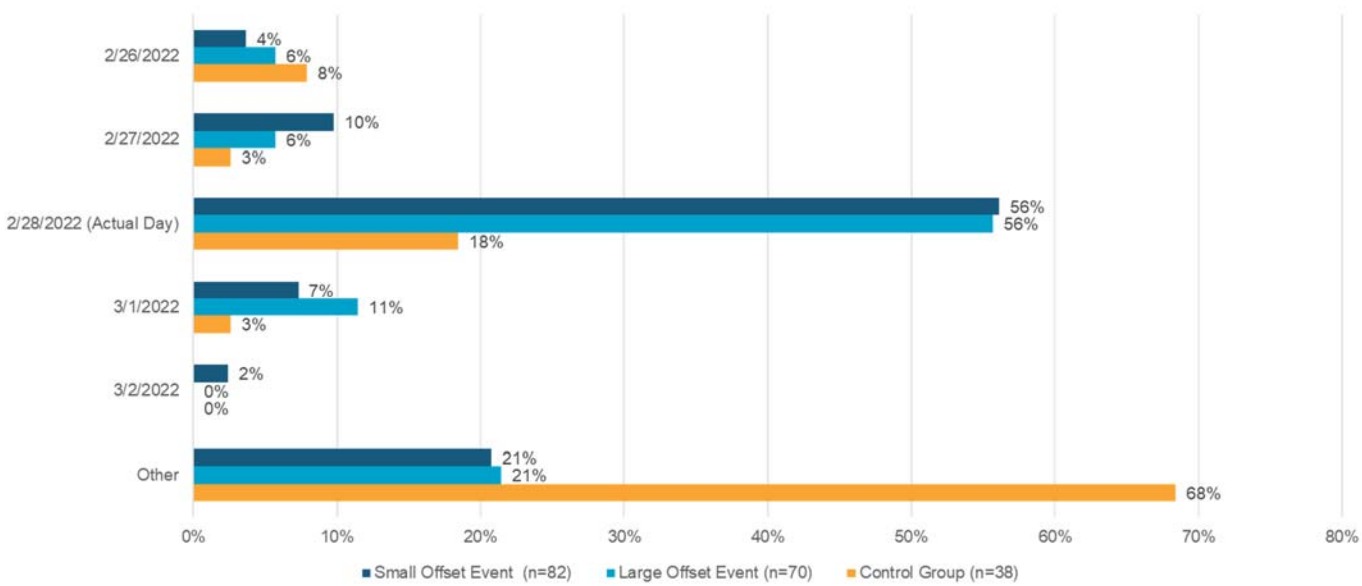
Table 7-2: Event Awareness – "Do you think a Power Manager event occurred in the past few days?"

Group	Yes	No	Don't Know	Total
Small Offset Event (n=150)*	55%	17%	28%	100%
Large Offset Event (n=149)*	47%	26%	27%	100%
Control Group (n=149)	26%	34%	40%	100%
Total	**42%**	**26%**	**32%**	**100%**

*Proportion who answered "yes" was significantly different relative to the control group

Of the treatment respondents who correctly indicated that an event had occurred, 56.1% of the small offset group and 55.7% of the large offset group correctly identified the date of the event, February 28. In comparison, 18.4% of control customers thought an event occurred on February 28. Additionally, 68.4% of control customers who believed that an event had recently occurred responded "Other", when asked what day the event occurred on, indicating that they believed the event had occurred prior to February 26. Some of these respondents may have been referring to a previous event that they actually experienced on February 14 or February 15. Figure 7-1 presents the days that respondents in each group believed the event occurred.

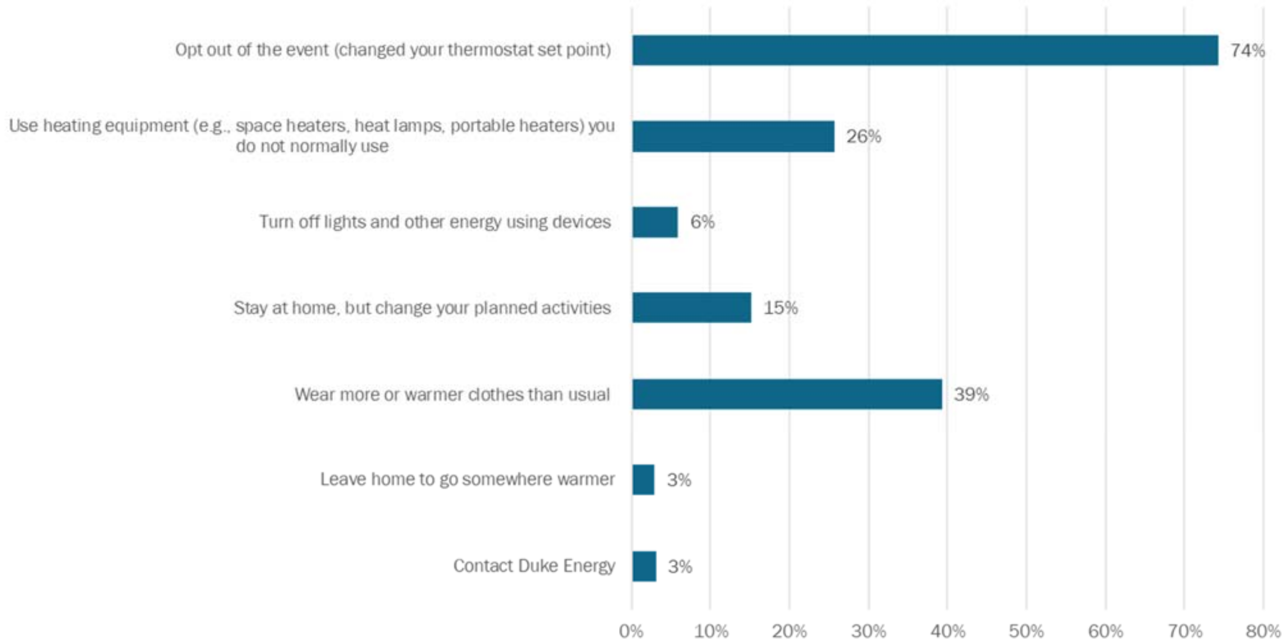
Figure 7-1: Date of Perceived Event- "On which day do you think an event occurred"



The most common way that respondents determined that an event was occurring was receiving an indication on their thermostat or thermostat app (68.0% of all respondents). The second most common reason why respondents believed that an event was occurring was cold inside temperature (27% of all respondents). Customers enrolled in Power Manager BYOT do not receive event notifications directly from Duke Energy other than through their thermostat or thermostat app.

