Final Learnings Report

Bring Your Own Device Battery Study

FINAL

OFFICIAL COPY

Jun 13 2023

Executive Summary

Duke Energy customers with solar power and home battery storage primarily use batteries as backup energy for power outages and to save money on energy bills; however, batteries can also be used to shift customer load during times of peak demand in exchange for compensation. Duke Energy would like to conduct a study to test battery related demand-response technology, evaluate the customer experience, gauge battery usage behaviors, and inform on the potential future benefit of an incentive-based battery demand-response program designed to build a smarter, cleaner, energy future.

Duke Energy Florida (DEF), Duke Energy Carolinas (DEC) and Duke Energy Progress (DEP) residential customers with an interconnected solar and a home battery storage system on net-metering billing were eligible to participate in this study to test the technology and provide feedback on customer experience, with some applicable exclusions. They will receive $200 total in compensation ($100 paid at start of study and $100 upon conclusion) for providing their battery data, allowing control of their battery, and participating in surveys throughout the study. Participants will allow Duke Energy to control their battery for 12 months with the ability to discharge up to 50% of the battery's stored capacity. The program calls up to 5 events per month which last until either a pre-defined time window (2–5-hour event duration) or 50% capacity-take threshold has been reached. Participants are also able to opt out of up to 5 events during the study. Battery manufacturers participating in the study were restricted to Generac and certain configurations from Solar Edge/LG Energy; customers with batteries from other manufacturers were not eligible. Customers that have leased or financed their battery storage systems through SunRun or PowerHome Solar were also eligible as of early 2021 after being brought on board due to learnings from the DEF launch.

A contract with third party aggregator Virtual Peaker ("VP") was executed and formal kick-off with the vendor occurred in early July 2021. Prior to contact signing, the Lab assisted with pre-work activities to develop and deliver a highly targeted customer email and Qualtrics pre-registration form to approximately 180 known solar/battery DEF customers with the desire to get 25-50 customers to confirm interest in participating in a future study. Upon conclusion of the pre-work in May 2021, 32 customers expressed interest in participating and solidified Leadership's commitment to pursuing the full-scale study which had an initial goal of 90-100 total participants across all service territories involved. The study was rolled out to customers in a staggered fashion, beginning with DEF customers in October 2021 and expanding to DEP/DEC NC and SC customers in Q1 2022. Initial acquisition targets were as follows:

- Overall: 100 participants (hard cap)
- Florida: 25
- North Carolina: 65
- South Carolina: 10*

**Note: In Q1 2022 Leadership made the decision to discontinue the study in South Carolina after identifying the need for an unexpected regulatory filing to gain study approval. As such, the study was only executed in the DEF and DEC/DEP North Carolina jurisdictions.*

This prototype explores customer satisfaction with the program, identifies process improvements, and provides insights into customer support needs and program desirability. The Lab was also involved in vendor communications and calling demand response events. These roles help to support exploring vendor feasibility, particularly the ability of the aggregator to receive battery data and dispatch commands to various customer-owned batteries. The Lab also assisted in customer acquisition, customer inquiries, data aggregation and summarization to provide insights into the viability of the program. Periodic surveys and other VOCs will also be facilitated by the Lab throughout the course of the study to drive insight into customer experience and learnings. The program data analytics team will gather and report on data to help determine and assess the timing of events and whether peak demand savings are large enough to generate attractive incentives for customers and battery manufacturers.

OFFICIAL COPY

Jun 13 2023

Final Learnings Report

Bring Your Own Device Battery Study

FINAL

DUKE ENERGY.

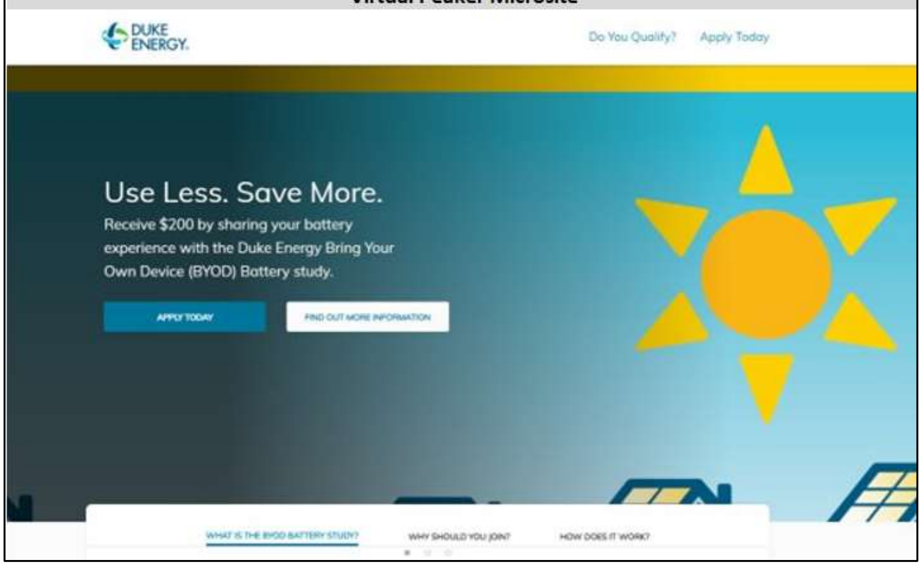
DEF Customer Launch – Marketing, Acquisition, & Enrollment

The Bring Your Own Device Battery Study (BYOB or "the study") DEF customer acquisition efforts launched in October 2021. The team planned for 1 month of acquisition and onboarding of customers with intent of calling events from November 2021 – October 2022. A potential customer list of approximately 190 eligible solar/battery storage system owners was identified (e.g., net metering customers with SolarEdge or Generac systems), including the ~30 customers that had expressed interest in the study during pre-work activities. The list was sourced from an existing Salesforce Interconnection DataMart file from Brian Dougherty, which made identifying potential participants easy. The team expected participation in the study to be high due to the interest form response rate from the same customer group during pre-work.

Marketing & Acquisition

The team leveraged the VP platform to develop a study microsite and enrollment form. Acquisition emails sent by the CPL included a link to the microsite for customers to learn more about the study and enroll. The microsite contained all pertinent study details as well as the enrollment form which simplified the customer enrollment experience. See Microsite and acquisition email screenshots below.

Virtual Peaker Microsite



Acquisition Email - Interest Form Customers | **Acquisition Email - All Other Customers**

OFFICIAL COPY

Jun 13 2023

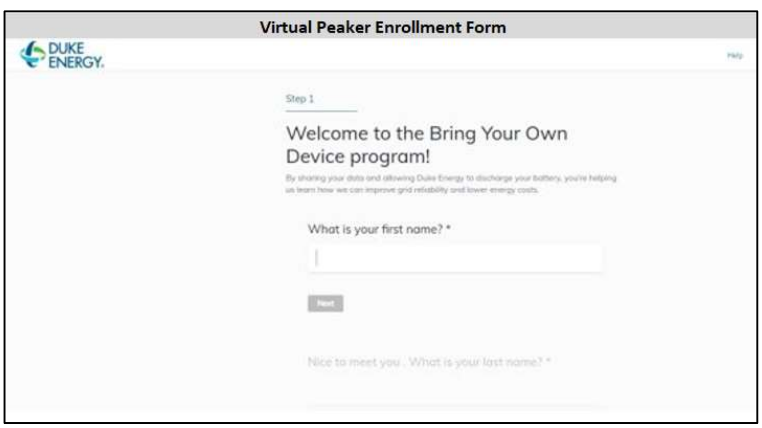
Given the limited number of participant slots in DEF (target 25) and anticipated interest in the study, the team chose to stagger marketing email sends. See dashboard screenshot below. The first campaign was sent on October 6, 2021, to the 32 DEF customers who had previously expressed interest in the study during pre-work. Beginning on October 11, 2021, emails were sent to the remaining customer list over 3 days in batches of ~50. Three additional "reminder" emails were subsequently sent through the end of October to all customers that did not enroll to try and boost participation. Despite higher than average open and click through rates, completed enrollment form submissions were lower than expected. The CPL performed outbound calling to 40 customers that had opened the marketing emails but did not submit an enrollment form, which yielded no additional enrollments. In total, 32 enrollment forms were submitted (16.7% of customers contacted).

