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October 25, 2023

Public Utility Commission of Oregon
Attn: Filing Center
201 High Street, S.E.
P.O. Box 1088
Salem, OR 97308-1088

RE: PGE UM 1856 2023 Annual Energy Storage Update

Pursuant to Public Utility Commission of Oregon (OPUC or Commission) Order No. 18-290, Portland General Electric Company (PGE) submits its fourth annual report on the progress of its energy storage proposal which includes: Camino del Sol (formally named Baldock), Coffee Creek, Microgrid pilot, Port Westward 2 (PW2), Residential Storage pilot (called the "Smart Battery Pilot"), and the controls for the energy storage systems. During operation of the projects, PGE will submit comprehensive evaluations in the third, sixth, and tenth operating year, along with annual progress updates. The following report details each project and includes progress, challenges, and preliminary learnings, as available.

History of Energy Storage Docket

The Commission opened Docket No. UM 1751 in September 2015 to implement House Bill 2193, which required Oregon electric companies (PGE and PacifiCorp) to submit proposals by January 1, 2018, to procure qualifying energy storage systems with capacity to store at least five megawatt hours of energy. PGE met this requirement and procured 11 MWh of energy storage (Port Westward 2 and a Microgrid site Beaverton Public Safety Center) as of December 31, 2019.

2023 Annual Energy Storage Update

Camino del Sol Mid-Feeder Energy Storage System (formally Baldock)

This project was planned to develop and build a 2 MW, two-hour energy storage system adjacent to PGE's Camino del Sol Solar facility and will be interconnected to the Canby-Butteville feeder.

This project remains on hold due to estimated costs that still exceed the stipulated cost cap for this project with no clear path to complete this project within the cost recovery limits in the stipulation. Due to these circumstances, PGE is not moving forward with the project at this time, but will review again in the future if cost drivers sufficiently change to allow the project to be completed within the cost cap[1].

Note that the project name was changed, though it is the same location and facilities. The adjacent solar array had been named after the Baldock freeway and rest area that it was geographically near, but when the Oregon Department of Transportation renamed the rest area in late 2022 PGE followed suit. The name of the solar facility and by extension the battery project were renamed to Camino del Sol.

Coffee Creek Substation Energy Storage System

This project will develop and build a 17 MW, two-hour energy storage system sited and interconnected at PGE's Coffee Creek Substation.

PGE selected FlexGen as the Engineering, Procurement, and Construction (EPC) Contractor for equipment supply and construction of the project in 2022. Battery module fabrication started shortly after contract award with factory acceptance testing of the modules completed in September 2023. Civil and structural design has been completed with electrical design nearing completion. Civil construction is expected to start mid-October. Site construction will carry into Q1 2024 with energization expected in Q2 and with testing and commissioning completion in Q3 2024.

Microgrid Projects (Beaverton Public Safety Center and Anderson Readiness Center)

Overview

The Microgrid Pilot Project completed its first microgrid at the Beaverton Public Safety Center (BPSC), commissioned in September of 2020. The second microgrid at the Oregon Military Department's Anderson Readiness Center (ARC) was commissioned in May 2023. Both microgrid sites are designed to support community resiliency.

PGE and the City of Beaverton signed an agreement to deploy the 250 kW, four-hour battery and microgrid at BPSC in 2019, with PGE owning and operating the battery. The microgrid is also powered by a 300 kW PV solar array and a 1,000 kW standby diesel generator, both owned by the customer.

PGE and the Oregon Military Department signed an agreement to deploy a 500 kW, two-hour battery and microgrid at ARC in 2020, with PGE owning and operating the battery. The microgrid is also powered by a 270 kW PV solar array and two 800 kW standby diesel generators, all owned by the customer.

[1] Drivers affecting the cost could be additional entrants into this market segment, alleviation of supply chain constraints, and tax credits and/or grants.

ARC Construction and Commissioning

ARC houses servers that are critical to the State of Oregon. Keeping this high availability site running during construction and commissioning required careful coordination to avoid any outages greater than ten minutes.

The ARC BESS equipment layout and conduit routing designs went through several iterations. This was partly due to updated requirements from the site owner that were shared partway through the project. Fortunately this was a Design-Build project which made it adaptable to those changes and the site owner has been pleased with the end results.

ARC microgrid commissioning included dozens of grid-connected and islanded tests to verify the microgrid's performance and reliability. One of the main challenges was integrating the existing diesel generation resources that are part of PGE's Dispatchable Standby Generation (DSG) program. The logic for control handover between the microgrid controller and the existing DSG Programmable Logic Controller (PLC) required several iterations to get right.

System Operation

These microgrid systems respond to system frequency events and are dispatched both for contingency reserve and demand response. System frequency is monitored at a central location near Sherwood and if a deviation is detected the site controller immediately dispatches the battery at full output for three minutes before ramping down and slowly recharging. Contingency reserves are centrally dispatched when needed by the Balancing Area Authority Operators. These systems have automatically responded to 51 frequency events and been dispatched for contingency reserves 48 times since September 2022.

Table 1 below shows the number of contingency reserve and frequency response dispatches of both the BPSC and ARC microgrid batteries over the last 12 months. Please note ARC data starts in May 2023 after the system was commissioned.

Table 1

	BPSC		**ARC**	
Month and Year	Number of Contingency Reserve dispatches	Number of Frequency Response dispatches	Number of Contingency Reserve dispatches	Number of Frequency Response dispatches
September 2022	0	0	-	-
October 2022	0	0	-	-
November 2022	0	0	-	-
December 2022	6	6	-	-
January 2023	6	6	-	-
February 2023	4	4	-	-
March 2023	6	6	-	-
April 2023	0	0	-	-
May 2023	0	0	0	0
June 2023	3	3	3	7
July 2023	2	2	5	5
August 2023	8	8	5	4

Preliminary Learnings

Our learnings to date include confirmation that the system can reliably respond to system frequency events and be dispatched for contingency reserve to provide those useful grid services to PGE's operators. Future operations testing plans over the 10-year life of this project will include expanding the BESS use to the other identified use cases, including testing that is being done for for autonomous proportional frequency support (freq/watt) and proportional voltage support (volt/var).

Both microgrids have the ability to support the customers' load during a utility outage, with the system at BPSC reacting numerous times to utility outages. The BPSC system's ability to form an island and support load has not been 100% successful and required several software and firmware changes. Since these changes were made, the system seems to be functioning as designed however more time is required to assess this.

The microgrid at ARC employs a simpler system for islanding during outage events and based on testing, this system seems to have worked properly from the beginning. However, the site has not been subjected to an actual outage since commissioning. Therefore, more time is required at this site as well to assess the efficacy of islanding.

There have also been additional learnings related to operations and maintenance (O&M) on the microgrid projects. O&M activities such as troubleshooting when equipment trips, resetting components, control system updates, and procuring replacement parts has been more involved than initially anticipated. PGE is capturing these topics and making updates to our project requirements and specifications in order to better address these items on future projects. Future operations testing plans over the 10-year life of this project will include expanding the BESS use to the other identified use cases.

Port Westward 2 (Generation Kickstart) Energy Storage System

Overview

This project has developed and built a 5 MW, two-hour energy storage system coupled with PGE's Port Westward 2 Generating Station (PW2). By coupling the energy storage system with PW2's reciprocating engines the combined resource becomes enabled to qualify as contingency reserve, even while the engine is not running.

The project design work was completed in November 2020 and the battery energy storage equipment was delivered to the site in December 2020. Construction and controls integration work commenced and continued through August of 2021. The battery was energized and the system testing and commissioning were completed in September 2021, upon when the project was put into service.

System Operation

Over the last year the system has continued to respond to system frequency events. System frequency is monitored locally and if a deviation is detected the site controller immediately dispatches the battery to full output and discharge for three minutes before ramping down. The system has automatically responded to approximately 47 frequency events since September 2022.

Table 2 below shows the number of frequency response dispatches of the PW2 battery over the last 12 months.

Table 2

Month and Year	Number of Frequency Response dispatches
September 2022	0
October 2022	8
November 2022	4
December 2022	4
January 2023	2
February 2023	8
March 2023	5
April 2023	0
May 2023	0
June 2023	6
July 2023	4
August 2023	5

Preliminary Learnings

Our learnings to date include confirmation that the system can reliably respond to system frequency events and provide that useful grid service to PGE's operators. Future operations testing plans over the 10-year life of this project will include expanding the BESS use to the other identified use cases. From a maintenance standpoint, Tesla has been monitoring the system and performing planned maintenance as required for the system.

Residential Storage Pilot

PGE's Smart Battery Pilot became effective in August 2020, and had a tariff update effective May 2023. The Pilot currently has 158 enrolled customers and a dispatchable potential of 936 MWh. A comprehensive assessment of the Pilot's performance for the first three years of operations is included as Attachment A of this document.

This concludes PGE's Annual Energy Storage Update for 2023.