All respondents who believed that an event occurred were asked if they took action as a result of the event. The majority of respondents (73.5%) took no action. Those that took action varied in their responses. Figure 7-2 highlights responses taken by those that did take action. The most common action respondents reported taking was opting out of the event by changing their thermostat set point (26 respondents). Other common responses included dressing in warmer clothes (13 respondents) and using additional heaters such as space heaters or heat lamps (9 respondents). Only 6 respondents reported that they changed their planned activities in response to the event, and only one respondent left their home while the event was occurring.

Figure 7-2: Actions Taken During Real or Perceived Events: Percent who answered "yes"

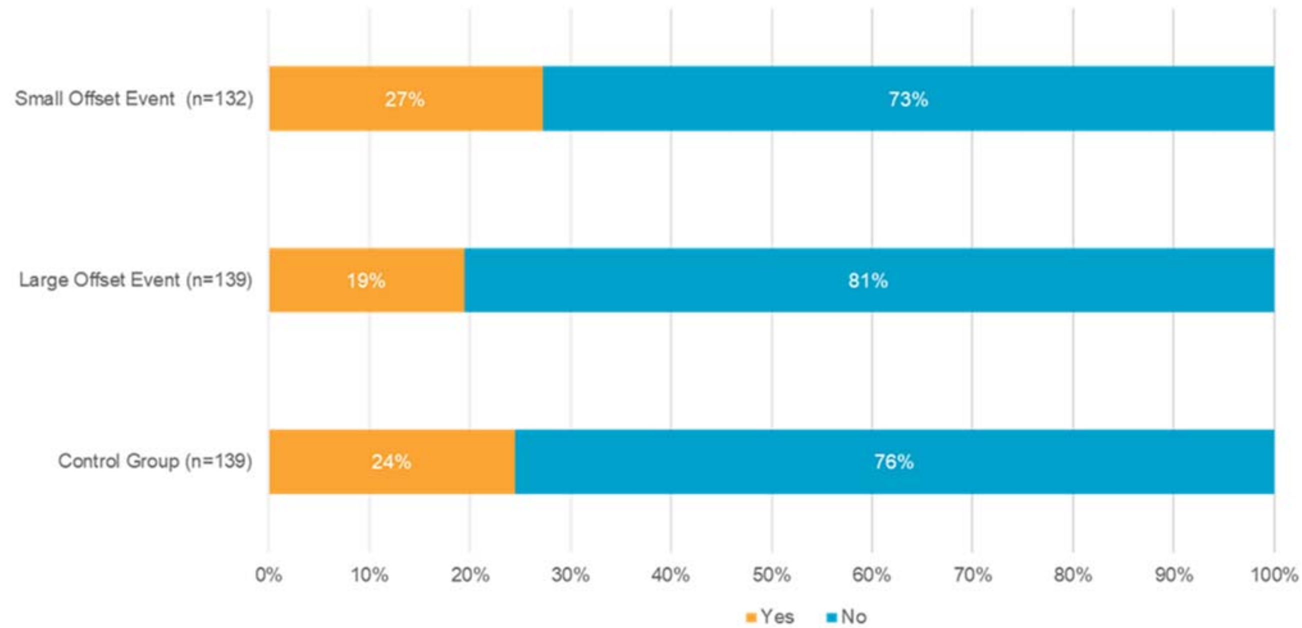


These findings indicate that some Power Manager customers are aware of events, but the majority of customers are not cognizant of event days. Of the customers who experienced an event on February 28, only 28.3% of them were both aware of the event occurring and correctly identified the day the event was held. The primary way that customers became aware of events was through notifications on their thermostats or apps. Importantly, real or perceived events are not disruptive to customers, as the majority of respondents who believed that an event was occurring did not change any of their planned activities due to the event. This provides evidence that Power Manager events did not greatly affect customers daily routines.

7.3 Respondent Comfort

Respondents were then asked whether they experienced any discomfort due to the temperature in their home on February 28. The majority of respondents (76.3%) in all three groups stated they did not experience discomfort. Figure 7-3 details the proportion of respondents who reported discomfort by group. There was no statistical difference in the percentage of respondents who reported discomfort between the two treatment groups or between either treatment group and the control customers.