Sent Date	Mailing Name	Subject Line	Number Sent	Number Received	Unique Opens	% Opened	Unique Clicks	% Clicked	Effective Rate
Wednesday, October 06, 2021	Previously Interested	Battery study is open! Claim your spot and $200.	32	32	19	59.38%	12	37.50%	63.16%
Monday, October 11, 2021	Interested Did Not Enroll/ First Additional 50	Want $200 to tell us about your battery?	75	75	34	45.33%	15	20.00%	44.12%
Tuesday, October 12, 2021	Second Additional 50	Want $200 to tell us about your battery?	50	49	14	28.57%	7	14.29%	50.00%
Wednesday, October 13, 2021	Third Additional 50	Want $200 to tell us about your battery?	59	59	19	32.20%	9	15.25%	47.37%

Recommendation: *Manufacturer participation was limited to Generac and SolarEdge. For full-scale program, a determination should be made as to which manufacturers, and how many, we need to participate to get desired benefit. For example, Tesla is the most common battery manufacturer in the DEF jurisdiction but did not participate in the study, thus significantly limiting our potential customer base.*

Enrollment & Provisioning

To enroll, customers were required to complete and submit the enrollment form on the VP microsite. The enrollment form (screenshot below) gathered key information about the customer and their device including name, address, battery system manufacturer (Generac/Pika or SolarEdge/LG Chem), and device serial number. It also required the customer to read and agree to the study terms and conditions. Once the terms and conditions were accepted and enrollment form submitted, a "house" was automatically generated in VP as a record of each customer's enrollment for tracking.



The team discovered early on that enrollment forms were regularly being submitted without the device serial number (e.g., no device associated with the house). Without the serial number, customer devices could not be provisioned/added to the VP – manufacturer API to allow VP to communicate with and control the device. Approximately 50% of the original 32 enrollment forms submitted in DEF did not contain the device serial number. The CPL performed both email and phone outreach to these customers to try and obtain the needed information but only successfully completed enrollment for 2

OFFICIAL COPY

Jun 13 2023

additional customers. The team learned that customers were struggling to find their device serial number or were not physically near the device to locate the serial number when completing their enrollment forms.

Recommendations:

- *Include link to VP's article on how to find battery serial number in the enrollment form and follow-up emails to customers who submit enrollment forms without this information. Also consider making device serial number a required field so enrollment forms must be fully complete prior to submission.*
- *Explore opportunities to allow a customer to return to their enrollment form at a later time to finish completing required fields. The VP form timed out after 15 minutes.*
- *Explore the possibility to obtain a release from the customer that would enable Duke Energy to acquire device serial number information directly from the equipment installer or manufacturer.*

Enrollment forms submitted with the device serial number automatically generate both a house record and linked device in VP. To complete enrollment, the customer devices have to be provisioned by the battery manufacturers. Per early discussions with VP, the team expected device provisioning to take no longer than 1-2 weeks per customer; however, it regularly took longer than this, sometimes in excess of 1 month. There were several reasons why provisioning took so long. First, there were no explicit service level agreements in VP's SOWs with the manufacturers to ensure timely provisioning. Second, device serial numbers were occasionally entered incorrectly, which required customer follow-up to resolve. Additionally, several enrolled devices were experiencing technical issues, which required manufacturer site visits and fixes. Unexpected delays in provisioning ultimately led to lost event calling opportunities in November 2021.

Recommendations:

- *Plan for a longer enrollment and provisioning window for the Carolinas launch to avoid losing any time for calling events.*
- *For future program/pilot, ensure explicit SLAs and expectations are established with all participating vendors for their respective tasks to drive accountability.*

During the device provisioning process, the team was informed by VP/battery manufacturers that 4 enrolled customers actually leased their batteries through SunRun. This called into question whether leased systems were eligible to participate and led the team to engage with SunRun directly to determine how to handle these customers. We eventually brought SunRun into the process, no fee/payment made, and determined that leased systems could participate as long as those customers were allowed to receive the incentive. SunRun worked with customers as necessary to resolve any system technical issues and we eventually were able to successfully onboard 2 of the 4 SunRun leased sites. The other 2 sites were not eligible to participate due to their device configurations.

Recommendation: *Determine whether leased and rented systems would be eligible to participate in a broader battery storage program/pilot and work with relevant vendors early on to iron out details of participation and receipt of incentive.*

After bringing SunRun onboard, we tried to leverage their customer relationships to obtain more participants. Note, we did not offer SunRun payment or a fee per customer enrolled. In January 2022, VP and SunRun sent over a list of 11 DEF customers for outreach. This did not pan out because no due diligence was performed by SunRun or VP with these customers to assess their level of interest. Despite the CPL performing email outreach, none of these customers enrolled in the study.

When enrollment officially closed Q1 2022, 11 total customers (44% of target goal of 25) had been successfully provisioned and included in DR events. By the conclusion of the FL study in October 2022, 2 participants had unenrolled. Unenrollment reasons included the volume of events and low incentive amount (1) and battery failure (1).

Carolinas Customer Launch – Marketing, Acquisition, & Enrollment

The study launched with customers in the Carolinas on January 10, 2022. Given our learnings from the DEF launch, the team planned for 2.5 months of acquisition and provisioning with a goal of calling events from April 2022 – March 2023. A potential customer list of approximately 810 eligible solar/battery storage system owners in DEC/DEP North Carolina (~670) and South Carolina (~140 customers) was identified.

Final Learnings Report
Bring Your Own Device Battery Study

FINAL

DUKE ENERGY.

OFFICIAL COPY

Jun 13 2023

Marketing & Acquisition

The team leveraged the same VP microsite, enrollment form, and email creative for the Carolinas customer launch as was used for DEF. We applied learnings from the DEF launch, specifically around low enrollment rates, and opted to send the acquisition emails to the entire customer group immediately rather than staggering the sends. Knowing follow-up marketing campaigns would be required, the team used our first email send as an A/B subject line test with 50% of the customer group receiving each. The test looked at one subject line with a renewable energy angle, and the second subject line referencing the $200 incentive (see “Carolinas First Send” stats in dashboard screenshot below). The email with subject line referencing the $200 incentive saw higher open and click through rates (16.75% vs. 11.84% click through rates). Therefore, the team referenced the $200 incentive in the subject line of each subsequent email campaign. A total of 5 campaigns over 3 separate dates were sent between January 10 and February 3 of 2022.

Email Statistics									
Sent Date	Mailing Name	Subject Line	Number Sent	Number Received	Unique Opens	% Opened	Unique Clicks	% Clicked	Effective Rate
Monday, January 10, 2022	Carolinas First Send	Help build a renewable energy future with your battery	398	397	150	37.78%	47	11.84%	31.33%
Monday, January 10, 2022	Carolinas First Send	Want $200 to tell us about your battery?	401	400	177	44.25%	67	16.75%	37.85%
Thursday, January 20, 2022	North Carolina Second Send	Get $200 to tell us about your battery – Spaces are Limited!	287	287	90	31.36%	23	8.01%	25.56%
Thursday, January 20, 2022	North Carolina Second Send	Want $200 to tell us about your battery?	320	319	111	34.80%	35	10.97%	31.53%
Thursday, February 03, 2022	North Carolina Third Send	Enroll Now - Last Chance to Earn $200 for Battery Study	584	582	194	33.33%	38	6.53%	19.59%

For the Carolinas launch, the team engaged with Pink Energy (previously PowerHome Solar) to assist with customer acquisition. Unlike our engagement with SunRun, Pink Energy was offered $250 per customer they helped enroll in the study. This relationship was more fruitful than that with SunRun and yielded 10 customer enrollments in a short 3-week window. Pink Energy did the legwork to contact those customers, work with them to accurately complete enrollment forms, and work with the manufacturers as needed to ensure successful provisioning of their devices.

In fall 2022, Pink Energy abruptly went bankrupt, leaving many study participants without a local installer to assist with device issues. Further complicating the situation, customers indicated that other local installers were limited and hesitant to work on Pink installed devices. Therefore, customers needed to work closely with OEMs to try and solve these issues, which led to several instances where customer devices were unable to participate for month. The team chose not to penalize these customers by terminating their participation given their transparency into the situation and desire to resolve device issues to continue participating.

Customer VOCs/verbatims received by the CPL include:

- “I have an issue with my Generac PowerCell system. It has been offline for a month, due to a problem we had with our Spectrum internet service. The internet service was restored, with a new router and modem, but the PowerCell was not reconnected to the new wireless signal…The PowerCell was installed by our friends at PowerHome Solar/Pink Energy, who are no longer in existence. Generac suggested that I try to find a local solar company to take over my service, but so far, the only LOCAL company that I have found is reluctant to take on systems installed by PowerHome Solar/Pink Energy.”
- “I noticed that my battery has been offline too. I am having trouble getting responses about how to resolve the problem. I am working on it. I hope to remain in the study.”

Recommendations:

- *For a scaled program/pilot, consider including more turnkey vendors in the customer marketing and acquisition process. Penetrating established customer relationships yields a smoother and more successful enrollment and provisioning process and improves the customer experience. However, consideration should be given to potential impacts to customers and Duke Energy if/when issues befall any engaged vendors, like in the case of Pink Energy.*

OFFICIAL COPY

Jun 13 2023

- *Explore opportunities to enter a broader program/pilot into the manufacturer/dealer device sales process with a rebate for purchase or ongoing incentive for program participation.*

We applied learnings from the DEF launch and updated the enrollment form to link to the VP article on locating device serial numbers; however, the same enrollment and provisioning issues noted during the DEF launch were also observed in the Carolinas. Enrollment forms were submitted without device serial number, provisioning often took more than 2-3 weeks, and issue resolution was slow due to inefficient communication channels with the battery manufacturers (e.g., all communications had to flow through VP). The team chose not to make device serial number a required field because we suspected that enrollment form submissions would decline. Allowing them to be submitted absent device serial number at least helped us identify interested customers that we could follow-up with to assist in completing enrollment.