Please direct any questions regarding this filing to Chris Pleasant at (503) 464-2555. Please direct all formal correspondence and requests to the following email address pge.opuc.filings@pgn.com

Sincerely,

\s\ Robert Macfarlane

Robert Macfarlane
Manager, Pricing & Tariffs

Enclosure
cc: UM 1856 Service List

Portland General Electric

Smart Battery Pilot Three-Year Assessment

Prepared By: PGE Smart Battery Team

Date: October 25, 2023

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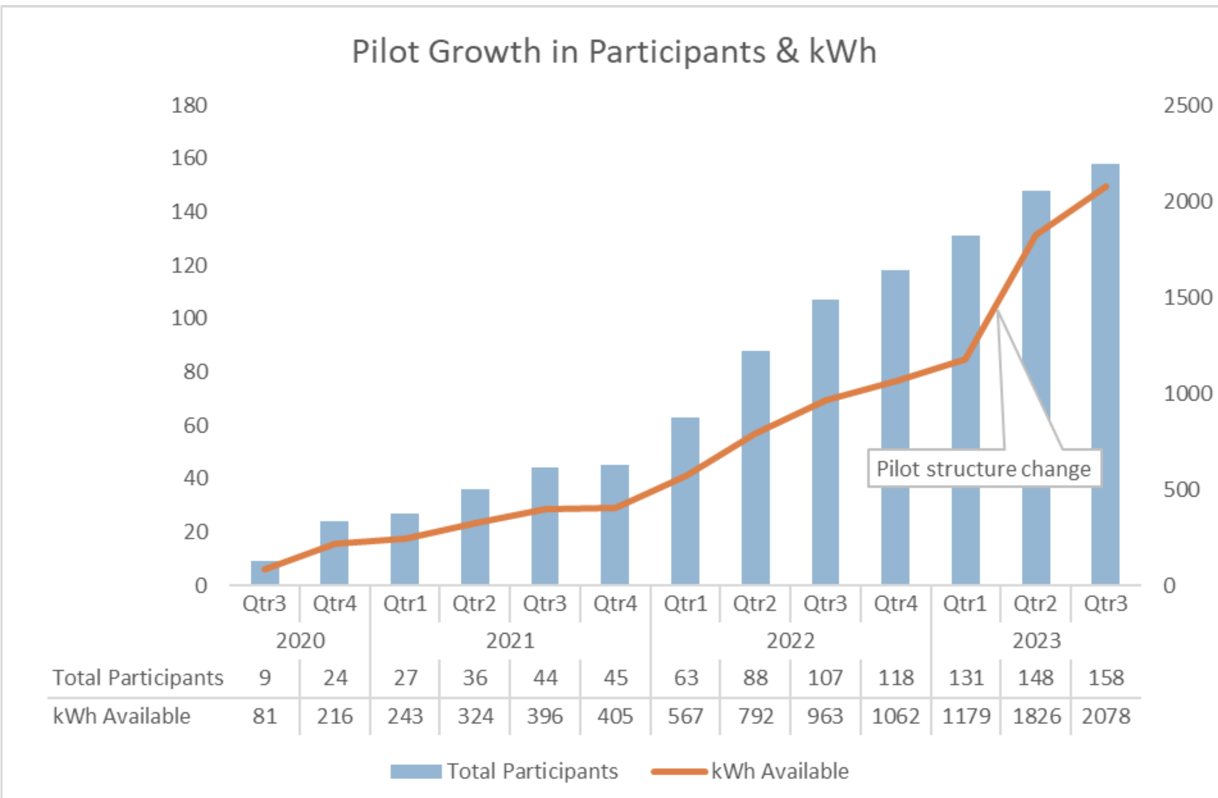
Executive Summary

Launched in August 2020, the Smart Battery Pilot ("Pilot") has been operating for three years with an objective to study and understand the usage of residential behind-the-meter customer batteries on PGE's system. The Pilot was developed in response to Oregon legislature's House Bill 2193 (2015) and proposed to the Oregon Public Utilities Commission (OPUC) in UM 1856.

While PGE sought to study a full spectrum of grid services, the batteries were primarily dispatched for peak shaving or demand response purposes, in addition to experimental dispatches for use case testing. As shown in Figure 1, the pilot has shown steady growth of participants and available energy, providing 1.26 MWh of energy during peak events in 2021, 4.88 MWh in 2022, and 6.56 MWh in 2023 YTD (through August).

Figure 1 Pilot Growth



There were technical limitations to the ability for more advanced grid services, with the manufacturer APIs (Application Programming Interface each having their own functionalities locked or unlocked. All batteries could receive charge and discharge signals from PGE, enabling generation capacity, energy optimization, and theoretically, fast frequency response and contingency reserves. However, the batteries could not respond fast enough to discharge within the 20 seconds required for fast frequency response. For contingency reserve, again, the batteries can theoretically provide the power when called for, but PGE did not complete the digital integration between the balancing authority and the Pilot to enable autonomous dispatch of the batteries in response to a system emergency at any hour of day and any day of the year. PGE is currently evaluating the prudence and technical feasibility of completing this integration in the second half of the Pilot. None of the battery manufacturers allowed for the autonomous function of Volt/VAr. Tesla devices allowed for autonomous frequency regulation, which the utility was able to test on customer batteries.

Customer satisfaction and tolerance of the Pilot is good, with 84% of customers saying they are satisfied with the Pilot and 97% saying they would recommend it to a friend or family member in survey research. Very few customers opt out of dispatch events, at only 1.9% across all events that offered an opt out option. The batteries reduced the durations of customer outages by 61%.

A survey of participating installers identified interest in streamlining enrollment as well as a desire for more Pilot details to aid installers with customer engagement. Unsurprisingly, the installers cite that cost is the biggest barrier for acquisition of a battery.

Overview

Regulatory History

The 2015 Oregon legislative session enacted House Bill (HB) 2193,[1] requiring Oregon electric companies (PGE and PacifiCorp) to submit proposals by January 1, 2018, to procure qualifying energy storage systems with capacity to store at least five MWh of energy. The Commission opened Docket No. UM 1751 in September 2015 to implement HB 2193, and, in Commission Order No. 16-504, adopted guidelines and requirements for energy storage proposals and a framework for the Energy Storage Potential Evaluations. The order encouraged PGE to "submit multiple, differentiated projects that test varying technologies or applications."

PGE filed its residential energy storage proposal and final Energy Storage Potential Evaluation on November 1, 2017, in Docket No. UM 1856. Commission Order No. 18-290 approved a stipulation filed by PGE and provided conditional approval for the five-year Pilot.

The Pilot sought to install and connect 525 customer-owned residential battery energy storage systems to contribute up to four megawatts of energy to PGE's grid. These batteries would comprise a virtual power plant of distributed assets that could be operated individually or in concert for grid services including flexibility, a grid service necessary to support PGE's transition to a clean energy future. Customer batteries enrolled in the Pilot would further provide customers with electricity resilience.

The Commission required PGE to submit an addendum to OPUC Staff (Staff) that detailed how PGE will optimize learnings and mitigate risks. Staff would then evaluate and determine whether PGE provided adequate evidence to allow the Company to move forward with the proposed pilot.

PGE submitted Advice No. 20-08/Docket No. ADV 1111 to establish a new Schedule 14 Residential Battery Storage Pilot in April 2020. Staff's report recommending the Commission approve PGE's Schedule 14 Residential Energy Storage Pilot was adopted by the Commission at the Public Meeting on June 30, 2020, with an effective date of August 1, 2020.

In December 2022, PGE filed a tariff update[2] to change the structure of the pilot to "pay for performance" and re-allocated funding for rebates to try to increase uptake for locational benefits. The Schedule 14 tariff revisions were approved by the Commission at the February 7, 2023 Public Meeting and went into effect on May 15, 2023.

[1] Oregon Legislative Assembly, "Enrolled House Bill 2193" (2015) https://olis.oregonlegislature.gov/liz/2015R1/Downloads/MeasureDocument/HB2193
[2] Portland General Electric "Advice No. 22-43 docketed as 1470" (December 12, 2022) https://edocs.puc.state.or.us/efdocs/UAA/uaa10278.pdf

Pilot Overview

PGE proposed to leverage battery energy storage systems (or simply, "batteries"), installed at residential customer homes behind the utility electric meter, as a dispatchable resource to provide PGE system services. Customers would receive an incentive payment in exchange for allowing PGE access to their battery for grid services.

As a fleet, the batteries act in aggregate to provide system services and individually for customer services. Prior to launching the Pilot, PGE modeled the value of some services; for others, the Pilot's aim was to seek to establish a value. The Pilot intended to aggregate 525 residential batteries totaling 2 to 4 MW in size and 6 to 8 MWh in duration. Each battery would provide between 3 to 6 kW of power output and 12 to 16 kWh of energy storage. PGE may send charge and discharge signals to the battery fleet according to system needs, except in the event of an outage when the batteries autonomously island to provide home energy back-up.

All battery systems are customer-owned, with the requirement that an approved Energy Trust of Oregon ("Energy Trust") solar trade ally install any systems receiving a rebate. Any customers wishing to enroll in the pilot with a qualified battery that is not newly installed by an approved Energy Trust solar trade ally must be verified prior to acceptance in the pilot to ensure safe operation.

In exchange for authorizing PGE to operate the battery for grid services, the original Pilot design compensated customers $40 per month or $20 if the battery was restricted to rooftop photovoltaic (PV) charging only. Customers within the Smart Grid Testbed were also eligible for an up-front rebate to encourage the density of adoption needed to test locational benefits. Income-qualified customers within PGE's service territory that also participated in the Energy Trust's Solar Within Reach program were also eligible for an up-front rebate of $5,000 in addition to the monthly bill credit. PGE's partnership with the Energy Trust addressed potential barriers to residential storage for income-constrained customers while also allowing PGE to better understand the needs of a more diverse set of customers.

In the first half of 2023, PGE revised the incentive structure for the Pilot to test the impacts of various compensation methodologies. The changes included a move to a "Pay-for Performance" incentive program structure of $1.70 per kWh/per event instead of the prior flat monthly payment. PGE also revised the up-front incentive for select customers in the Smart Grid Testbed. Previously, the rebates started at $3,000 for the first 67 customers, $2,000 for the next 67 customers, and $1,000 for the next 66 customers (for a total of 200 total customer rebates). The changed structure offers customers $405 per kWh of nominated capacity as an up-front rebate to induce customer adoption. The aim is for higher incentives awarded to the more targeted customer group will provide better data collection based on better locational density levels. These proposed changes are described in detail in PGE's tariff update filing.[3]

The contents and finding of this report largely center around the original structure of the Pilot unless otherwise specified.

Research Objectives

The key objective of the Pilot is to gather information about the impact of residential battery storage in the following four areas: the Distribution Grid, the Energy Portfolio, Customer Impact, and Program Design.