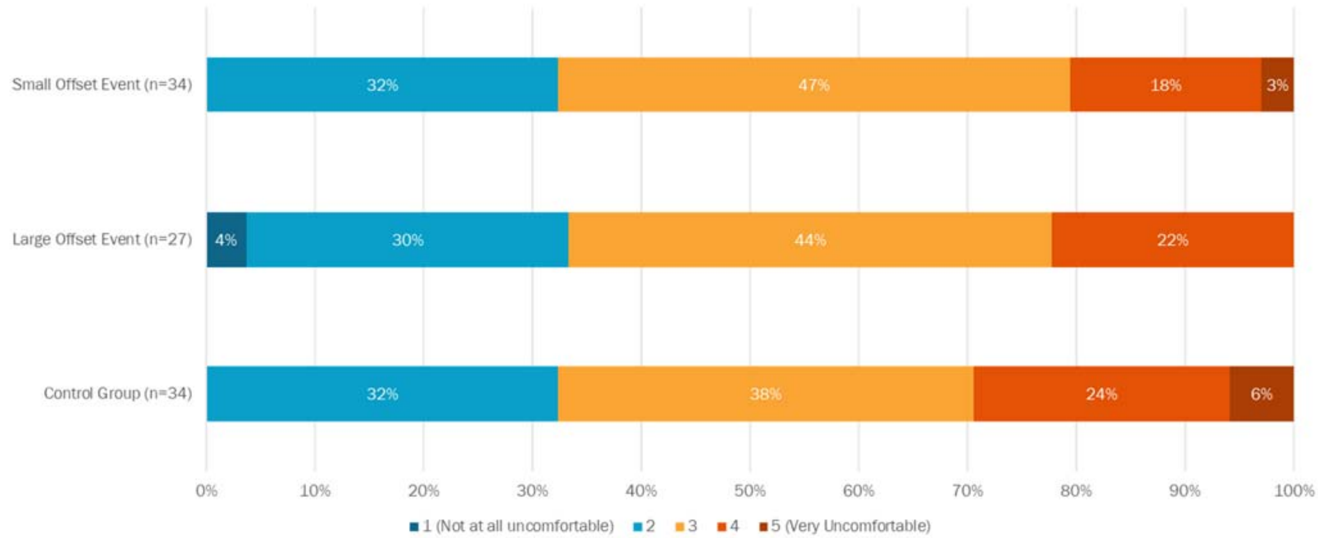
Figure 7-3: Respondent Reports of Discomfort- "Was there any time on February 28th when the temperature in your home was uncomfortable?"



Of the minority of customers who reported discomfort, those in the large offset and small offset groups were more likely to report the start of their discomfort closer to the start of the actual event (6 AM) than the control customers. However, there was no statistical difference in when respondents reported that their discomfort ended or the total hours of reported discomfort between the treatment and control groups.

Next, the respondents who reported feeling uncomfortable were asked to rate their discomfort on a scale of 1 (not at all uncomfortable) to 5 (very uncomfortable). The majority of respondents in all groups (75.8%) rated their discomfort between 1 to 3 on this scale. There was no statistical difference between the control, small offset, and large offset customers in the proportion of respondents who rated their discomfort as a 4 or 5. Figure 7-4 showcases ratings of discomfort between the three groups.

Figure 7-4: Perceived Discomfort- "Please rate your discomfort using a scale of one-to-five..."



Of those that reported thermal discomfort above, the most common attributed cause was cold weather (40.9% of all respondents) and the second most cited reason was Power Manager (22.7% of all respondents). Additionally, a modest number of respondents (9.1% of all respondents) reported feeling hot during the event day.[4] Respondents feeling uncomfortably warm can potentially be attributed to the pre-heating feature built into Power Manager events.

The overall results for thermal discomfort indicate that customers in the two treatment groups were not more uncomfortable than control customers who did not experience an event. Customers that experienced a temperature offset were not more likely to report any discomfort during the event day, and while those that did report feeling uncomfortable were more likely to state that their discomfort began near the start of the event, neither the magnitude of this described discomfort nor the total number of hours that they felt uncomfortable differed from that reported by unaffected customers. Additionally, of the small number of customers who experienced discomfort, cold weather was the number one cited reason for discomfort, not the Power Manager event itself. These findings provide evidence that participants are not overly burdened by temperature changes in their home caused by Power Manager events.

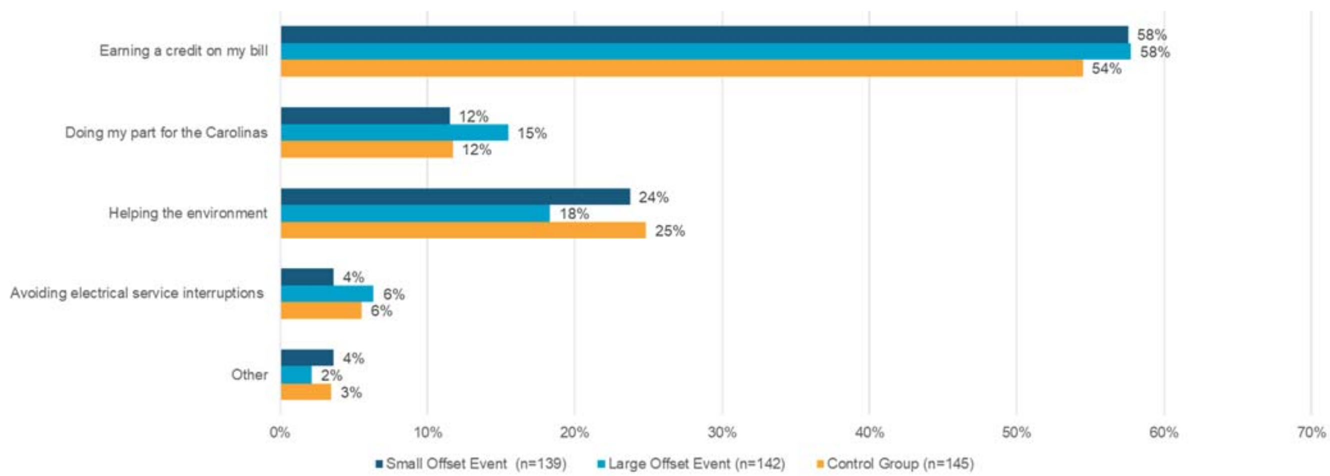
7.4 Motivation, Satisfaction, and Barriers

Respondents were provided with a list of possible reasons for enrolling in Power Manager and asked which reason was most important to them. Survey responses reveal that BYOT Power Manager participants were primarily motivated by monetary incentives, but were also motivated to enroll for

[4] The high temperature in the cities where surveyed respondents were located ranged from 60 to 65 degrees Fahrenheit on February 28.

altruistic and environmental reasons. The largest driver of enrollment was earning a bill credit[5] (56.6% of all respondents) and the second largest reason for enrollment was helping the environment (22.3% of all respondents). Given these findings, highlighting the non-monetary benefits of Power Manager enrollment in future marketing materials could be a point emphasis when recruiting new customers. Figure 7-5 details these motivations.