Recommendations:

- *Add screenshots to the enrollment form itself on where customers can locate the device serial number. VP's article was inadequate, and customers continued to lack clarity on how to find necessary information. Also consider making device serial number a required field so enrollment forms must be fully complete prior to submission.*
- *Consider a platform where all parties can communicate status and customer follow-up needs. The email communications with VP and the manufacturers were inefficient and difficult to stay on top of as we were often following-up on several devices across several email threads.*
- *Consider offering a customer a program/pilot like this upon establishing their interconnection agreement which would provide an opportunity to ensure all information is available and vetted before enrollment.*

When enrollment officially closed for DEC/DEP at the end of Q1 2022, 62 customer devices in North Carolina (95% of target goal of 65 customers) had been successfully provisioned. By the conclusion of the study, 5 NC participants had unenrolled, leaving 57 participants remaining at close. The reasons for unenrollment included:

- Customer devices were offline for 2+ months and customers were not responsive to reconnection efforts *(2)*
- Too many events/too low incentive (1)
- Customer moved and transferred system ownership (1)
- Customer was dissatisfied with study device settings (a self-supply mode customer) (1)

As previously noted, the study was discontinued in South Carolina. All 15 SC customers, 8 that were already provisioned and paid their initial $100 incentive and 7 that were pending provisioning, received email notification of the study ending in May 2022. No events were called on their systems.

Compensation

Per the study Terms & Conditions, customers were compensated a total of $200 for participation. First, a $100 check was issued to each customer upon successful device provisioning and a second $100 check issued upon completion of their 12-month participation obligation. Also noted below in "Survey Results" section, the team incentivized NC participants with a $15 e-gift card upon completing and returning the study-end customer satisfaction survey. Total compensation + incentives paid out for the program was just under $15K, as broken down below:

Compensation/Incentive	FL Study	NC Study
1st Compensation Check	$1,100	$6,200
# participants receiving comp:	*11*	*62*
2nd Compensation Check	$900	$5,700
# participants receiving comp:	*9*	*57*
$15 Survey Completion Gift Card	N/A	$390
# participants receiving comp:	*N/A*	*26*
Total Customer Incentives Paid:	**$2,000**	**$12,290**

Customer feedback on study compensation:

- "I personally would have liked a greater amount. Solar is a relatively new concept and way of thinking. Studying my battery and household gives invaluable information to do things better in the future for all of us. Results are priceless in my opinion."

FINAL

DUKE ENERGY.

OFFICIAL COPY
Jun 13 2023

- "I think a monthly stipend would have been better, based on how much energy was collected by Duke."
- "Compensation felt insufficient, especially on winter days. A year was a long time to go through this study."

Recommendation: *Perform more thorough analysis of incentive amount and method of payment for a scaled program or pilot. The $200 study incentive appears to be insufficient for the volume of events being called, especially when considering the cost of the technology. We should assess the best method for paying the incentive out as well, whether that be lump sum payment, monthly payments or monthly bill credits dependent upon energy supplied by the customer, or other alternatives.*

Events

Throughout the 12-month study, Duke Energy had the ability to call 5 demand-response events per month in each jurisdiction. Within the VP platform, customer devices are grouped into platoons for event calling based on various characteristics including location, battery manufacturer, battery mode (backup vs. self-supply), and capacity. Note that location and manufacturer were not used in NC after learning these were not influential characteristics for DEF. Therefore, 5 customer platoons were leveraged for DEF and 3 for NC. The other 3 platoons shown below were utilized internally by the project team for testing Duke Energy owned batteries in both jurisdictions.

Platoons

	Name	Description	Total Houses	Total Devices
1	Customer Hold - DEFAULT	default platoon to hold enrolled customers until assigned to more granular platoon	1	1
2	Duke Florida Test	SolarEdge Battery at Florida Test Home	1	1
3	Generac-FL-Self-Supply	All FL Generac Batteries configured to Self-Supply Mode	2	2
4	Generac-Orlando-Backup-<12kWh	To capture all Generac batteries <12kWh max capacity in the Orlando region, set in Backup mode.	0	0
5	Generac-Orlando-SelfSupply->12kWh	To capture all Generac batteries >12kWh max capacity in the Orlando region, set in Self-Supply mode.	0	0
6	Mt. Holly Battery Test	Platoon solely designed for Mt. Holly Test devices	1	2
7	NC – Backup – Large	All NC batteries configured to a backup mode with >10kWh max capacity	4	4
8	NC – Backup – Standard	All NC batteries configured to a backup mode with <10 kWh max capacity	37	37
9	NC – Self Supply	All NC batteries configured to self-supply mode	21	21
10	Solaredge-Orlando-Backup	To capture all houses with Solaredge devices in the Orlando region that utilize backup as their control mode	3	3
11	Solaredge-St. Pete-Backup	To capture all houses with Solaredge devices in the St. Pete region that utilize backup as their control mode	3	3

Events were called at the platoon level and were generally planned for based upon anticipated weather conditions and peak times in each jurisdiction. During March 2023, the team also ran 2 events during peak solar hours (1pm EST) to learn more about inverter saturation. See charts below for the event summaries for each jurisdiction through the end of the study (3/31/23):

FL Event Summary

Month	# Morning Events	# Afternoon Events	# 3 Hour Duration Events	# 4+ Hour Duration Events	Total Events
21-Nov	0	1	1	0	1
21-Dec	3	2	5	0	5
22-Jan	5	0	0	5	5
22-Feb	4	1	5	0	5
22-Mar	0	5	5	0	5
22-Apr	0	5	5	0	5
22-May	0	5	5	0	5
22-Jun	0	4	0	5	4
22-Jul	0	5	0	5	5
22-Aug	0	4	2	2	4
22-Sep	0	3	3	0	3
22-Oct	0	3	3	0	3
FL Totals	**12**	**38**	**34**	**17**	**50**

NC Event Summary

Month	# Morning Events	# Afternoon Events	# 3 Hour Duration Events	# 4+ Hour Duration Events	Total Events
22-Apr	2	3	4	1	5
22-May	0	3	3	0	3
22-Jun	0	5	0	5	5
22-Jul	0	5	0	5	5
22-Aug	0	4	2	2	4
22-Sep	0	3	3	0	3
22-Oct	2	1	3	0	3
22-Nov	3	1	4	0	4
22-Dec	4	0	4	0	4
23-Jan	2	0	2	0	2
23-Feb	1	0	1	0	1
23-Mar	2	2	2	0	4
NC Totals	**16**	**27**	**28**	**13**	**43**

**Event calling windows for DEF and NC were 11/1/21 – 10/31/22 and 4/1/22 – 3/31/23, respectively.*

OFFICIAL COPY

Jun 13 2023

As noted above, device provisioning in DEF took longer than anticipated and therefore, we lost out on the ability to call all 5 events during November 2021. Additionally, 2 of 5 NC events were lost in May 2022 due to the event "opt-out" function failing in the VP customer platform (see customer verbatims below). Beginning in August 2022, at Leadership's direction, the team focused on calling events only when morning or evening peaks were expected based on weather and load conditions. As a result, fewer than 5 events per month were called for the majority of the NC study.

In general, event calling utilizing the VP platform is simple. Event templates are created to establish the parameters of each event (duration, mode, customer notification language, etc.) and events are scheduled at specific dates/times determined by the project team. Additionally, the VP platform sends automatic customer notifications (email and/or SMS based on customer preference) in advance of scheduled events at the project team's discretion (terms and conditions assure a minimum of 2 hours advanced notice). Customers are allowed to opt out of up to 5 events during the 12-month study. Each customer event notification includes a link for the customer to follow to utilize one of their opt outs.

Customer VOCs/verbatims received by the CPL include:

- "How many of these events will there be? Please remind me – how long will our battery be part of the Battery Study? I ask because there have been 3 so far, for none of which have I seen a credit on our electric bill. This is not a complaint, however, just a statement of fact. Given that Duke Energy is proposing rather sweeping changes in its Net Metering 2.0, though, I hope you can understand my concerns about the amount of energy you are obtaining for free from our battery."
- "My main complaint is that I have tried multiple times to use my opt outs. I responded to texts and emails. I would be taken to a web page with instructions, I would follow them and the opt out would not work. I have no interest in continuing to be part of a study that does not allow me to opt out when I should be able to. In addition to that, I had no idea that the number of days that the discharge would occur. I was expecting once every couple of weeks, not multiple times a week."
- "You have discharged my battery 2 times and now doing it again. This is costing more than the $100 you sent out. How many more time you doing this?"