> The Distribution Grid: Evaluate the ability of residential batteries to deliver locational value in support of PGE's electrical system. Use cases PGE sought to study include autonomous Volt/Var support, localized demand response for the provision of distribution congestion relief, and upgrade deferral.
>
> The Energy Portfolio: Evaluate the ability of Pilot participants' batteries to stack values relevant to PGE's bulk energy portfolio. These use cases include generation capacity, energy resource optimization, contingency reserves, and autonomous frequency response.
>
> Customer Impact: Evaluate customer amenability to PGE control of the battery, preference for up-front rebate or ongoing compensation, hurdles to battery adoption, target market, messaging, device communication, etc.
>
> The Program Design: Evaluate how PGE can cost-effectively implement and receive value from this Pilot.

Assessment Approach

When initially proposed to the OPUC, PGE envisioned using a third-party evaluator for the Pilot hired through an RFP process. However, while conducting the Pilot and reviewing the capabilities of third-party vendors, an internal assessment was conducted on the need for an evaluator due to the unique nature of the Pilot that sets it apart from other flexible load pilots. Specifically, during the initial phase of the Pilot, PGE was focused on more technical aspects of the roll-out, such as communications set-up and dispatch testing; topics capable of evaluation by PGE's internal experts.

Additionally, batteries and the reporting enabled by the inverter metrology are sophisticated and detailed enough that the complex evaluations typically performed by third-party evaluators is not required to determine program impacts. For example, a reading of the event performance is available to PGE in near-real time data without the need to perform complicated baselining and measurements with customer meter data.

[3] Portland General Electric "Advice No. 22-43 docketed as 1470" (December 12, 2022) https://edocs.puc.state.or.us/efdocs/UAA/uaa10278.pdf

Due to these twin factors of PGE having more technical and programmatic knowledge of the pilot in-house than could be found externally, as well as the alleviated need to perform complex AMI baselining calculations to quantify the energy impact, PGE discussed the topic with OPUC Staff who agreed that PGE was capable of assessing the Pilot in-house and the use of a third-party evaluator was unnecessary.

Methodology

Quantitative Analysis of Battery Performance

PGE selected the Electric Power Research Institute's (EPRI) open-source Storage Value Estimation Tool (StorageVET®5) software for evaluation and has included modeling results and data in this report. The software co-optimizes bulk system and locational benefits based on provided inputs. This modeling informed PGE's operation of the batteries.

All technical data included in this report were collected via either the Virtual Peaker (VP) API, or PGE's outage management system (OMS). Table 1 show the fields used for analysis, and their sources.

Table 1 Technical Data Fields

Events (VP API)	Devices (VP API)	Metrics (VP API)	Outages (OMS)
Event type	Device type	Battery Power	Start & end times
Command details	House address	PV Power	Cause
Start and end times	Manufacturer	House Power	House address
Contacted devices	Enrollment date	Present Capacity	
Cancellation status	Enrollment status		
Device opt-outs	UID		
Device responses	Charge preference		

Some technical data sets in Table 1 were unavailable for 22 houses enrolled in the initial phase of the Pilot and are not included in the following sections unless stated otherwise. Due to small samples sizes of three or less, Sonnen, Sunverge and Generac devices have also been excluded from most analysis. See Table 3 for a full overview of device enrollment.

The Virtual Peaker API allows for programmatic access to data on a larger scale. A Python interface for the API was developed that allowed access to the information used for quantitative analyses.

Using the API, 5-minute metrics were downloaded for each participating device over the two-year study period. The data were exported and stored locally in a custom format for faster access. The export of all available metrics over the study period (totaling 3.34gb when stored) was autonomous and took approximately 5 hours.

The quantitative elements of the report conform with established industry standards (e.g., the Department of Energy's Protocol for Uniformly Measuring and Expressing the Performance of Energy Storage).[4]

Survey of Market Experiences

PGE also conducted customer and trade ally outreach via a few different methods to better understand satisfaction and experiences. The Customer Conversations platform is a market research online community that enables asynchronous conversations with participants, surveys, and the display of videos and other visual materials. PGE launched a research session on this platform in July 2021 with current Pilot participants to conduct discussions and answer questions from participants and allowed them to chat with each other as a means of gathering early information.

In December of 2021 PGE conducted research again on this Customer Conversations platform with customers deemed likely to install energy storage and current participants. Over a two-week period, PGE conducted a second research session with 47 participants to gather information about awareness of the Smart Battery Pilot, willingness to participate, and feedback on marketing materials.

In preparation for this assessment, a 2023 quantitative survey was also conducted to obtain updated feedback on the Pilot. The survey had 126 respondents, 71 not currently in the Pilot and 55 currently participating. PGE pre-sorted participants into groups prior to entering the survey, these were split by those who are enrolled and those who have a battery but are not currently enrolled. PGE also identified who among participants had received a rebate and who had not.

To understand the perceptions and experiences of the Pilot's business partners, PGE also fielded a quantitative survey targeted at vendors who install residential batteries and conducted an in-depth interview with partners at the Energy Trust that focused on program design. The vendor survey, which launched on May 24, 2023, was sent to 15 trade allies who have installed a battery for a Smart Battery Pilot participant and yielded 5 responses. Though a small sample size, the surveys contained useful qualitative commentary on program design and customer experience with the Pilot. The in-depth-interview with the Energy Trust was conducted by a PGE Product Developer on April 3, 2023.

Findings

Events Overview

The Smart Battery Pilot began recruitment in Fall 2020 and dispatched the first event on January 26, 2021. In the first calendar year of operation, the pilot provided 1.26 MWh of energy to the grid through discharge events, and as the enrollments grew the energy

[4] Rosewater, David. Scott, Paul. Santoso, Surya. "Application of a Uniform Testing Protocol for Energy Storage Systems" (2017)

capacity also increased. In May 2023 the Pilot updated its structure to seek to unlock additional capacity, yet as Table 2 demonstrates, with slightly more participants and fewer events due to only including 2023 levels through September, the total dispatched energy in 2023 exceeds the amount in the previous year. PGE hopes to continue growing the available capacity for peak events through the remainder of the pilot.

Table 2 Events, Participants, and MWh Per Year

Year	Number of Events	Year End Number of Participants	Total Dispatched Energy
2021	10	47	1.26 MWh
2022	14	136	4.88 MWh
2023 YTD[5]	9	158	9.36 MWh

Table 3 shows the make-up of participating devices over the course of the Pilot. Early in the Pilot, Tesla had the majority of devices installed, but SolarEdge has increased to about half of installed devices due to supply chain constraints and customer-reported challenges obtaining a Tesla Powerwall. Generac (branded as Pika when the study started), Sunverge, and Sonnen have fewer participants, and Sunverge withdrew their API support with Virtual Peaker (and as a result was removed from the Pilot) in late 2022. Duracell was added as a qualified product in mid-2023 but at the time of this report does not have any installed devices.

Table 3 Number of participating devices by manufacturer

	Quantity by Brand			
Manufacturer	2020	2021	2022	2023 YTD
Tesla	27	56	68	84
SolarEdge	2	11	63	71
Generac	1	1	3	3
Sunverge[6]	2	2	1	0
Sonnen	1	1	0	0
Total	33	61	129	158

[5] YTD Figures are accurate as of September 30th 2023.
[6] Suverge withdrew their API integration with Virtual Peaker in October of 2022 and is no longer available as a qualified product.

Table 4 and Table 5 show an overview of commands sent in 2021 and 2022. Events refer to groups of commands sent to the battery fleet, while commands refer to individual event-device pairs. Response rate refers to the percent of devices logged as responding by Virtual Peaker. A charge command asks the battery to draw power from the grid while a dispatch command provides power from the battery to power the home or flow onto the grid if the home is consuming less energy than the dispatch has called for.

Table 4 Overview by command type (2021)

Command	Events	Net kWh	Commands	Opt-	Response
Charge	7	203.5	263	0	14%
Dispatch	13	-1,261.6	519	0	71%
Total	21	-856.5	815	0	54%

Table 5 Overview by command type (2022)

Command	Events	Net kWh	Commands	Opt-	Response
Charge	9	992.5	754	9	14%
Dispatch	15	-4,880.3	1248	11	71%
Freq. Support	1	0.0	67	0	0%
Total	25	-3,887.8	2069	11	48%

Table 6 and Table 7 show each test event over 2021 and 2022.