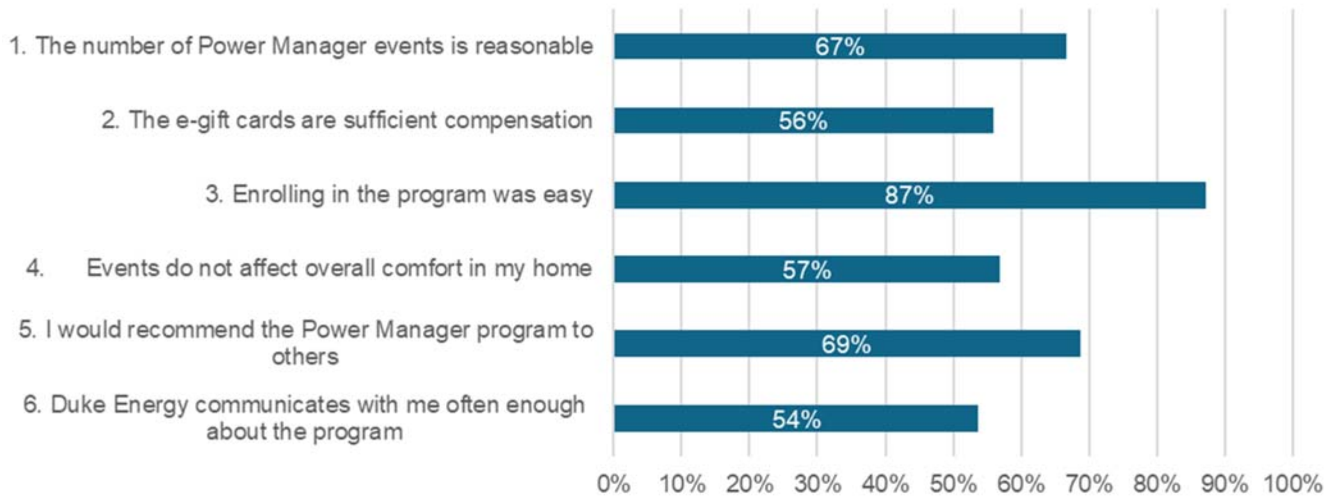
Figure 7-5: Motivations to Enroll – "Which of the following reasons was most important to you when enrolling in the Power Manager program?"



Next, customers were asked a series of questions to gauge their satisfaction with Power Manager. 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 attributes. Customers largely agreed with these statements by selecting 4 or 5 on the scale for the following questions: 87% of all respondents felt that enrolling in the program was easy, 68.7% of respondents would recommend the program, 66.7% of customers agreed that the number of events occurring was reasonable, and 56.9% of respondents agreed that events did not affect overall comfort in their homes. Figure 7-6 presents the percentage of respondents who "agree" or "strongly agree" with a series of statements regarding Power Manager.

[5] The survey question referred to the incentive as a "bill credit" in this survey question. The participants received an electronic gift card for participating in the program.

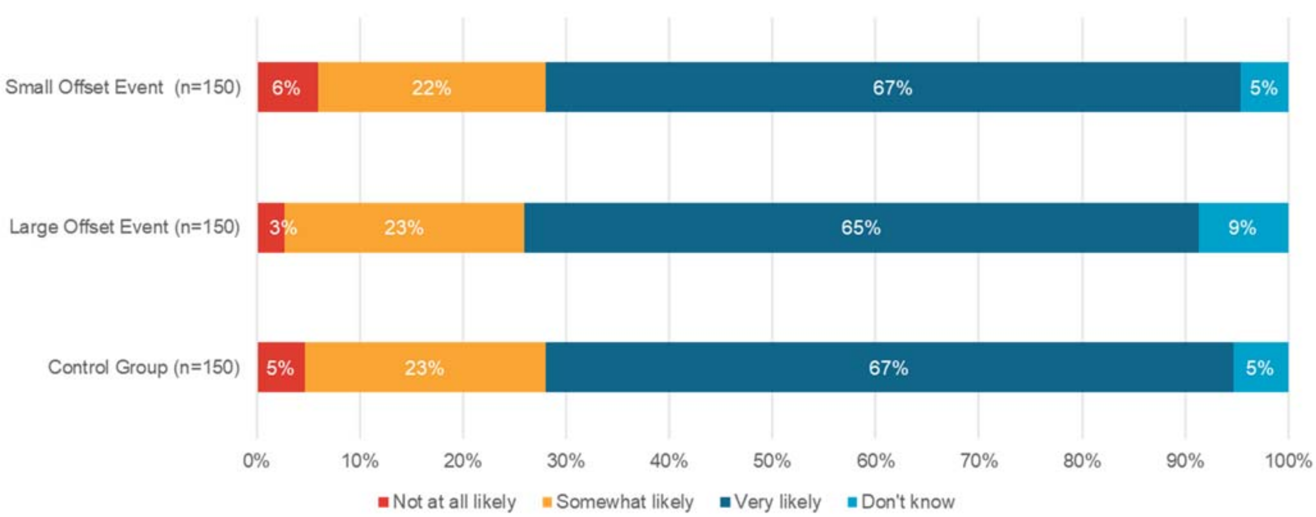
Figure 7-6: Percentage of Participants that Agree or Strongly Agree with Satisfaction Statements (n=450)



The results shown above provide strong evidence that the majority of Power Manager participants are satisfied with the program. The findings that are particularly revealing include the high percentage of participants satisfied with the ease of enrollment. Duke Energy should continue efforts to make enrollment as easy and seamless as possible. Also, the high likelihood of program recommendation is an indication that participants would be willing to tell their friends or family about the program.

Respondents were also asked how likely they were to stay enrolled in Power Manager, from 1 (not at all likely) to 3 (very likely). The majority of respondents across all groups (66.4%) indicated that they were "very likely" to remain enrolled. The proportion of respondents who responded "very likely" was not statistically different for treatment and control customers. Figure 7-7 highlights these responses.

Figure 7-7: Likelihood of Retention- "How likely are you to stay enrolled in Power Manager?"