Recommendations:

- *Perform more thorough analysis of incentive amount and method of payment for a scaled program or pilot. The $200 study incentive appears to be insufficient for the volume of events being called, especially when considering the cost of the technology. We should assess the best method for paying the incentive out as well, either lump sum payment or monthly bill credits.*
- *Customers seem to enroll without fully familiarizing themselves with the study terms and conditions. Consider ways to inform them of study details on an ongoing basis. The project team modified event notifications to provide a reminder that up to 5 events may be called per month to help remedy this issue.*
- *Consider regular end-to-end testing of the platform to ensure all features and functions continue to operate as expected. We want to avoid any negative impacts to the customer experience, especially when issues potentially violate the study terms and conditions (e.g., opt out function was unavailable for an unknown period of time).*
- *Customers are currently only allowed to opt out of an event prior to it starting. For a better customer experience, consider allowing a customer to opt out at any point in the process, even after an event as begun. This would need to be reflected in the terms and conditions.*

Another event related learning is that customer batteries in "self-supply" mode (e.g., automatically covers home load not covered by available solar power). Self-supply mode inherently limits strain on the grid by covering home load not supplied by solar during peak afternoon hours; however, has limited benefit in a DR program. These batteries have often already discharged down to the 50% threshold in the evening and are unavailable for dispatch in the morning. Batteries in "Backup" mode are typically only dispatched when there is a power outage and therefore are usually charged prior to DR events, thus delivering higher benefit during an event.

There does not appear to be any financial or economic incentive for customers to place batteries in self-supply mode, but the project team observed that customers changed the mode of their batteries for various reasons throughout the study, shifting between self-supply and backup modes. Reasons identified through customer feedback include:

OFFICIAL COPY

Jun 13 2023

- the Outage Guard feature on Generac systems/app, which monitors weather forecasts and prompts the battery to automatically charge before a storm, returning system to original mode after threat of outage subsides
- Intentionally cycling batteries daily to take advantage of the ability to oversize their PV system with a DC coupled battery (e.g., energy efficiency and cost minimization)
- being less dependent on the grid/Duke Energy

Customer VOCs/verbatims received by the CPL include:

- "I got a notification that my battery is going to be discharged in the morning. I am curious as to why it's going to be taking place in the morning? I set my inverter to self supply mode typically except when the temperature falls below freezing. Which means that I probably won't have enough energy to send back to the grid in the morning"
- "I use self supply mode, because I want to make myself less dependent upon the grid and more dependent upon solar generation and storage"
- "I use self supply mode because it was set up for me that way"
- "Sometimes I try self-supply mode... it's still only been a year and half and I'm playing around with the different settings. It does seem that in the winter, self-supply mode will be better to use, since there's less sunlight and our battery can be of more help. This is because we don't produce enough energy total from our solar panels to fully supply our home in general...."

Recommendation: *Consider separate programs/pilots for self-supply and Backup modes as they provide different benefits to the Company. If a DR program, require that customers remain in Backup mode in order to participate and receive the incentives. Also, continue to try to obtain a better understanding of why customers choose to utilize self-supply mode and consider ways to incentivize customers to utilize this mode, thus limiting use of grid generated energy during peak times automatically.*

Data Driven Learnings – Events

Battery storage technology is still fairly new, as are programs/pilots to test their benefit for demand-response. Through the API with VP, the team was able to pull and analyze all relevant event data at the device level to assess the performance of the batteries, the DR benefit obtained, and other pertinent learnings. Given the minimal benefit obtained from batteries in self-supply mode, as well as evidence of a high volume of devices not responding during events (discussed further in "Technology" section below), the team cleansed the event data to focus only on batteries in Backup mode that truly participated in each event. By eliminating the event data for devices in self-supply mode and those that did not respond to each event, the team was able to determine the anticipated benefit obtained from a fleet of batteries, assuming they respond as expected, to DR events (e.g., covering home load during event window, as opposed to dispatching back to the grid). As a reminder, the study structure and requirements related to calling events and battery dispatch were as follows:

- Battery cannot discharge to the grid, can only discharge to cover home load during event. This is a regulatory requirement in FL, so the logic was also applied to the NC study, though rules for NC are less clear. Thus, DR benefit is limited to the home load.
- Excess PV (solar) power should be dispatched to the grid during events where the battery is covering home load
- Event cannot drain battery below 50% total capacity
- Learnings are limited to small sample size of study participants (57 in NC and 9 in FL, respectively, at conclusion of study)

The below data driven learnings are derived from event data for the NC battery fleet, which was a much larger sample group, restricted to batteries in Backup mode. Aside from the top half of figure 1 below, which is presented only to show how much the benefit drops when including non-responsive devices, all other metrics were further restricted to only devices that "participated" in each event. For a deep analysis of the FL devices and events, see BYOB FL Study Results

FINAL

DUKE ENERGY.

OFFICIAL COPY

Jun 13 2023

Figure 1: Backup Mode Devices (Averages)
(Aggregate of all Events)

		Battery kWh	kWh Home Load	kWh PV Alone	Net Home kWh	Remaining kWh Home Load	# Backup Devices	% Backup Devices
All Devices	***Overall***	*-2.60*	*7.24*	*-2.97*	*4.27*	*1.67*	*42*	*75%*
	AM Events	-1.94	5.56	-1.25	4.31	2.37	45	78%
	PM Events	-3.04	8.35	-4.10	4.25	1.21	42	74%
Participating Only*	***Overall***	*-3.54*	*8.15*	*-3.56*	*4.59*	*1.05*	*31*	*83%*
	AM Events	-3.02	6.25	-1.49	4.76	1.74	30	99%
	PM Events	-3.81	9.16	-4.66	4.50	0.69	34	77%

Participated is defined as net activity from battery during the event is negative (e.g. meaningful net discharge). See **Appendix A below for monthly breakdown of these averages.*

Figure 2: Event Dispatch by Hour for Participating Backup Mode Devices (Averages)

Event Hour	Battery kW	kW Home Load	kW PV	kW PV + Battery	Adjusted Demand Per Home w/o Event	Adjusted Demand Per Home in Study	Notes
Hour 1	-2.04	2.62	-1.31	-3.34	1.32	-0.72	Dispatching to Grid
Hour 2	-0.99	2.39	-1.11	-2.10	1.28	0.29	Response weakens
Beyond Hour 2	-0.51	3.14	-1.14	-1.65	1.99	1.48	Large response drop

As illustrated above, the average overall response for participating devices in Backup mode across the duration of events was 3.54kWh, lower for morning events and higher for afternoon events. Breaking this down by hour tells us that average power for these participating backup mode devices during the first hour was 2.04kW and dropped as the events progressed. Response varied by month/timing (am/pm) and hour of event.

Learning: Most devices do not respond to events for the full 3+ hour duration (see **Appendix B**). This is primarily due to average battery capacity (see **Appendix C** which illustrates that most participant batteries were 8-9kWh), and the study restriction of 50% minimum capacity threshold for dispatch. During the 1st hour of events, we see a robust response due to available battery power and home load. Response is weaker in hour 2, it cannot fully offset demand of home, less PV, and beyond hour 2 the response continues to decline.

Recommendation: *To have a meaningful impact on peak loading, a scaled program would need to consider lowering the 50% minimum capacity threshold for dispatch. It would also need to focus response on peak hours and limit the length of response to obtain coverage. Device dispatch could also be staggered to provide robust response over course of entire peak.*

Also illustrated above, we see that the average power discharged from batteries over the course of events was significantly less than the house load. Upon further investigation, it was determined that this was primarily due to a combination of control issues (latency), units failing to respond to events (see "Technology" section below), and inverter saturation from PV due to these systems being DC coupled. The control latency issues exist due to the intervals at which data is sent to/from the device to the aggregator, VP, and the inability of the battery to perfectly mirror home load once the command to dispatch is sent. Additionally, the team learned that the solar + battery DC coupled systems are typically oversized compared to their inverter rating. As a result, during events whereby all PV is exported to the grid through the inverter, the inverter becomes saturated by that PV and therefore the battery dispatch is limited to remaining available capacity and home load. Refer to BYOB FL Study Results for in-depth analysis on inverter saturation for FL events/devices.

Note: At the time this report was generated, the team was still investigating opportunities to conduct similar analyses on the NC events/devices to try and better quantify impacts to battery dispatch due to inverter saturation.

Learning: Due to the regulatory landscape and our inability to export to the grid, we are leaving available capacity on the table, particularly during winter peaks, night, and solar fade (duck curve issue). Control latency issues would be moot if batteries could export to the grid. Additionally, there are serious concerns about maximizing the DR/peak load shaving benefit of DC coupled solar + battery storage systems where the inverter rating is less than the potential PV harvest and battery capacity.