Table 6 Events Overview (2021)

Event Time	Command	Net Energy (kWh)	Commands Sent	Response Rate
01/26/21, 07:00	Dispatch	-47.7	18	39%
01/26/21, 13:00	Charge	9.8	18	11%
02/04/21, 18:00	Dispatch	-17.1	27	74%
02/04/21, 22:00	Charge	31.3	27	19%
06/21/21, 12:00	Dispatch	-123.9	39	85%
06/21/21, 21:00	Charge	51.8	39	13%
07/29/21, 16:00	Dispatch	-157.5	42	88%
07/30/21, 16:00	Dispatch	-140.8	42	76%
08/11/21, 16:00	Dispatch	-170.0	42	67%
08/13/21, 16:00	Dispatch	-101.2	42	81%
09/06/21, 19:30	Dispatch	-91.8	43	67%
09/06/21, 21:45	Charge	28.5	43	12%
09/09/21, 16:00	Dispatch	-140.0	44	68%
09/21/21, 12:15	Dispatch	-5.2	44	73%
11/01/21, 19:30	Dispatch	-81.3	45	60%
11/01/21, 21:45	Charge	26.5	45	16%
11/03/21, 19:30	Dispatch	-82.3	45	60%
11/03/21, 21:45	Charge	27.4	45	16%
11/05/21, 19:30	Dispatch	-102.7	46	70%
11/05/21, 21:45	Charge	28.2	46	15%
Total (2021)		-856.5	815	54%

Table 7 Events Overview (2022)

Event Time	Command	Net Energy (kWh)	Commands Sent	Response Rate
01/28/22, 01:00	Dispatch	-159.4	48	83%
01/28/22, 06:00	Charge	43.1	48	6%
01/29/22, 01:00	Dispatch	-164.0	48	88%
01/29/22, 06:00	Charge	46.8	48	6%
03/18/22, 14:00	Freq. Support	0.0	67	0%
04/14/22, 03:00	Dispatch	-52.8	70	87%
04/14/22, 04:00	Charge	48.4	70	7%
04/26/22, 03:00	Dispatch	-52.6	70	90%
04/26/22, 04:00	Charge	73.9	70	9%
07/12/22, 00:00	Dispatch	-434.6	94	66%
07/12/22, 04:00	Charge	165.3	94	16%
07/26/22, 23:00	Dispatch	-506.3	95	74%
07/27/22, 03:00	Charge	136.9	95	15%
07/28/22, 23:00	Dispatch	-474.0	95	74%
07/29/22, 03:00	Charge	137.0	95	16%
08/08/22, 23:00	Dispatch	-436.4	93	73%
08/17/22, 23:00	Dispatch	-461.0	98	72%
08/18/22, 23:00	Dispatch	-400.8	98	65%
08/30/22, 23:00	Dispatch	-466.3	102	69%
09/07/22, 00:00	Dispatch	-463.5	103	72%
12/16/22, 01:00	Dispatch	-344.3	118	50%
12/16/22, 06:00	Charge	201.4	118	17%
12/22/22, 01:00	Dispatch	-464.3	116	64%
12/22/22, 06:00	Charge	139.8	116	24%
Total (2022)		-3,887.8	2,069	48%

The Pilot was limited in its study of what grid services could be tested according to the functionality enabled by each manufacturer's API. Table 8 shows an overview of the presently viable use cases for each device manufacturer. All devices were able to be charged and discharged, which enables demand response and contingency reserve functionality, but only Tesla was able to perform frequency support activities and none of the devices could provide Volt/VAr dispatch or autonomous frequency response.

Table 8 Use Cases by Manufacturer

	Use case 1: Autonomous Volt/VAr dispatch	Use case 2: Autonomous Frequency response	Use case 3: Generation Capacity/ Demand Response	Use case 4: Contingency reserve	Use case 5: Frequency Support
Tesla	N/A	No	Yes	Yes	Yes
Generac	No	No	Yes	Yes	No
SolarEdge	N/A	N/A	Yes	Yes	No
Sonnen	N/A	N/A	Yes	Yes	No
Sunverge	N/A	N/A	Yes	Yes	No

Objective 1: The Distribution Grid

Within the original filing application PGE stated that it sought to study the following topics and their effect on the electrical grid:

Explore the effectiveness in shaping load, and the potential for distribution upgrade deferrals.

While PGE was not able to induce locational density in the first portion of the pilot and continues to pursue this use case, the battery fleet has proven a capable and valuable resource for load shaping through peak shaving during demand events.

Evaluate and refine setpoints and settings for advanced inverter capabilities to maximize locational value while maintaining local system reliability and retaining battery longevity. Understand the effectiveness of batteries to support Volt-Var optimization.

The ability to utilize advanced inverter capabilities is limited by manufacturer settings and the willingness to support these functionalities within the APIs. As shown in Table 8, none of the manufacturers enable autonomous frequency response or Volt/VAr optimization.

Understand the ability of residential batteries to relieve hosting capacity constraints.

For the first half of this study, the ability of batteries to relieve hosting capacity constraints was not evaluated due to the limited participant pool, the technology readiness (the lack of a VPP) and the infancy of the pilot study. PGE anticipates that as the Pilot matures, and as more participants are enrolled, along with PGE's budding VPP initiative, the batteries will be used to relieve hosting capacity constraints.

Understand the compatibility of stacked services, and the prevalence of conflicting dispatch priorities between locational grid services and bulk energy services.

The initial program design was meant to be rudimentary and as such, lacked the pay for performance model. For the second half of the study, PGE has introduced a pay for performance model and plans to test these additional ancillary services.

Understand the balance of battery use for grid services with customer reserve in the event of an outage.

PGE sought to avoid conflicts between dispatch of the devices and instances when there was a higher than typical likelihood of a power outage. We did this by not dispatching batteries during severe weather and encouraging customers to prioritize their home resilience.

Response Rate

To evaluate the potential for the battery fleet to perform load shaping and demand response, several technical tests were conducted, and the performance of the devices was measured through the DERMS platform.

Response rate was evaluated between each battery manufacturer to ensure that devices were responding appropriately to PGE signals for dispatch and charging. Table 9 shows response rates by manufacturer in each year. The "Response Rate: Total" column shows the dispatch response rate for all devices in the row. The "Response Rate: Non-Responsive Devices Excluded" column shows the dispatch response rate for devices that responded to at least one command during the study period. The latter is provided to allow for more accurate projections of dispatch response rates, given the assumption that non-responsive devices will continue not to respond.

Results show that Tesla and SolarEdge (the bulk of the PGE fleet) consistently responded well, but with room for improvement. Reasons for non-response may be related to participant behavior, local settings of the battery, or devices being offline. The second iteration of the Pilot has a goal to improve device response and participation by providing more direct incentives for customers to correct errors, and PGE expects improvement in the second half of the Pilot.

Table 9 Dispatch response rate by manufacturer

Manufacturer	Number of Commands	Response Rate: Total	Response Rate: Non-Responsive Devices Excluded
Tesla	1137	79%	81%
SolarEdge	572	59%	69%
Generac	19	95%	100%
Sunverge	26	4%	N/A%
Sonnen	1	100%	100%
Total	1755	72%	78%

Dispatch Prediction Accuracy

PGE evaluated the dispatches according to their accuracy, and Figure 2 shows the distribution of reported power output in response to dispatch commands. In other words, how effectively and accurately the devices respond to communications sent by PGE. Each shape represents the distribution of dispatched power corresponding to the amount commanded by PGE.

The thicker parts of each shape indicate ranges where recorded values are the most likely to be. The commanded dispatch on the X axis is the command sent via the PGE Virtual Peaker portal while the response of the battery is recorded on the Y axis. Amongst other reasons, the deviation is due to communications delay and conflicting device settings.

As shown below, variance in recorded power dropped in all categories in 2022 vs 2021, meaning that the load-shifting ability of the participating devices has become more reliable with time.

Figure 2 Distribution of Recorded Dispatch by Year

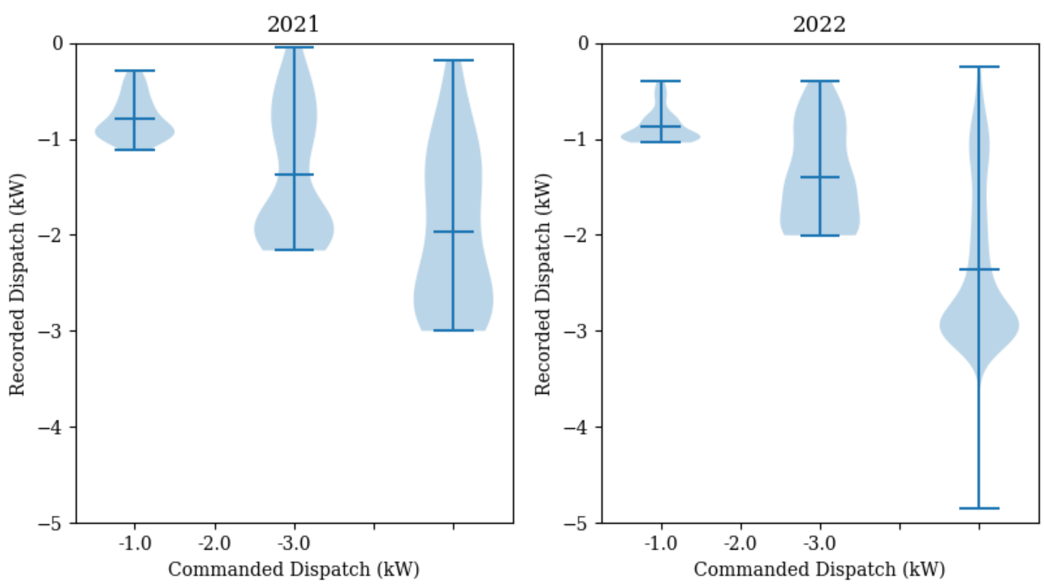
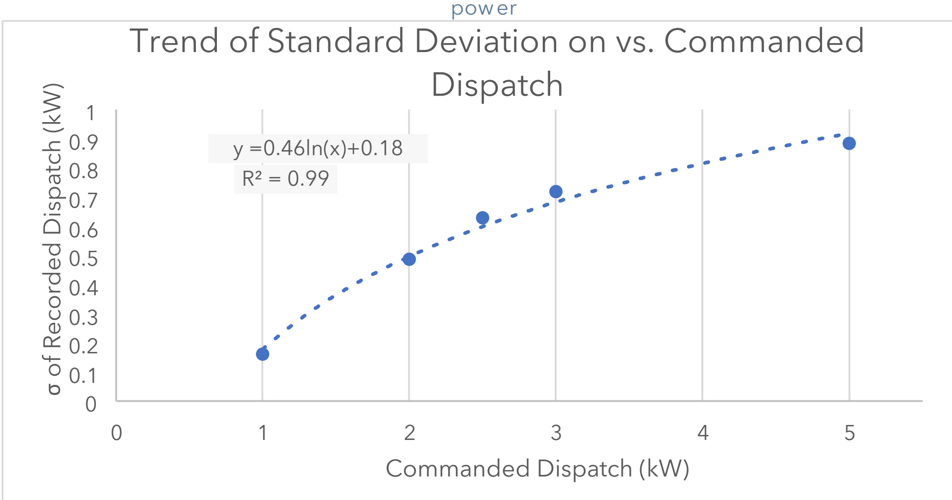


Figure 3 shows the relationship between the dispatch rate requested by Virtual Peaker and the standard deviation of the recorded dispatch in response. Standard deviation is a measure of the space between data points; a small standard deviation indicates that the mean dispatch is a reliable projection of recorded dispatch.