The small number of respondents who answered they were "not at all likely" to remain enrolled were asked a follow-up free response question about why they were intending to leave Power Manager. A selection of responses are highlighted below. A common reason echoed by six respondents was that the change in temperature was not worth the incentive offered.

- "It's inconvenient in the winter when it's cold."
- "The discomfort isn't worth the small credit Duke gives me."
- "It isn't worth being hot or cold to get a nominal gift card"

Some respondents mentioned a need to keep their young children warm as the reason why they were leaving the program.

- "The nursery temperature needs to be the same, and the program would turn the temperature down at night"
- "I have a new baby, so I need the house to stay heated"

Finally, the survey concluded with an opportunity for customers to provide suggestions on how they think the Power Manager program might be improved. In total, 175 respondents offered feedback for Power Manager. Of those that wrote-in responses, 35 respondents stated that they were pleased with the program and had no suggestions. The most common suggestion, mentioned by 46 respondents, was a desire for better communication from Duke Energy regarding the program.

- "Better communication from Duke Energy about upcoming events"
- "Send the event notification by text. I don't often see the email or message in the Nest app"
- "24 hour advanced notice of a potential event"
- "Give us an after event email summarizing why, when, and what we gained from participating in Power Manager"

Also, 22 respondents suggested greater cash incentives for enrollment in the program.

- "More incentives/credit for even less use"
- "Increase compensation"

The third most common request, reported by 21 people, was allowing customers more control over their thermostats.

- "Nothing much but need to allow owner to change the temperature if it is really cold outside"
- "I'd like the ability to set min and max acceptable emergency limits. Having heat sensitive equipment that needs to be temperature regulated needs to have a set point that should not be exceeded. I've almost unenrolled because of this"

Table 7-3 summarizes categorizations of the free-form responses. Many responses fit into more than one coding category, thus the percentages add up to more than 100%.

Table 7-3: Respondent Suggestions to Improve Power Manager

Statement	Frequency
Better communication	27%
Increase monetary incentives	13%
Allow customers to adjust thermostats	12%
Fewer/shorter events	9%
Make incentives easier to claim	5%
No suggestions/happy with program	21%
Miscellaneous	12%

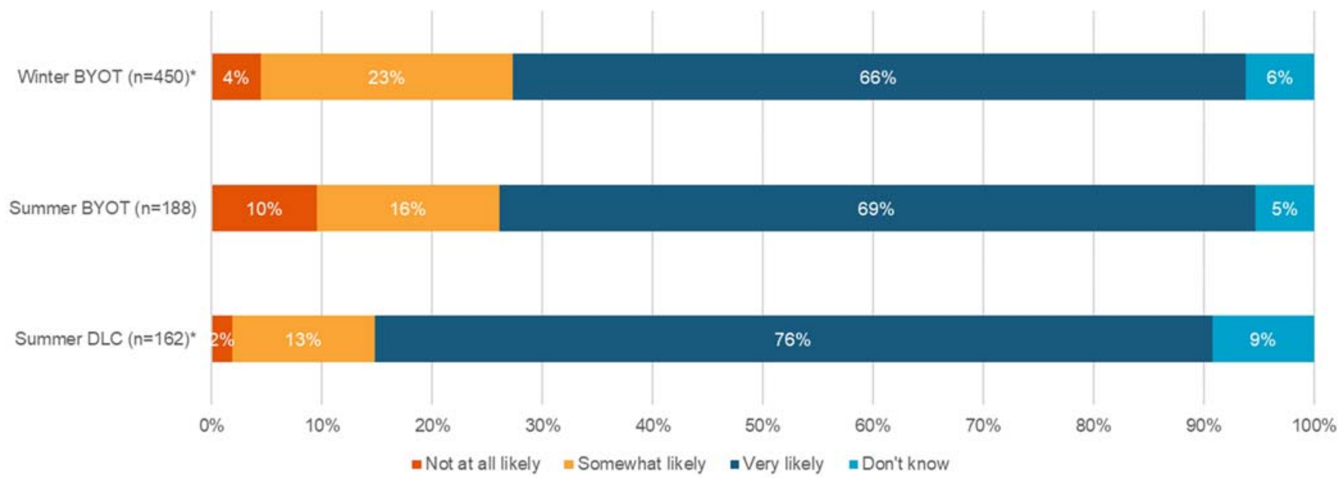
The high percentage of respondents who indicated they had no suggestions or were happy with the program provides further evidence that customers are generally satisfied with Power Manager. However, a common theme in the suggestions offered by respondents was respondents wanted increased communication from Duke Energy. Based on write-in responses, some participants would like advanced notice or event notifications. Duke Energy could consider implementing event notifications in the future so customers can prepare accordingly and are aware when events are occurring.

Additionally, clear and transparent communication about events can help reinforce that participation has tangible benefits to the electric grid. As shown in Figure 7-5, participants join Power Manager not only for financial reasons, but for altruistic motives as well. Some customers would like to know their efforts to save energy are actually making a difference. For example, one respondent wrote, "…help people understand when an energy event occurred, was the adjustment helpful i.e., did it save energy throughout the system." Additionally, one customer said, "It would be great to see an email saying the effect of the Power Manager event (i.e., "this much CO_2 reduce[d], this much total cost reduction") Power Manager is unique because it is a simple and straightforward program that allows individuals to make a quantifiable contributions to grid management. In other words, participants feel empowered when they can personally contribute to solving larger energy issues. Duke Energy can potentially communicate with customers the specific ways their participation is helping the environment and the grid so it is evident to them Power Manager is helping achieve broader goals.