Recommendation: *Continue to explore opportunities to modernize the regulatory landscape in order to allow battery export to the grid (e.g., allowance of potentially non-renewable energy) to maximize the potential benefit of these systems for DR purposes. Also consider speaking with manufacturers about other configurations of these systems to eliminate or minimize the impacts of DC coupled system inverter saturation (e.g., AC coupled or larger inverters).*

Another finding relates to the natural tendency of these batteries to lose small amounts of power over time while they sit idle. Typically, these devices are charged to 100% and if in backup mode, sit idle until a DR event or outage occurs. During this idle time, the battery charge level slowly drops until it gets to around 95%, at which point the system automatically initiates recharging when PV is available. Additionally, batteries are naturally degrading over time, slowing seeing dips in overall max capacity. They tend to degrade more quickly earlier on in their lifespans and then degradation slowly tapers off as the system ages. See **Appendix D** for an example diagram of how the battery max capacity follows a saw tooth pattern, dipping down to around 95% capacity during idle times before recharging as well as the degradation of the battery capacity over the course of the study.

Learning: When an event is called, it is possible devices are not fully charged, thus again limiting the potential dispatch (e.g., losing up to 5% capacity per battery).

Recommendation: *Structure future programs to allow the utility to fully charge batteries prior to the executing a DR event to ensure they are at 100% capacity.*

Technology / System Observations

In addition to those described in the previous section, the technical requirements of the study (e.g., performance of VP platform and battery technology) are:

- VP must be able to connect to and control the device, sending commands to discharge for DR events, and battery must be able to receive the commands to respond
- Battery must be online and linked to a stable Wi-Fi, cellular, or hard-wired connection
- Battery should charge only from solar

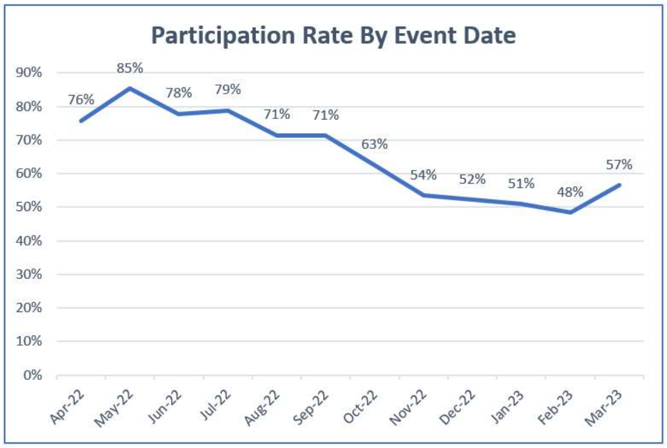
The following battery behaviors and results were persistently observed throughout the study, some improving slightly, but none ever reaching full resolution. Despite VP working with the manufacturers to try and identify the root cause of some of these issues, VP reported back that in most instances the issues observed were at the device level, making it very difficult to provide advice for resolution.

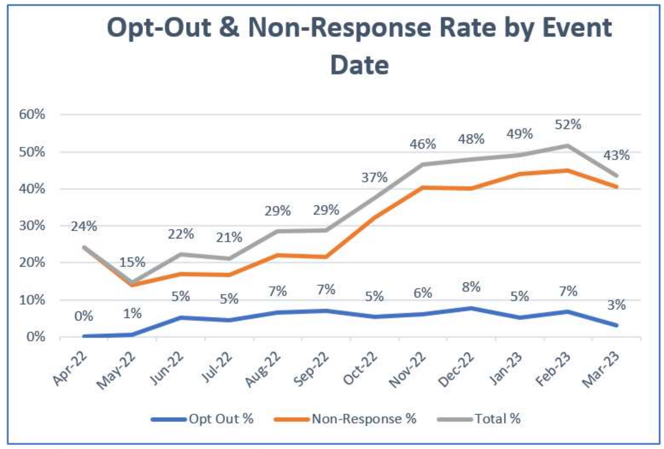
- Upon enrollment, approximately 20% of the devices had configuration issues that prevented immediate participation, and about half of the observed issues persisted several months after launch, delaying provisioning and device participation.
    - There is no clear way to classify these issues or mitigate them coming up. The team expects that even more issues would arise with the addition of more batteries and manufacturers.
- Batteries are discharging to the grid on occasion, as well as not zeroing out house load, due to how VP has set up the API for device control. As discussed above, control latency exists because the control was implemented at the cloud level whereas it would have been more real-time if performed at the inverter level. This was a conscious choice by VP and one that they have since continued to explore alternatives for and work with OEMs to implement improvements.
- Some devices exhibit counterintuitive behavior where they inexplicably charge the battery during events.
- Some devices (10%) exhibit behavior where they do not recharge only from solar, but rather directly from the grid. This results in a post-event grid impact that could potentially affect DR measurements.
- Devices are going offline more often than anticipated. On occasion, every device for a single manufacturer has gone offline at the same time and this issue was not immediately caught and resolved by VP.
- As the study progressed, there was an increase in customer initiated opt outs, devices breaking down/not communicating with VP, and others simply not responding/participating to the events. See graphs below for an illustration of NC Event Participation rates, including opt outs. As noted above, VP was unable to determine the root cause of increased non-responsiveness but indicated that it most commonly appeared to be device specific.

OFFICIAL COPY

Jun 13 2023

VP primarily attributed instances of non-response to: device connectivity time outs (e.g., command sent to device, but it timed out prior to accepting/responding to command), unusual mode shifts, and unexpected device responses.





Avg. Participation	Avg. Non-Response	Avg. Opt Out	Avg. Non-Response (excl. Opt Out)
65%	35%	5%	30%

Recommendations:

- *Maintain reasonable expectations for device provisioning and incorporate long lead times for provisioning into timeline of a future program/pilot. Consider provisioning early on for adequate testing and issue resolution.*
- *The VP platform can send an automated message to participants with offline batteries; however, the root cause of why batteries are going offline should be further investigated and a determination made about which type of connection (Wi-Fi, cellular, hard wire) is most reliable/desirable for program participation.*
- *Assess grid export goals and ensure the integrator for a future program/pilot can establish APIs/control points to achieve those goals.*
- *The "charge during event" state must be monitored and reported, and if it happens repeatedly, the device should be removed from participation. Devices that do not respond as expected to discharge commands may be experiencing hardware issues or have some other undesired device setting that should be resolved with the OEMs to allow continued participation, or the device removed from the program altogether.*
- *Assess the impacts to DR measurements of batteries charging from the grid after an event. Determine whether grid charged batteries should be allowed to participate in full-scale program/pilot and evaluate if this is a behavior that can be avoided/controlled through the chosen integrator. If needed, remove any batteries from participation that exhibit this behavior if it cannot be resolved.*
- *Generally, device responsiveness and behavior need to be actively monitored and issues addressed after each event for a scaled program. Ideally, there would be monitoring controls built into the aggregator platform, and the aggregator/vendor would take an active role in identifying, reporting, and resolving issues.*

We also learned that our participants aren't always highly knowledgeable about their battery systems and assume that Duke Energy has more control of/impact on their devices through the study than we actually do. Study participants will typically report any issues with their devices to Duke Energy (CPL) whether they are associated with the study and DR events or not. Customer VOCs/verbatims received by the CPL include:

- "What kind of study is this? will my battery go back to full power by the end of the study."
- "Saw my battery was discharged today. Also noticed that my internet connection (blue light on inverter) is out. Please fix."
- "I'm sorry my batteries are not working at the moment, they had to order some parts, hopefully they will have them back up and running in a couple of weeks."

OFFICIAL COPY

Jun 13 2023

- "I had asked Ben Phillips of YesSolar (our representative for Generac, our battery's manufacturer) to ask Generac to reset our battery's mode to "self-supply". However, the battery remains set to "priority backup" despite Generac's efforts to re-set it (the completion of these efforts has been relayed through Ben).

  Are you setting our battery to "priority backup" after you complete a discharge?

  If so, could you please change the mode you set for it to "self-supply", so that we can use the stored charge to defer our use of the grid?"

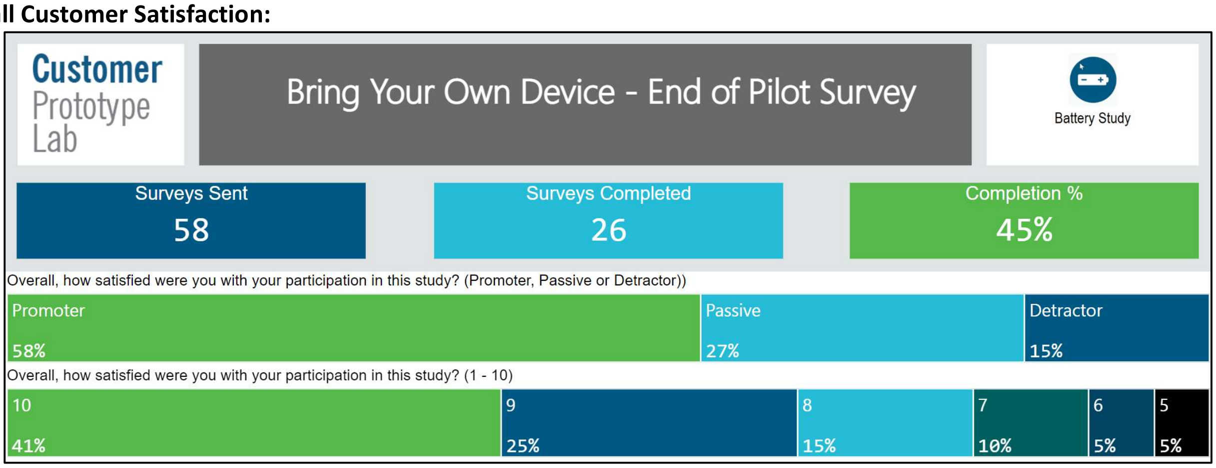
Recommendations:

- *Provide more clarity in program/pilot background around what Duke Energy and the integrator can and cannot do during an event and what battery behaviors may be due to an event vs. what behaviors are unrelated.*
- *Work with the battery manufacturers to ensure there is a clear path to resolving customer issues that are reported to Duke Energy whether or not they are associated with events called during a program/pilot. Ensure communication channels with the battery manufacturers are clear to drive timely customer issue resolution.*

Survey Results

At the conclusion of each jurisdictional study, remaining participants were sent their final incentive checks and a closing email with link to a survey. The survey was sent to FL participants in November 2022 and 2 of 9 (22%) customers completed the survey. Given the larger participant base and desire for more feedback, when the NC participants were sent the survey in April 2023, a $15 e-gift card incentive was offered. This resulted in 26 of 58 (45%) customers completing the survey. See dashboard screenshots below for summarized survey response information from the NC participants. Raw FL survey responses have been memorialized on our Teams site (FL survey responses) but were consistent with what is displayed below from the NC study (NC survey responses). Customer verbatims obtained through the surveys have been presented in applicable sections above, with additional verbatims highlighted below related to the survey topics displayed.

Overall Customer Satisfaction:



Promoter customer verbatims include:

- "It was very simple to participate and I was always notified"
- "It was a no brainer. I did not have to do anything or worry about forgetting to do anything."
- "I didn't have to do anything to participate in this study. I also got paid for participating. I hope this helped Duke Energy."
- "I'm glad I can be part of a study to promote clean energy and battery storage for our future! I'm only concerned that our battery wasn't functioning for part of the study so we weren't able to provide great data."
- "I was pre-notified of each instance and given the option to opt out if it wasn't convenient."

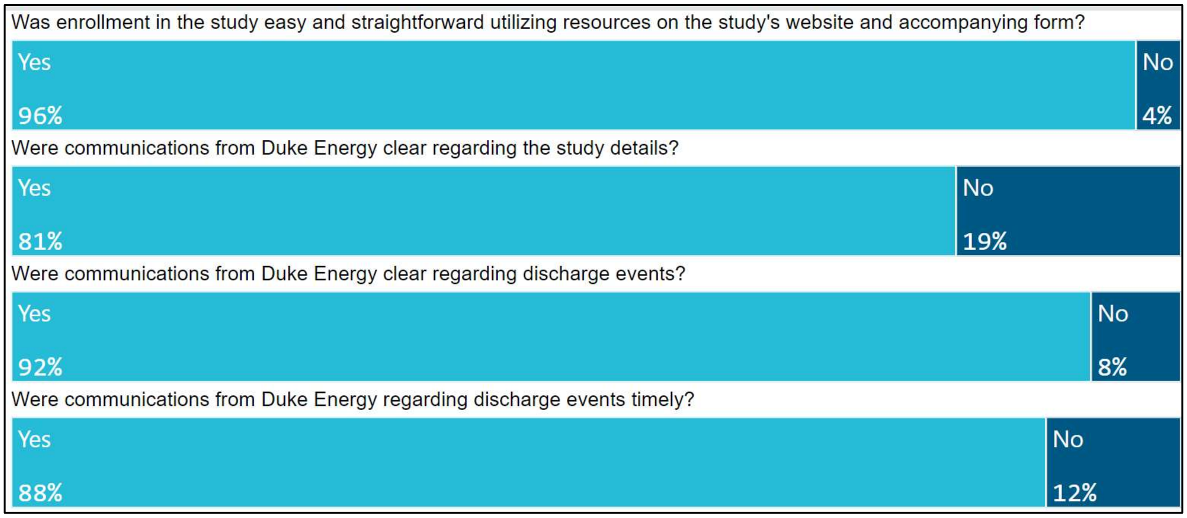
Passive and Detractor customer verbatims include:

- "It was neat to participate in the study like this, though during certain times of the year it would've been more ideal. Discharge my battery earlier in the day rather than in the evening when my wife is cooking dinner."

OFFICIAL COPY
Jun 13 2023

- "I understood that my battery was going to be drained numerous times over the course of a year in the study, however I do not know if I lost money in doing so, in so far as that collected energy that I freely allowed to be taken by Duke, while receiving just $200."
- "I did not really do anything except give you access to my battery. it was neither positive nor negative."
- "It was not difficult to allow the process to run its course. I did not like the days selected often times."
- "Seemed like a lot of discharges."

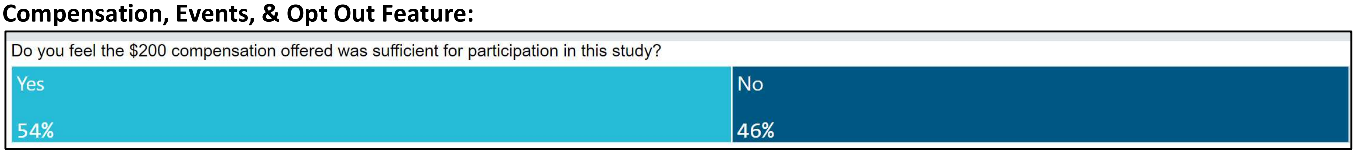
Customer Communications:

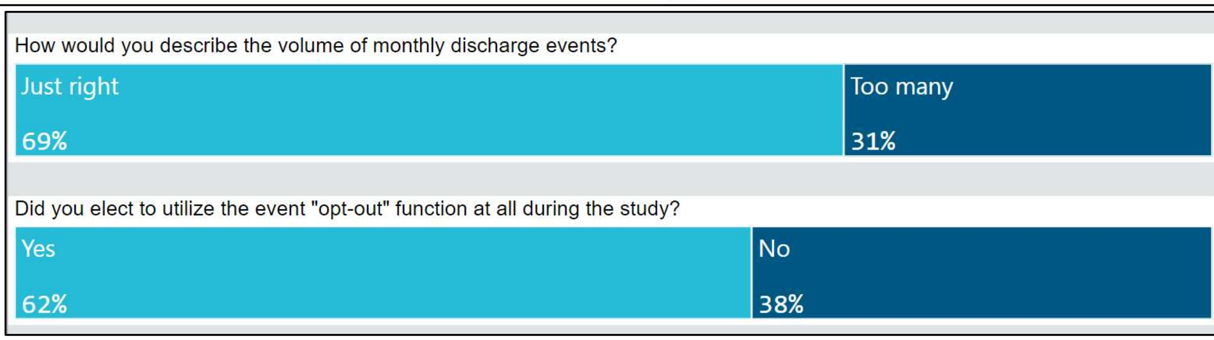


Customer feedback related to communications:

- "I got text on my phone and emails when it was going to happen!! They gave me plenty of time before it was going to happen!"
- "Most events were conducted on very short notice - like the same day. I would have appreciated notice more in advance of the actual battery discharge."
- "In the beginning, I was given a few hour notices, then later it was the day before."
- "I am curious to know what was found out during the study"

Compensation, Events, & Opt Out Feature:





Refer to "Compensation" section above for further discussion and verbatims related to study participant compensation.

OFFICIAL COPY

Jun 13 2023

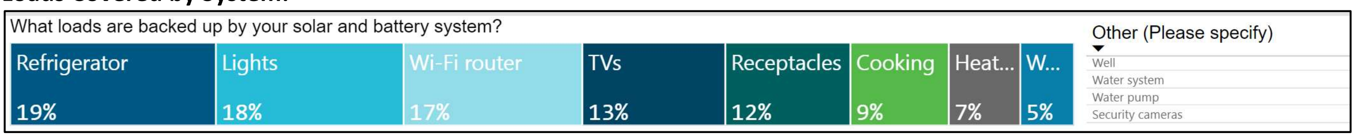
Customer feedback on study events:

- "power is money and it felt like a lot was lost through the discharging"
- "How many times were there a month - I forget. Sometimes it felt like, "oh another time?! They just did that!" But perhaps that was just perception. I was glad to participate in the study so didn't mind too bad."
- For the amount of money you paid me, it was too many.