No significant difference in reliability was found between manufacturers. One hundred percent (100%) of responding devices reported a non-negligible energy dispatch, although the amount reported was highly variant in trials above 1kW. There is a strong logarithmic correlation between commanded dispatch power and the standard deviation of the resulting dispatch, indicating that lower-power dispatch commands result in a more reliable output.

While this metric was improved from 2022 over 2021, this is more to do with the larger participant pool than actions taken related to dispatch.

Figure 3 The logarithmic trend between the standard deviation of recorded dispatch power and commanded dispatch power



This difference was compared to device manufacturer, time of day, time of year, and event duration, but no significant correlations were found.

Charge Events

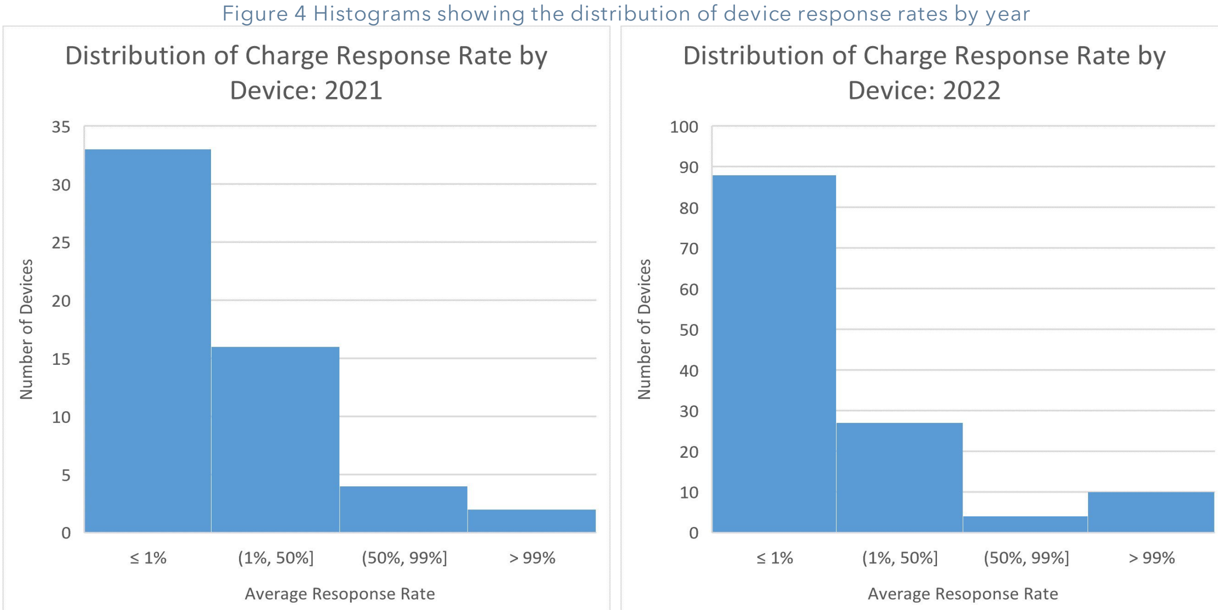
While responsiveness to discharging of batteries was fairly high, due to restrictions put on batteries ability to grid charge from the Federal Investment Tax credit (ITC), few were able to respond to PGE signals to charge the battery. The original structure of the pilot had a tiered incentive, offering a higher monthly payment for devices that could grid charge, but as shown in Table 10 fewer than a third of the customers who claimed the higher incentive rate had devices that would respond to charge signals.

Table 10 Devices Responding to Charge Commands

	All Enrolled Devices		Customer Reported Grid Charging Enabled	
Year	Devices	Respond to Charge Signal	Devices	Respond to Charge Signal
2021	55	10 (19%)	7	2 (29%)
2022	124	36 (29%)	33	10 (30%)

The histograms in Figure 4 show the distribution of response rates by device. Each bar represents a set of devices with an average response rate within the given range. The non-responsive devices referenced in Table 10 are reflected in the "≤ 1%" categories.

Figure 4 Histograms showing the distribution of device response rates by year



Response rates were also evaluated based on initial capacity, after Virtual Peaker staff suggested that low battery response rates may be caused by batteries receiving commands while already near full charge. This was found to be true for SolarEdge devices, which showed zero responses for devices with initial capacities within 2.8kWh of their maximum, but not for Tesla devices, which showed no limit. Devices near maximum capacity account for 2% of non-responses.

Non-responding devices accounted for 5% to 10% of non-responses, implying that device settings are not a strongly related to the battery's dispatch response rate. The starting capacity of the battery did not have a significant correlation with response rate.

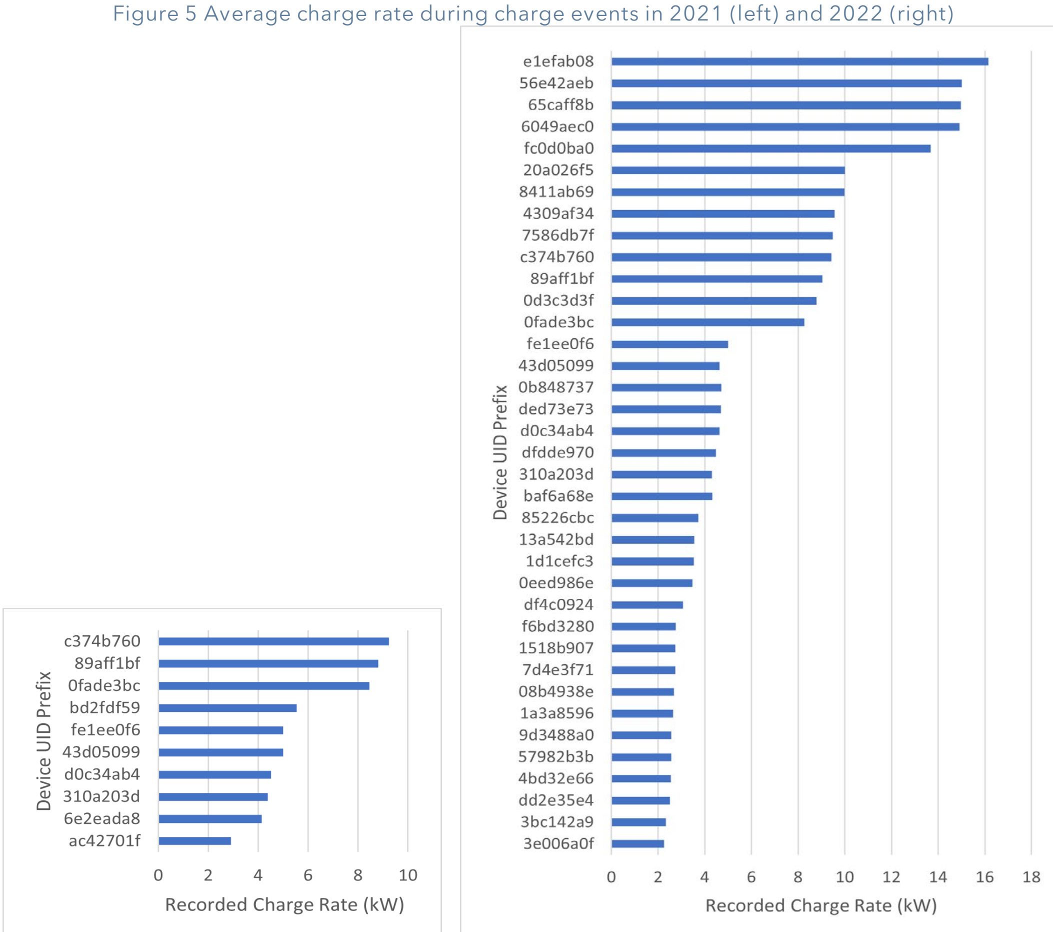
The response rate to charge commands was lower than what was expected based on known factors. Devices with zero-percent response rates accounted for most non-responses, indicating that device settings are a factor in response, however charge preference was not found to have a significant correlation with response rate. Another device setting, or device activity at the start of the event may be the cause, but these possibilities have not been thoroughly examined.

After excluding non-responsive devices, the response rate of charge commands is still an average of 28.2% lower than dispatch commands, indicating that these non-responses are specifically related to the type of command.

Rate of Charge

Figure 5 shows the average charge rate of individual devices in response to charge commands in 2021 and 2022. All commands requested charging at the maximum rate. The Device UID Prefix is an anonymized code for each participating customer.

Figure 5 Average charge rate during charge events in 2021 (left) and 2022 (right)



All charge events requested that each device charge at its maximum rate, so some variance was to be expected between manufacturers and battery quantities. The high variance in device charge rates likely corresponds to the number of batteries connected to the reporting gateway. Tesla Customer Support staff confirmed that all gateways reporting >5kW average power were Tesla gateways connected to multiple batteries. All responding gateways reported charging at the expected rate for groups of 1 to 4 batteries.

Autonomous Volt-VAr[7]

Although the IEEE 1547-2018 standard includes interconnection technical specification and performance requirements for reactive power capabilities and voltage/power control requirements for batteries, the Virtual Peaker platform and the OEM APIs currently lack the functional capabilities to measure/record voltage support. Because of this, no voltage support testing has been performed up to this point in the Pilot.

Objective 2: Energy Portfolio

Beyond the distribution system impact of battery energy storage, the Pilot also sought to study the ability of batteries to stack values relevant to PGE's bulk energy portfolio such as

[7] VAr stands for Volt-Amps Reactive and is the measuring unit for reactive power.

generation capacity, energy resource optimization, contingency reserves, and frequency response.