7.5 Comparison with Summer Power Manager Events

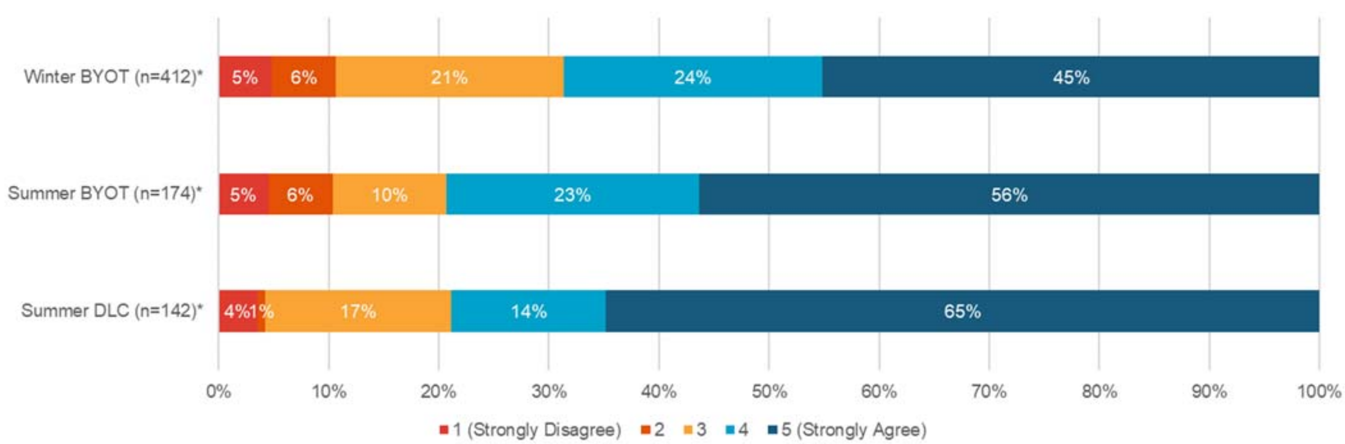
To compare customer perceptions of Power Manager over time, results from the Winter surveys were compared with responses from the Summer 2021 BYOT and DLC process evaluation surveys. Both the BYOT and DLC programs collected responses for the 2021 Summer season. In all three surveys, respondents were asked how likely they were to stay enrolled in the program and how likely they were to recommend it to others. We find that the percentage of customers in the Winter BYOT who responded they were "very likely" to remain enrolled was similar to that in the Summer BYOT survey, but was significantly lower statistically than the same metric in the Summer DLC survey. Likewise, the percentage of respondents who stated that they were likely to recommend the program in the Winter BYOT survey, while still the majority of all respondents, was significantly lower than that in the Summer BYOT or DLC surveys. Figure 7-8 and Figure 7-9 present comparisons of these key metrics for each survey.

Figure 7-8: Comparison to Previous Surveys: "How likely are you to stay enrolled in Power Manager?"



*Proportion who answered "very likely" in the Winter BYOT survey was significantly different from the Summer DLC survey

Figure 7-9: Comparison to Previous Surveys: "How likely are you to recommend Power Manager to others?"



*Proportion who answered "strongly agree" in the Winter BYOT survey was significantly different from the Summer BYOT and Summer DLC surveys

7.6 Interview Findings

Power Manager is an established Duke Energy demand-side resource that is actively used in the course of operating the Carolinas electric system. The demand savings delivered by Power Manager are made possible through the teamwork of internal and external stakeholders that support two distinct program options, the legacy DLC option and the newer BYOT program option. The team manages program budget and goals, communicates with participants, maintains the event dispatch software for the DLC option, coordinates with the BYOT implementer on event option set-up, uses the BYOT implementor software for event dispatch, and generally manages to event dispatch protocols. The Power Manager team also interacts with the customer at every stage of the program lifecycle, from enrollment, device installation, to device removal. Four primary stakeholder groups – the Duke Energy program management team, EnergyHub, Eaton Power Systems, and Franklin Energy – work together to deliver Power Manager to Duke Energy Carolinas customers. Resource Innovations interviewed four individuals from all four organizations. Through our conversations with the Power Manager team, we observe that Power Manager continues to maintain customer-focused and team-oriented program operations.

The remainder of this section will describe the Power Manager customer offering in the Carolinas and what Duke Energy's activities are to bring in new program participants and deliver demand response load impacts to the system. A description of program operations follows immediately below, which is followed in turn 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.

7.6.1 Program Participation Recruitment and Enrollment

Duke Energy's 2021-2022 enrollment and operational objectives are driven by their integrated resource plan (IRP) and carbon plan. Recruitment of Duke Energy Carolinas customers into Power Manager takes place year-round in order to meet program objectives. As of year-end 2021, Duke Energy had more than 280,000 customers in the Carolinas enrolled in the DLC and BYOT program options and with approximately 5,000 customers specifically enrolled in the winter-focused BYOT option. The recruitment approach for the legacy DLC program offer and the BYOT program offer differ; for brevity, we only describe the BYOT program option recruitment activities.

Duke Energy relies on participating smart thermostat manufacturers for most enrollment into the BYOT program option. Each of the participating thermostat manufacturers communicate with their customers through combinations of email, SMS text, mobile app, website, and via the thermostat itself. As an example of a typical BYOT enrollment scenario, when the customer sets up a new smart thermostat, they are prompted to enter their ZIP code. The ZIP code enables the thermostat provider to recommend enrollment in Power Manager if the ZIP code is within the service territory of Duke Energy Carolinas. Most enrollments are generated through this pathway. Other enrollments occur after thermostat setup when the thermostat providers periodically email or send in-app messages their customers with invitations to sign up for Power Manager.

EnergyHub is a service provider engaged by Duke Energy to administer the BYOT program option. They operate a customer service center that is responsible for BYOT program option customer service – which includes providing support to Franklin Energy which serves as the first line of BYOT customer service – answering customer questions and administering program enrollment and unenrollment. EnergyHub is also responsible for aggregating the enrollments from all partner thermostat manufacturers into their program management system. Their system enables visibility into the connectivity (and dispatchability) status of nearly all enrolled thermostats.[6] After verifying connectivity, EnergyHub sends enrollments to Duke Energy for customer identification verification and eligibility verification. Identification verification is necessary because customers are not required to provide their Duke Energy account number for enrollment, which significantly increases program uptake. Duke Energy additionally verifies that the customer is not already enrolled in the DLC program option. EnergyHub is also responsible for distributing enrollment incentives. BYOT program option participants receive a $75 e-gift card upon enrollment as well as $25 annual e-gift cards for each year of enrollment thereafter.