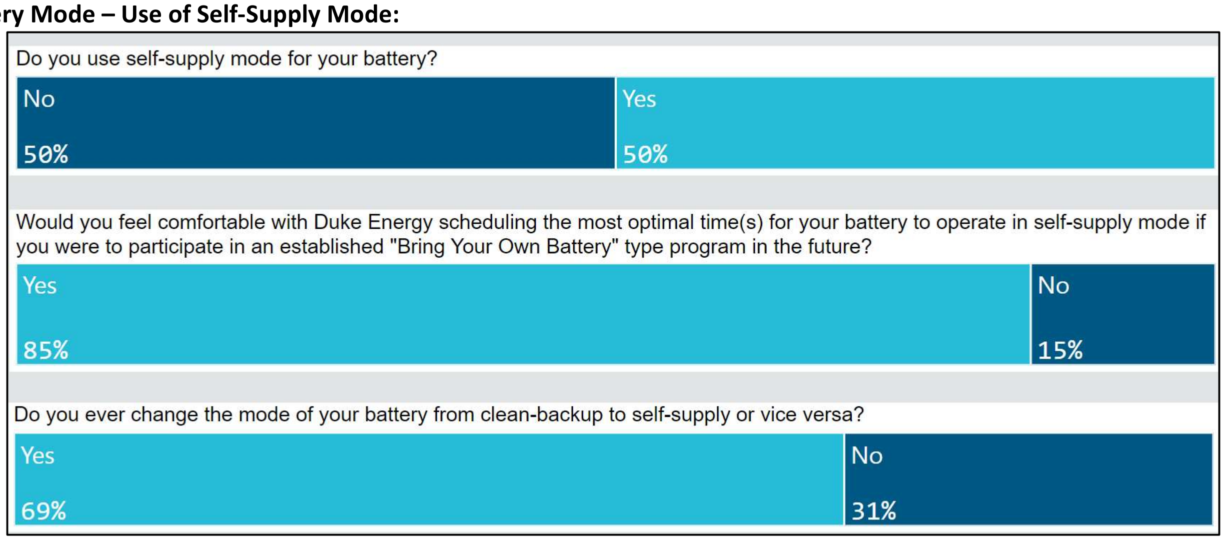
Customer feedback on why they took advantage of the Opt Out feature:

- "When my battery was low already, or I thought a storm was coming and I wanted it charged."
- "I did it once because I was having a problem with my solar panels at one point in time and there was no sense in discharging only to have to use the grid to recharge again"
- "the frequency of the discharges"
- "Late discharge times requiring battery recharge from the grid"
- "Because I could."

Loads Covered by System:



Battery Mode – Use of Self-Supply Mode:



Refer to "Events" section above for further discussion and verbatims related to customer use of self-supply mode and the impacts.

Other insightful feedback:

- "Give more details how my device contributed to the overall study and what was learned"
- "When we have a power outage, we modify our behavior to minimize energy use (change the thermostat, minimum hot water, etc.) and the battery is able to keep up."
- "I would like to know what information you were able to gather and how my system is working"

VP & Platform

Third party aggregator, Virtual Peaker, is providing software as a service (SaaS) for this study. VP's platform and services were leveraged to provide a study microsite, execute customer enrollment, approve and distribute customer incentives, establish APIs with the manufacturers to connect to and control enrolled devices, and design and call DR events.

OFFICIAL COPY

Jun 13 2023

Various features of the platform and other support services were highly functional and helped the team streamline different tasks and processes as follows:

- The study microsite and linked enrollment form make it easy for customers to learn about the study and enroll with little confusion.
- Once a house is approved, it automatically generates an available incentive for the customer. Incentives can be easily reviewed and approved for distribution through the platform. VP handles the distribution of incentive checks and any issues with delivery or check return.
- API was established so Duke project team could easily extract event data for analysis.
- Event templates are easy to prepare and allow for automated customer event notifications that can be customized.
- Event scheduling is quick and easy. Events can be cancelled at any time.

However, the team has encountered several challenges with the platform and VP's support services as follows:

- Determining whether a device has been successfully provisioned is manual and can only be done on a house-by-house basis. This was manageable for a small study but with a scaled program/pilot, this would be very time-consuming.
    - VP attempted to help with this by sending weekly provisioning updates via email; however, this work around would likely still not be efficient enough for a scaled program/pilot.
- Tracking and tagging the 3rd party website was spotty due to the setup of the website. This meant the team had no visibility into what part of the enrollment process (if any) customers might have been dropping out.
- Not all data points we are interested in are available (e.g., ambient temps around the device which affect response/performance).
- The support ticket process is clunky and inefficient. It is difficult to track who/what each ticket is waiting on and we are unable to see any updates provided by Generac and SolarEdge, which creates challenges as many tickets end up in their queue as opposed to VP (but ticket must be submitted to VP to pass along).
- VP owns the SOWs and relationships with the participating battery manufacturers. Getting the SOWs completed took longer than expected and ultimately did not include things like service level agreements for provisioning and support tickets, which resulted in these tasks not being completed timely. The project team was rarely allowed to discuss issues directly with the manufacturers; rather, had to go through VP for everything, which was inefficient.
- There are no system flags to identify device issues with ease; rather, manual pulling and review of data from each individual event is necessary to identify whether or not devices responded as expected, providing the anticipated DR benefit.
- Similarly, there are no system flags to identify when a participant is nearing or has exceeded their allotted opt outs. The team was under the impression the system would notify us if opt outs were exceeded; however, that was not the case, and it was not identified as a gap until late in the study. At that point, the team had to manually pull opt out data from each event, then aggregate results across all events to quantify the total number of opt outs used by each participant. This was another inefficient, manual monitoring point that would be difficult to maintain without dedicated resources on a scaled project.

Recommendations:

- *Prior to choosing an aggregator for a scaled program/pilot, perform a deep dive of platform features, automated controls, available data, and support requirements to ensure any vendors submitting a bid can provide accordingly.*
- *Consider modifying structure of the program (e.g., creating direct working relationships with the battery manufacturers), choosing a different integrator (or even potentially developing an in-house, proprietary communication protocol), and establish control over APIs directly.*
- *Ensure SLAs are set with every participating vendor, as needed, in order to hold everyone accountable for timely completion of related tasks and processes.*

OFFICIAL COPY

Jun 13 2023

Prototype Team and Stakeholders

Name	Role	Responsibilities on the Prototype
Austin Atkins / Katie Rochelle	Prototype Requester	Delivers the requirements/specifications of the prototype, offer, product and/or customer experience (offer definition, go to market strategy, eligibility requirements, service level requirements, etc.) Provides budget/accounting for out-of-pocket expenses (campaign materials, customer incentives, etc.) Ensures regulatory approval is secured and team understands regulatory requirements. Secures vendor contracts. Participates in Lessons Learned sessions. Uses prototype learnings to inform decisions and refine business case.
Ashley Randall	Prototype Manager	Leads the prototype project and delivers the milestones on time. Is the Prototype Requester's single point of contact. Delivers the prototype's project management plan, develops required processes, coordinates the customer list development, develops master customer communications calendar, contributes to messaging, confirms dashboard & reporting requirements, training requirements, resolves escalated customer issues, performs quality control, conducts lessons learned, & produces learnings reports
Jessica McConnell	Marketing Communications	Develops Marketing Plan, Marketing Strategy and assists in identifying target audience and coordinating the customer list. Develops creative brief. Coordinates with Corporate Communications regarding messaging, design, campaign budget, printer(s), etc. Completes customer material review with legal and regulatory. Coordinates with Digital Strategy/Electronic Data Management for website deployment. Produces & distributes campaign closure report and participates in Lessons Learned sessions.
Tim Pike	Prototype Analyst	Communicates prototype results and delivers the tools, applications, and analysis/dashboards/ad hoc reporting as required. Ensures delivery of the final customer list and ongoing list management. Delivers the Customer Email, Text, Automated Outbound messaging, gift cards, as required. Processes electronic sign-up forms. Posts final electronic communications versions delivered to SharePoint.
Cam Jones	Prototype Specialist	Develops the training materials for fellow Prototype Specialists. Delivers the specified customer experience. Ensures Customer Care Operations is aware of prototype and knows what to do if a customer contacts the CCO. Shares Insights & Voice of the Customer & participates in Lessons Learned.
George Gurlaskie	Emerging Technology Office	Oversees Florida Technology Development Fund. Primary interested party in understanding the insights and learnings from the Study, both customer and battery behavior/demand response related, in order to gauge viability and ability to develop a cost effective, battery driven, demand response program in Florida.

Subject Matter Experts (Contribute but aren't on regular project status calls)

- Marsha Frederick – Master customer list(s) pullers
- John Swann (replaced Tracy Li) – Data Analytics Program Manager
- Paul Halstead – Rates & Regulatory Strategy – Pricing & Regulatory Solutions
- Fred Frost & Mike Shagena – Data Science Consultants, leading efforts on scheduling and analyzing DR events
- Stacy Phillips – Demand Response SME
- CCO Liaison – liaison responsible for ensuring customer facing employees are aware of prototype
- Sourcing – Coordinates securing vendors
- Virtual Peaker (VP) – Data aggregator and event calling software (application) owner
- Ashley Dempsey – Assigns Lab resources, assists knocking down hurdles that may impede the prototype.