Peak Event Dispatches

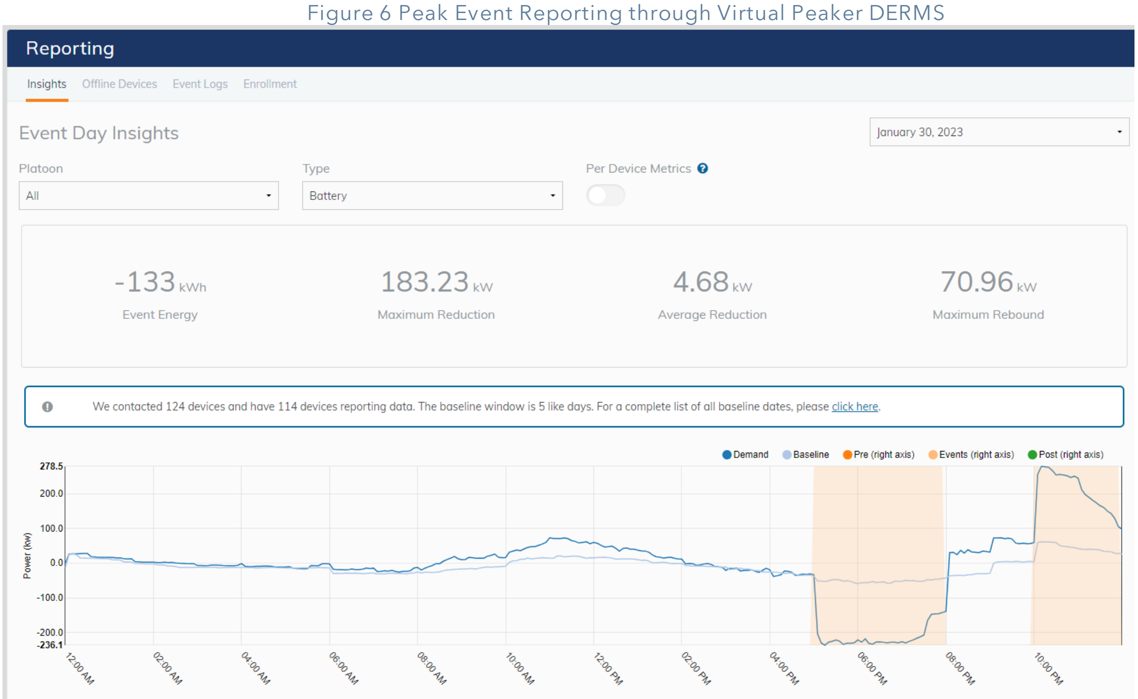
The dispatch events outlined in the Events Overview section were largely dispatched for demand response purposes in alignment with the larger PGE VPP portfolio (consisting of Smart Thermostats, Peak Time Rebates, Energy Partner / business demand response, Multifamily Water Heaters, and Smart EV charging). These events were typically called for meteorological reasons, such as for high heat or low temperatures that put strain on the grid necessitating the usage of higher emitting peaker plants and/or more expensive marginal power. A summary of the dispatched peak events is in Table 11.

Table 11 Events, Participants, and MWh Production Per Year

Year	Number of Events	YE Number of Participants	Total Energy
2021	10	47	1.26 MWh
2022	14	120	4.88 MWh
H1 2023	9	158	9.36 MWh

Through the Virtual Peaker DERMS PGE can view in near real-time the dispatched performance of the resources through the advanced inverter metrology that is unique to batteries. PGE Power Operations is seeking a predictable and stable dispatch of energy during peak events. The performance of the fleet during peak events has been sufficiently stable and provides a flat dispatch of power throughout the event. If PGE wanted to improve this at larger volumes, we could stagger the dispatch of the devices to avoid the trailing off of power at the end of the event as observed in the example provided below in Figure 6.

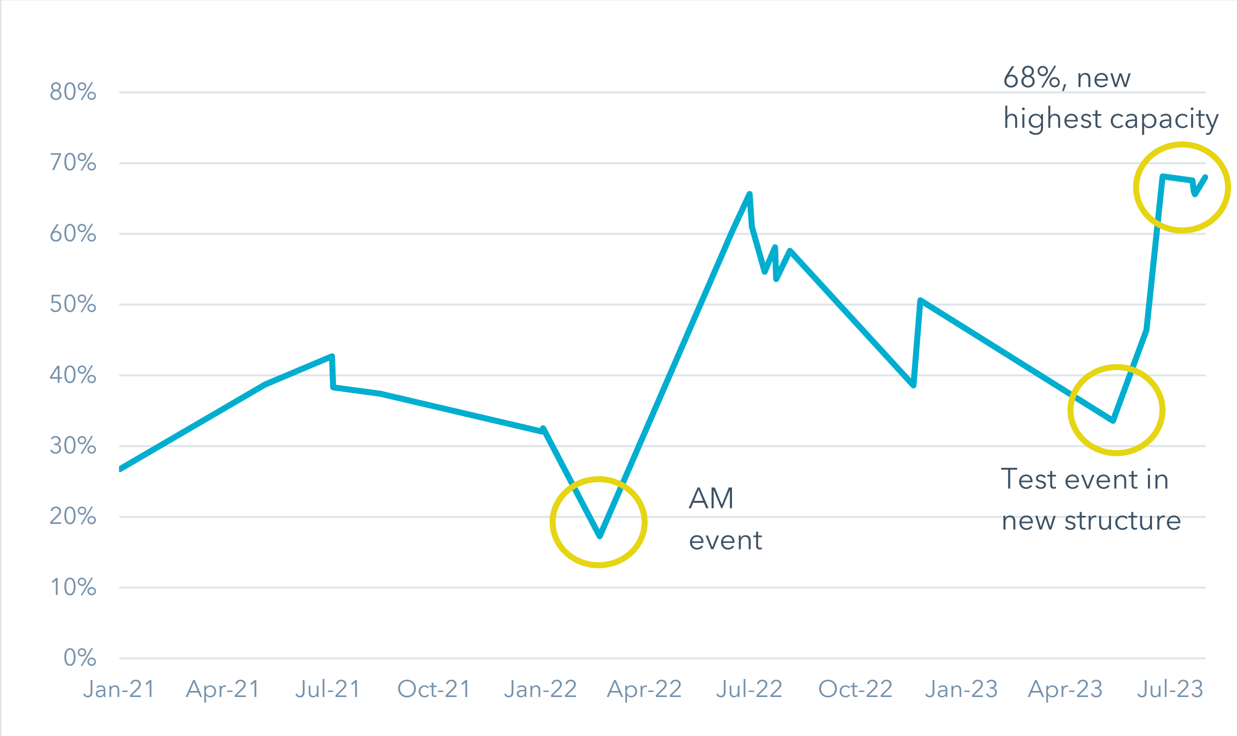
Figure 6 Peak Event Reporting through Virtual Peaker DERMS



The predictability of the provided dispatch is something PGE has been working to improve, as there has been more variability in what the events have been delivering versus their nameplate capacity than what is desired. The proportion of the delivered capacity as compared to the available capacity is shown in Figure 7. In other words, if the entire fleet is projected to provide 500 kWh during a peak event dispatch but only provides 250 kWh, the availability would be 50%.

As shown in the graphic, summer events have been performing better than winter due to the available capacity of the batteries when solar production is high, with the lowest performing event being a winter morning. PGE may opt to experiment with scheduling a charge event prior to dispatch this winter to see if that helps with predictability, however PGE is cautious to avoid operating customer batteries in a way that may increase their electric bills. The first test event of the new pilot structure had a programming error caused by the increase in complexity of the dispatch and thus had a lower than desired performance, but the subsequent five events dispatched in summer 2023 delivered between 66-68% of nameplate capacity. This combination of greatly increased capacity plus predictability is a great step in the right direction for the Smart Battery Pilot.

Figure 7 Percent of Available Capacity Delivered Per Event



Available Capacity

Available capacity is included to judge the energy available for demand response and as a contingency reserve throughout the study period. This was chosen over maximum capacity as the desired metric, as most devices never reach their listed maximum capacity due to device settings and energy usage.

Available capacity was calculated by exporting 15-minute present capacity data from every device in the fleet, over the two-year study period. These values were then interpolated and summed over regular 15-minute intervals, to estimate the fleet's overall available capacity over time. Figures 8 and 9 show the daily distribution of these calculated values.

Capacity metrics were not available for devices that were unenrolled during the study period. This means that the values shown are likely lower than the actual total, especially in 2021. The estimates should grow more accurate as they approach the end of 2022, as very few devices have been unenrolled between then and the time of this report.

The following tables demonstrate the monthly distribution of total capacity in the customer battery fleet. The mean value indicates the overall trend of total capacity over the study period, while the minimum, maximum, and range values indicate the total distribution of capacity in each month. The Mean Daily Range is a measure of the typical range of capacities seen in a 24-hour period.

Table 12 Monthly Distribution of Available Energy from the Smart Battery Pilot

Month	Mean (kWh)	Min (kWh)	Max (kWh)	Range (kWh)	Mean Daily Range (kWh)
Jan '21	329	228	347	119	48
Feb	422	247	496	249	69
Mar	449	301	439	138	72
Apr	489	303	524	221	86
May	566	330	537	207	104
Jun	621	246	582	337	115
Jul	706	406	647	241	127
Aug	753	476	722	246	130
Sep	738	482	712	231	123
Oct	753	517	765	248	123
Nov	766	530	808	279	128
Dec	845	542	1,022	480	128
Total 2021	620	228	1022	794	104
Jan '22	896	610	921	312	144
Feb	963	641	1,027	386	153
Mar	1,151	703	1,141	438	188
Apr	1,162	838	1,143	306	181
May	1,151	791	1,145	354	183
Jun	1,370	838	1,395	556	232
Jul	1,553	891	1,534	643	280
Aug	1,714	1,009	1,788	779	281
Sep	1,731	1,238	1,628	390	277
Oct	1,674	1,187	1,700	513	254
Nov	1,731	1,287	1,933	646	250
Dec	1,795	1,417	1,800	384	53
Total 2022	1,407	6,10	1,933	1,323	206

Figures 8 and 9 show the distribution of total capacity (the sum of the current capacity of every battery in the fleet) in 2021 and 2022. Each data point represents information aggregated from one 24-hour period. The Daily Minimum and Daily Maximum lines indicate the total range of capacity in the day, while the Daily Mean shows the average trend. The black line shows the total number of enrolled devices.