EnergyHub observes that multiple marketing touches through different channels increase program uptake. For example, if a customer sees a Power Manager promotion from Duke Energy, followed by another promotion from Nest, they are more likely to sign up after receiving the second prompt that appeared in the different communication channel. EnergyHub also observes that BYOT program option participants tend to be in higher income brackets. They recommend reaching customers with lower levels of income via utility-operated online stores where the thermostat is sold at a discounted price.

Duke Energy also directly promotes Power Manager (both the DLC and BYOT options) through direct mail, email, and in MyHER reports. Customers who have purchased qualifying thermostats through Duke Energy's online store, are routinely targeted with Power Manager offers. Figure 7-10 shows the presentment of Power Manager promotions in MyHER.

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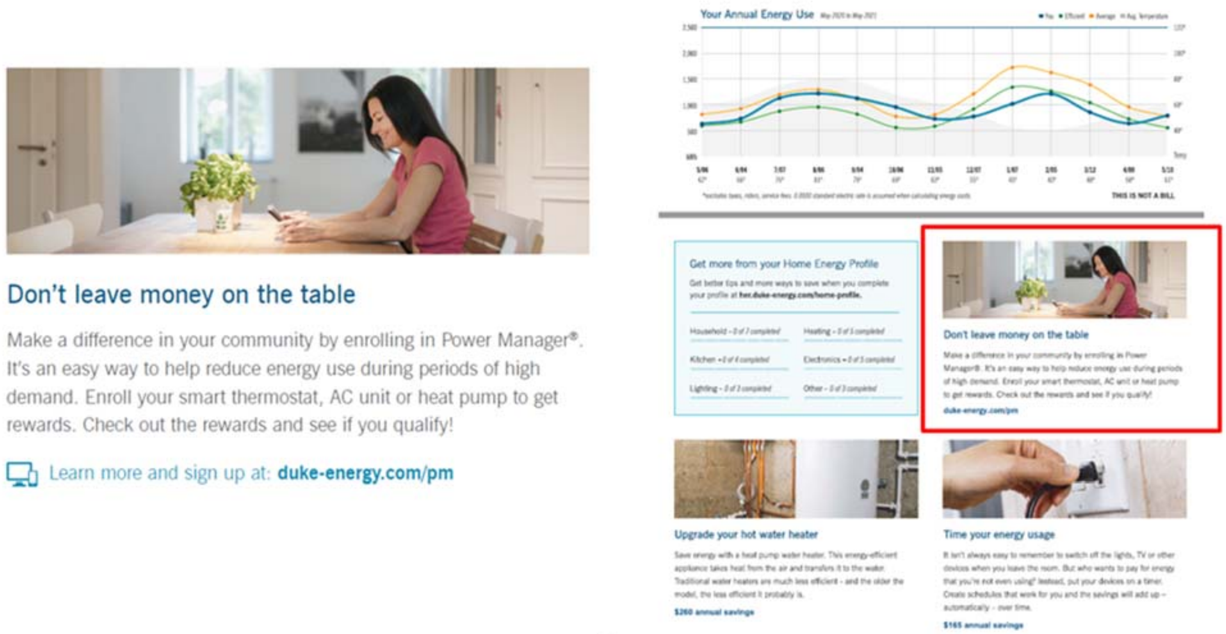
6 Nest thermostat connectivity status was not visible to EnergyHub in 2021 but will be in 2022.

Figure 7-10:: MyHER Power Manager Promotional Message



7.6.2 Power Manager Program Operations

Power Manager BYOT program option events are scheduled primarily by the Power Manager program manager, mainly considering local system and weather conditions as well as EM&V testing needs.

In anticipation of possible event days, the Power Manager program manager includes staff from Duke Energy's Energy Control Center and Fuel and Systems Optimization groups in event decision discussions. Advance event discussion and preparation makes the day-of event calling process operate smoothly. The Power Manager program manager maintains control of the decision to call nonemergency events. Power Manager is viewed as an important resource for the Duke Energy Carolinas system that depends on the participating customers' willingness to remain enrolled. Therefore, all events are called with the program manager's view towards whether or not it will be a detriment to the experience of the participants and their continued participation. Considerations taken in this area are the number of events that have already been called during the current winter, during that week, at what hours and duration events are taking place, and the depth of the load shed under consideration (i.e., setpoint offsets).

Apart from determining whether a given day will be a Power Manager event day, Power Manager program operations for the DLC and BYOT options are different, largely because Duke Energy manages the operations of the DLC option and outsources the operations of the BYOT option to EnergyHub. The following subsection describes operations for the BYOT program option.

The BYOT program option requires a lower level of overall effort and coordination for Duke Energy and its contractors in terms of planning and activities involved in preparing the BYOT program option for operations, as compared to the DLC program option. This is a result of the value that EnergyHub brings to the program as the implementer and because participants provide their own thermostat. At the outset of each heating season, EnergyHub communicates with Duke Energy to understand their goals for enrollment and per household load impact for the year, and to affirm commitments to platform availability uptime, and the timing of delivering preliminary estimates of load impacts from the thermostat manufacturers. EnergyHub additionally advises Duke Energy on dispatch strategy (i.e., number of degrees setback, pre-heating duration) that will help ensure Duke Energy meets their operational goals. The EnergyHub and Duke Energy teams meet weekly to coordinate.

As soon as Duke Energy verifies an enrolled customer's eligibility for the program, their thermostat is immediately available for dispatch by EnergyHub. Experimental groups are set up in the fall to support RCTs that the Resource Innovations impact evaluation depends on. In this case, Resource Innovations provides the RCT group assignments to Duke Energy, and Duke Energy simply provides it to EnergyHub for implementation – Duke Energy staff are not involved in addressing thermostats enrolled in the program. The group assignments ensure that there is always a group of customers held back from each event to serve as a control group for the impact evaluation. EnergyHub reports that their system is flexible enough to accommodate programming many experimental groups. Their system can launch any of those groups with any combination of dispatch strategies. They report that programming the 2021/2022 winter experimental groups was a straightforward task to carry out.