OFFICIAL COPY

Jun 13 2023

Appendix A: Monthly Response Metrics – Participating Backup Mode Devices

The below chart illustrates the average event kWh response for participating backup mode batteries by month and event time of day, morning and afternoon. A few noteworthy items related to this chart include:

- *Generally, average kWh response was higher for afternoon events during warm weather months given the increased home load experienced when A/C units are cycling.*
- *Additionally, we see a higher volume of devices in backup mode during warmer weather months, which is consistent with feedback we received from customers indicating they are more likely to switch to self-supply mode during winter months when there is less PV available to supply home load.*
- *The 10.87 average kWh PV for PM events in March 2023 is high due to the fact that these events were called at 1pm (higher solar time) vs. all other afternoon events being called at 3 or 4pm. The team ran these events specifically to learn more about inverter saturation during high PV hours and the impacts to battery dispatch, as discussed in the "Technology" section of this report.*

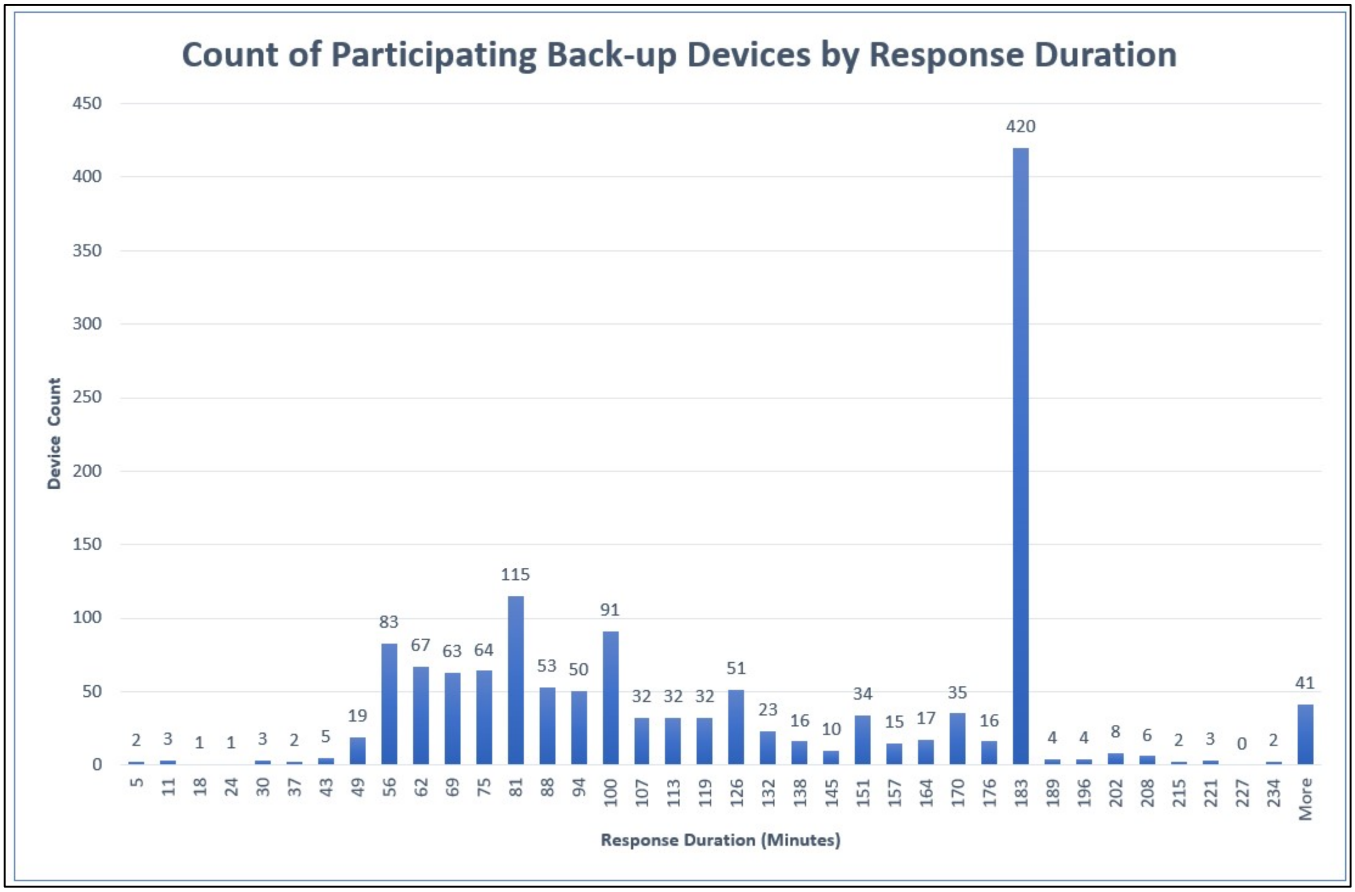
	Participating Backup Mode Devices (Averages) - Monthly Response Metrics					
AM Events						
Month	**Battery kWh**	**kWh Home Load**	**kWh PV Alone**	**Net Home kWh**	**Remaining kWh Home Load**	**# Backup Devices**
Apr-22	-2.80	4.35	-1.39	2.95	0.15	36
May-22						
Jun-22						
Jul-22						
Aug-22						
Sep-22						
Oct-22	-2.96	5.26	-1.13	4.13	1.16	32
Nov-22	-3.14	7.29	-1.16	6.13	2.99	27
Dec-22	-3.13	7.00	-1.13	5.87	2.74	30
Jan-23	-3.13	7.10	-1.58	5.52	2.39	29
Feb-23	-2.92	6.20	-2.30	3.89	0.97	28
Mar-23	-2.92	5.79	-2.83	2.96	0.03	26
PM Events						
Month	**Battery kWh**	**kWh Home Load**	**kWh PV Alone**	**Net Home kWh**	**Remaining kWh Home Load**	**# Backup Devices**
Apr-22	-3.41	6.46	-3.52	2.94	-0.47	37
May-22	-3.31	6.37	-3.95	2.42	-0.89	35
Jun-22	-4.21	12.98	-7.72	5.26	1.05	33
Jul-22	-4.38	12.52	-4.50	8.02	3.64	36
Aug-22	-4.24	11.57	-3.54	8.02	3.79	31
Sep-22	-4.13	8.33	-2.26	6.06	1.93	29
Oct-22	-3.18	4.52	-0.05	4.47	1.28	36
Nov-22	-3.10	4.39	-0.18	4.21	1.11	33
Dec-22						
Jan-23						
Feb-23						
Mar-23	-2.69	4.03	-10.87	-6.83	-9.53	32

OFFICIAL COPY

Jun 13 2023

Appendix B: Device Event Response Duration (NC Devices)

*The below chart illustrates the count of participating backup mode devices (across all events) by their response duration in minutes. As depicted, most devices do not respond for the full 3+ hour duration of the event due to capacity (see **Appendix C**) and the study restriction of not draining batteries below 50% maximum capacity.*

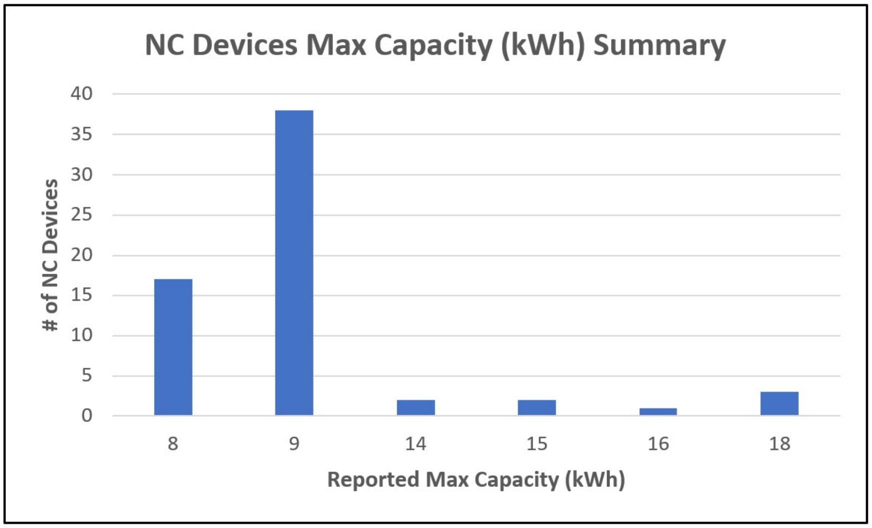


OFFICIAL COPY

Jun 13 2023

Appendix C: Battery Fleet Max Capacity Details (NC Devices)

Most enrolled NC devices reported an average max capacity of 8-9 kWh over the course of the study. A small number of devices reported max capacities greater than 14 kWh.



Device Max Capacity (kWh)	# Of Devices
8	17
9	38
14	2
15	2
16	1
18	3

OFFICIAL COPY

Jun 13 2023

Appendix D: Battery Max Capacity Throughout Course of Study (Sample NC Device)

The below diagram illustrates, using one NC backup mode device, how the battery max capacity follows a saw tooth pattern, dipping down to around 95% capacity during idle times before recharging. It also illustrates how the battery max capacity overall declined by about 3% from the beginning to end of the study, which demonstrates natural battery degradation over time.