Figure 8 Distribution of daily battery fleet capacity in 2021

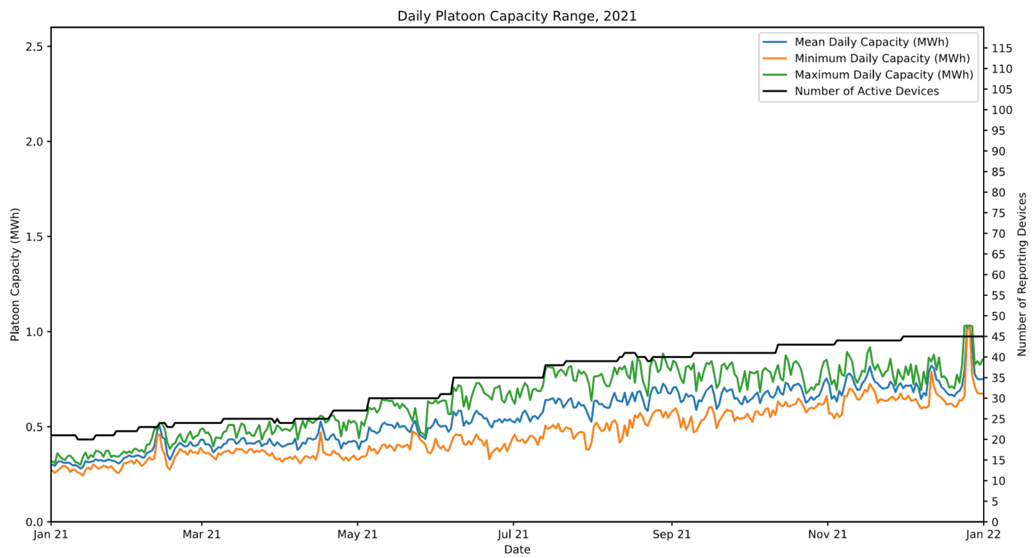
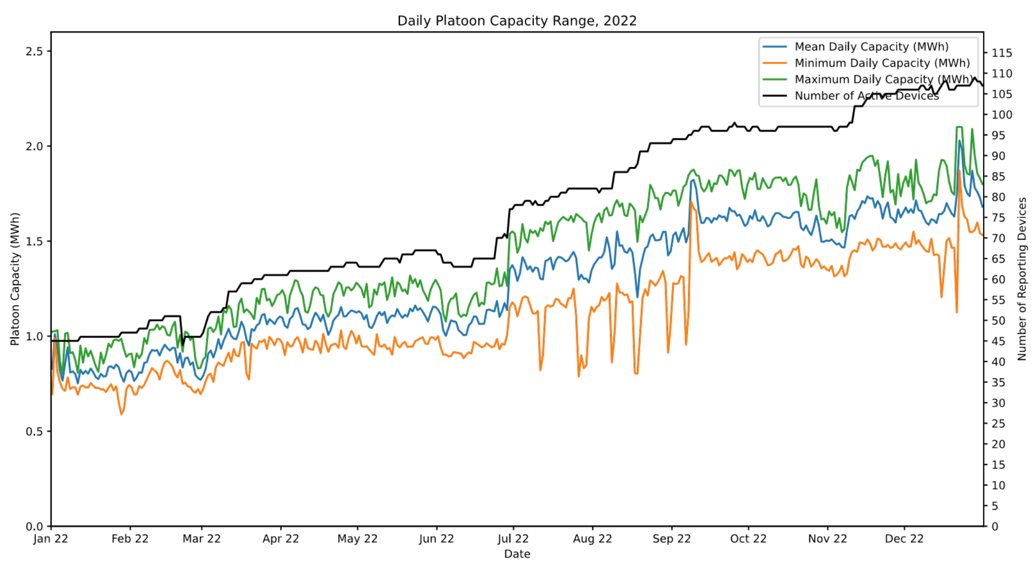


Figure 9 Distribution of daily battery fleet capacity in 2022



As expected, the amount of available capacity increased proportionally with the number of devices in the fleet. Capacity also correlated with time of day, with the highest capacities consistently being reached in the hours between 12:00 and 16:00. The maximum capacity achieved was 2.57 MWh on 12/23/2022.

With current enrollment rates, these findings indicate that the program is on track to reach its 4MWh goal available capacity by 2025.

Frequency Response

Traditionally, frequency response is provided by synchronized generators, though modern DERs like BES can also be used to provide this service. Each time the grid frequency drifts outside the 60 Hertz dead band, each participating BES will be allowed to respond to correct the excursion. By responding, the BES can be called upon to partake in a frequency response event. Further, because there are currently no frequency response markets, pricing for frequency response can be challenging, because the RES BES pilot when aggregated will be used to provide frequency response, there exists an opportunity cost that needs to be quantified.

The frequency-watt operating boundaries shall be set to autonomously dispatch in support of grid frequency by modulating the power output of the inverter. Control, response, and operation data shall be collected from the inverter based on the measured grid frequency according to a frequency-watt droop strict user-defined parameter.

This use case will demonstrate that customer cited BES can help defer capital upgrades to existing generation resources by displacing the frequency response services otherwise provided by conventional generation using aggregated BES systems.

Fast Frequency Response

Two tests of frequency support were performed on March 18th, 2022, with PGE owned test batteries, a Generac, and a Tesla. Response times were measured via stopwatch between signal send and response seen by a meter. Each communication pathway was tested 3-4 times, and the times were then averaged to get the final performance result.

The first test was to see if residential batteries could respond fast enough to a command given to the battery through the Virtual Peaker API, and, additionally, if the PGE's GenOnSys system could be used to autonomously send the "go" signal to VIRTUAL PEAKER using pre-programmed set-points (as Virtual Peaker does not have frequency monitoring nor autonomous control based on random triggers). The ideal target would have the batteries respond in under 20 seconds, which is the upper time limit for measuring system response to a frequency event per NERC standards.

Communication Pathways:

Path 1:			VP	→	Vendor Cloud	→	Battery-Connected Router	→	Battery
Path 2:	GenOnSys	→	VP	→	Vendor Cloud	→	Battery-Connected Router	→	Battery

The results of the four manufacturer / communication pathway combinations are shown in Table 13; and none of the trials met the 20-second NERC standard.

Table 13 Meter response times by vendor and communication pathway

Vendor	Communication Pathway	Average Time to Respond
Tesla	Path 1	59.96
Tesla	Path 2	61.34
Generac	Path 1	48.05
Generac	Path 2	53.81

None of the four manufacturer / pathway combinations responded within the 20 seconds necessary to credit PGE for the response. Path 1 does not currently have a means of working autonomously, and therefore would not be feasible even if response times were improved. The conclusion is that residential batteries cannot do fast frequency response using an outside command to discharge.

Frequency Support

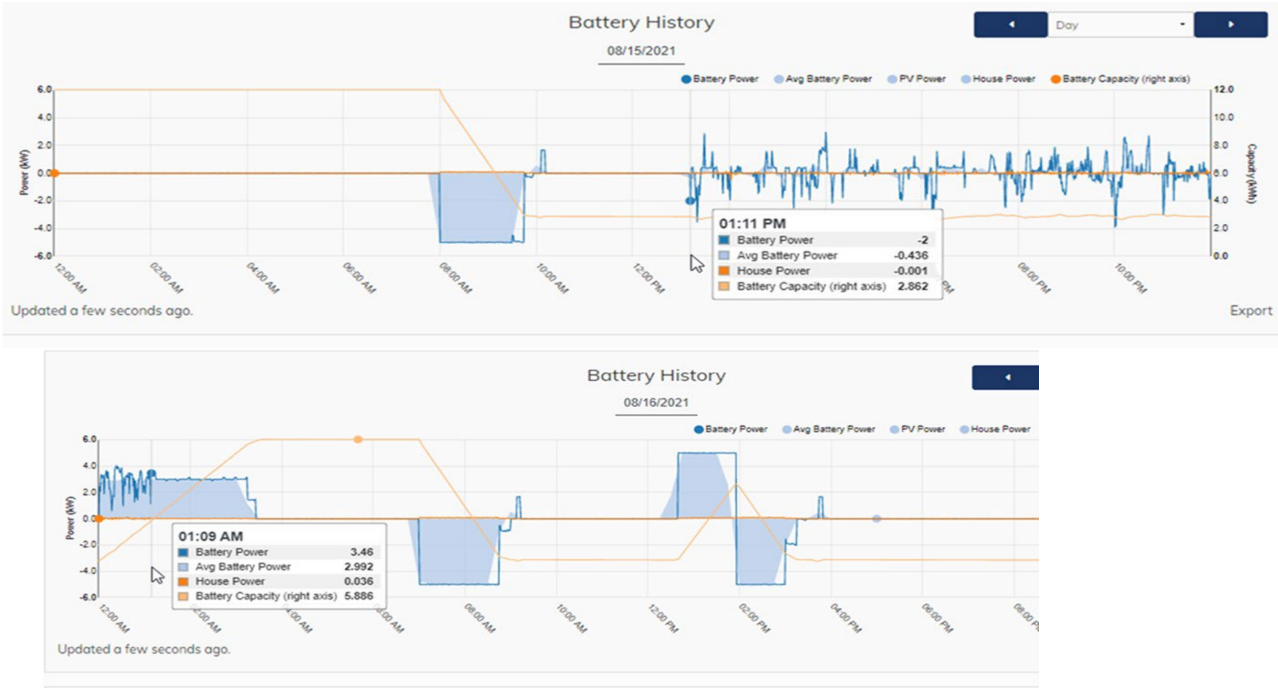
After the fast frequency response test was found to not be successful, the Pilot initiated a second test of the Virtual Peaker "frequency support" function, which provides a means of hard-coding the batteries to proportionally respond to changes in frequency based on a Hz-watt curve. This function allows residential battery a locally controlled means of providing frequency response.