EnergyHub, per scheduling and set-up of the event by the Duke Energy program manager, dispatches BYOT events using their headend system that communicates with all enrolled thermostats via API calls to the thermostat manufacturers which in turn communicate with the thermostats. EnergyHub has the ability to dispatch events with at least 15 minutes' notice.

The BYOT program option offers the capability of pre-heating participants' homes prior to events (so long as EnergyHub receives enough advance notice to leave time for pre-heating). Pre-heating enables deeper thermostat setbacks during event hours with less impact on thermal comfort in the home. Unlike the DLC program option, BYOT option participants are informed prior to and during events through their thermostat provider's mobile apps or websites and on the thermostat itself.

BYOT program participants can opt-out of events by adjusting their thermostat setpoints. They also have an opportunity to opt-out in advance of the event if they receive or see the notification. EnergyHub reports that very few customers opt-out in advance (3%); they report that overall, opt-out rates during the course of events typically range between 20-30%. EnergyHub works to minimize opt-outs by advising utilities like Duke Energy to avoid overburdening program participants with very deep setbacks or very long events, or overcommunicating with too many pre-event notifications.

7.6.3 Program Monitoring and Postseason Maintenance

EnergyHub performs an annual connectivity optimization activity whereby customers are removed from the program if their thermostats remain disconnected for more than 60 days. The existence of the $25 annual participation incentive helps when EnergyHub communicates with these customers prior to removal from the program – the reminder that the annual $25 incentive will be lost motivates customers to reconnect their thermostats. EnergyHub also engages with Duke Energy on strategies that have the potential to increase the load shed. EnergyHub's dispatch team often runs API test calls to make sure the platform is meeting uptime requirements with all thermostat manufacturers during the event season.

7.6.4 Upcoming Program Changes and Initiatives

Duke Energy and their partners are continuing to maintain Power Manager, the BYOT option in particular, as a cost-effective system resource for the Carolinas. Duke Energy's partners also offer somerecommendations to contribute to continuous program improvement:

- EnergyHub recommends enhancing the annual goalsetting process to include an EnergyHub-hosted survey to get feedback on the customer segments that the program option is succeeding with, and which segments could stand increased focus to increase uptake.
- EnergyHub also notes that most BYOT participants are from upper income levels. Duke Energy should drive enrollment of households from income brackets lower than that of the current typical BYOT customer by continuing to offer discounted BYOT-eligible thermostats on Duke Energy's-sponsored online storefront.

7.7 Key Findings

- 450 BYOT Power Manager participants were surveyed beginning the afternoon of February 28, 2022, following a Power Manager event that morning. Of these 450 respondents, 150 were randomly assigned to experience a small offset event, 150 were randomly assigned to experience a large offset event, and 150 were randomly assigned to not experience an event at all.
- A large majority of all survey respondents, 88.2%, reported that they are familiar with the Power Manager program.
- About 23.7% of both sets of survey respondents—those that had and those that had not experienced an event—reported that their homes were uncomfortable during the event day. There was no measurable increase in customers' stated thermal discomfort due to Power Manager events generally or due to the larger offset in comparison to the smaller offset.
- 56.6% of respondents reported that financial motivations were the primary reason they are participating in Power Manager. The second-most common motivation was "helping the environment."
- Overall, 89.3% of survey respondents state that they are "very" or "somewhat" likely to remain in the program.
- 68.7% of respondents "strongly" or "somewhat" agreed that they would recommend the Power Manager program to others.
- The most common suggestions that customers had to improve the program were better communication from Duke Energy (175 customers) and greater monetary incentives (22 customers)

8 Conclusions and Recommendations

8.1 Impact Evaluation Conclusions and Recommendations

Conclusion: The Power Manager BYOT program produces significant results in reducing peak load demand for Duke Energy's residential customers. On average, Winter 2021-2022 events achieved 1.24 kW (35%) load reduction per household.

> **Recommendation:** Continue to promote the Power Manager program to DEC 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 to demand savings.

Conclusion: Differences in event period temperatures are typically larger drivers of differences between event impacts than the pre-heat and offset scenarios.

> **Recommendation:** Reserve the use of extreme pre-heat and offset scenarios for days with critical system conditions, as the impacts from large offsets may only be marginally greater, but there could be a higher risk of customer discomfort.

Conclusion: The time-temperature matrix predicts demand reductions of -2.33 kW per household for a 1-hour event beginning at 7:00 AM with 90-minute 3 degree preheat with a 4 degree event offset.

> **Recommendation:** Revisit the time-temperature matrix requirements after the upcoming heating season and confirm that current methodologies accurately reflect the current dispatch strategy under a realistic set of temperature conditions.

8.2 Process Evaluation Conclusions and Recommendations

Conclusion: There were no statistical differences between the percentage of respondents who reported discomfort among the control and treatment groups. While respondents in the treatment group were more likely to report that they believed an event occurred, most of those respondents did not adjust their behavior.

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

Conclusion: 68.7% of survey respondents state that they are likely to recommend the program to others. 89.3% of survey respondents state that they are likely to remain enrolled. There were no differences between event and nonevent respondents for either question, nor for any other satisfaction questions. Therefore, Power Manager events do not measurably affect customer satisfaction in either direction.

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

Conclusion: The majority of suggestions for improvement from customers spoke to perceived communication gaps from Duke Energy. 46 BYOT respondents suggested that Duke Energy communicate better with participants prior to and following Power Manager events. Respondents often suggested that these notifications be sent by text message or email.

Recommendation: Evaluate Power Manager's participant communication approach – before, during, and after load control seasons – and consider ways to communicate with participants more, even if only through opt-in communications that interested participants can elect to receive. Increased program communication is the most-requested program improvement mentioned in participant surveys. Improved communication could improve customer satisfaction and increase positive word-of-mouth awareness.