This test was performed exclusively on Tesla batteries, as Tesla is the only vendor that currently supports the frequency support function through Virtual Peaker. Customers were notified in advance that frequency support would run for 12 hours. All Tesla batteries in the fleet were programmed with an aggressive Hz-watt curve was used with limited deadband to provide maximum visibility into each battery's response. The chosen curve used the following VIRTUAL PEAKER parameters:

- Low Frequency (Hz): 59.985
- Low Freq Delta (Hz): 0.01
- Low Power Delta (W): 1000
- High Frequency (Hz): 60.015
- High Freq Delta (Hz): 0.01
- High Power Delta (W): -1000
- Hysteresis Freq (Hz): 0.01

Figure 10 shows an example of typical battery behavior during the fast frequency response event. The figure shows the battery charging or dispatching up to 4kW in response to changes in frequency between 13:00, 8/15/2021 and 1:00, 8/16/2021.

Figure 10 Example of battery activity during frequency response event, between 13:00, 8/15/2021 and 1:00, 8/16/2021



Nearly all the contacted batteries successfully responded to deviations in frequency by either charging or discharging proportionally to the frequency deviation. During the event period, the frequency support mode did not interrupt other battery functions, such as solar self-consumption or TOU optimization. Total kWh performance of each battery was partly dependent on other modes and functions the customer was using the device for at the time of the event.

Because kWh performance of each battery was partly dependent on other modes and functions the customer was using the device for at the time of the event, actual performance can only be verified by checking the battery activity graph for each individual enrolled device. This creates a challenge for scale-able verification of performance for a pay-for-performance tariff. Because high-frequency metering was not available at each battery, it was not possible to determine whether the battery responded within the necessary window to frequency deviation. The results indicate that Tesla batteries may be able to provide frequency response in small amounts (per-battery) without needing to be used exclusively for that purpose. To confirm viability, the Tesla battery group’s speed of response to frequency events will need to be verified.

Since the battery’s charge or discharge activity will be based on how severely frequency deviates from 60 Hz, the battery’s contribution will typically be less than what we could achieve with an autonomous command as was tested above, but in aggregate the response may still be significant with many batteries operating on this curve.

EPRI StorageVET

PGE sought to better understand the accuracy of PGE's modeling inputs to EPRI StorageVET and its suitability as a planning tool that can inform IRP values for use cases as part of the Pilot. EPRI's StorageVET tool (now re-branded as DER-VET) has been under development since 2016. It works by taking in technical requirements and pre-calculated values for different energy storage services and calculating the optimal dispatch to achieve the best cost-benefit ratio. DER-VET added DER sizing and resilience analysis for potential microgrids.

DER-VET requires the values of services ahead of its calculations, so we realized that the IRP values must inform the DER-VET values, rather than the hypothesis that StorageVET/DER-VET could inform the IRP. Different utilities have different values for services at both the bulk system level and the distribution level, so financial modeling must be done in advance to feed DER-VET's models.

With the financial values of services as an input to DER-VET, for batteries that have no limits on operation (ability to charge, ability to export), the value of batteries scales up regardless of location on a $/kW & $/kWh basis, due to bulk system services making up the majority of DER value except in future cases where energy storage can be targeted for an NWS project. Due to this, DER-VET is largely used now for its resilience simulation metrics for prospective microgrid projects.

Contingency Reserve

According to the National renewable Energy Labs (NREL), contingency reserves are capacity services that are set aside as backup and are enough to cover the unplanned disconnection or outage of a large generator or transmission line and these reserves are required to maintain system balance. Contingency reserve is required for the reliable operation of the interconnected power system. Adequate generating capacity must always be available to maintain scheduled frequency and avoid loss of firm load following transmission or generation contingencies. NERC requires that PGE plans for both spinning and non-spinning reserves. BES can be used for spinning contingency reserves since they are online and can respond immediately. The BES can also be reserved for non-spinning reserves. In both cases, this can be achieved by reserving a fraction of the BES for a period, as a contingency reserve. We define the seasonal reserve as a percentage of each connected BES.[8] This available capacity in each BES must at no time fall below the sum of the minimum threshold stipulated by the BES OEM and the contingency reserves stipulated in this document.

To utilize the Smart Battery Pilot for contingency reserves the Pilot must be directly connected in with PGE's balancing authority so that the batteries may provide the necessary power within seconds to minutes of an event occurring. This is not practical with manual dispatch, although the batteries have the technical capability to discharge in response to a signal. One pathway to connect a battery into the Balancing Authority is through GenOnSys,

[8] Suggested reserve may vary by manufacturer and unit rated capacity.

which would send a dispatch signal to Virtual Peaker to discharge the batteries. PGE successfully completed a demonstration for this dispatch pathway but did not sustainably implement it. The benefits and practicality of completing this pathway will be evaluated in the second half of the Pilot.

Objective 3: Customer Impact

Customer Discussion Board

In December 2021 PGE fielded research to understand customers' experience with power outages, discover their familiarity and interest with our Smart Battery pilot program, and open a discussion about what they might want or need from the program to opt for getting a battery. Using the program description itself to discover what customers did and did not like about this program and decipher what types of barriers are keeping customers from purchasing a battery.

PGE used the Customer Conversations qualitative research platform to engage potential home battery candidates over a two-week period. The platform enables asynchronous conversations with participants. The Conversation ran from Dec 8th to Dec 17th and 47 individuals participated. Only two customers already owned a home battery energy storage system, and six had solar panels. The majority live in a single-family home and one lives in a multi-family home.

The first set of questions posed for the customer discussion were around power outages. Lack of heat, food loss, and lack of cell service/internet were the most mentioned impacts of a loss of power. Many participants mentioned the February 2021 outage and the negative effects it had on them. The only ones not worried about an outage were those who have already invested in back-up power.

Thinking of power outage preparedness, most customers in the conversation just had the basics such as candles and flashlights, but a few want or already have back-up systems. Many respondents think they are prepared for a few days, but few feel prepared for a longer-term outage. Despite this lack of longer-term preparedness many believe that installing a back-up power resource is too costly to be worth it.

> Q: First I'd like to ask you how power outages have impacted you and your household. I'm speaking of power outages in general, so if you have not had an outage experience with PGE, I'm still interested in hearing how other outages have affected you.

Figure 11 Customer Quotes- Outages

We lost power in the big snow/ice storm last year and probably would have been less stressed about it if we didn't have small kids (3-yo and 3-month old at the time). It got cold very fast in our house and I was surprised to discover that even our gas furnace couldn't run without electricity. Maybe that seems obvious, but you'd think that a non-electric furnace should be able to keep going, maybe with a small, dedicated battery backup.

We've had a few power outages in the past couple of years…the outage during the ice storm was about a week long and was fairly disruptive for us since I work from home

The most significant power outage was Valentine's weekend 2021. A neighbor's tree fell on the power line for our dead end street. Not only were we without power, heat, cell service, but we were also trapped on our road. Because it only effected the houses on our block, despite a neighborhood cluster of outages, we were not high on the priority list. The fact that live wires impeded entry and exit was beyond troublesome.

My neighbor has a generator and he has peace of mind. I'm thinking about investing in one as well.

I haven't experienced a power outage in years, and I'll probably never have a power outage again since I purchased large batteries that recharge themselves using my solar production; the batteries are Tesla Powerwalls, but other companies make systems that do the same thing. I've had full power in my home even when the grid was down in my neighborhood (including the February 2021 event in Portland) and the switchover between grid and batteries is almost instantaneous. Prior to my battery system, I hated power outages (such a huge disruption to activities), which was part of the reason I purchased my Tesla Powerwalls.

The hardest power outages are when it happens for days and you lose your food! That's expensive!

Q: Have you taken any steps to prepare for power outages? If so, what specific steps have you taken?

Figure 12 Customer Quotes- Outage Preparedness

Other than candles, and backup files for my business, I have no real backup for power outages.

*We have candles, flashlights, Coleman lanterns, lights you can hand crank, and a small battery that can be used to charge cell phones. We also have one of those saucers that we take out and put wood in. I have a small pile of wood that could be used to make a fire to cook with. We also have food that does not require heat.
People lived without power for a very long time. We would be fine.*

We have flashlights and a few candles

The most consequential step we have taken in to add solar to our home and a backup battery at some point in the future when Tesla figures out how fill their backorders. We also learned from last winter's ice storm the value of extra batteries and candles.

Yes, we have basics like an army of candles, small propane tank, firewood, gas fireplace insert/water heater, and a generator. I'd love have a battery option with maybe a solar panel system to charge it, but there are significant costs to implementing those systems which is hard to squeeze into a typical family budget.

Gas water heater, stove, and fireplace. Lots of trees around us that limit the use of any solar options.

Q: What sort of challenges (if any), have you faced in preparing for future outages? Do you feel like you have enough information to properly prepare for outages?

Figure 13 Customer Quotes- Preparedness Challenges

No real issues in preparing for outages. We have lots of dried goods and a bbq for cooking. Extreme temperatures are always a factor. Cold in winter means you need to bundle up. Summers become more difficult if you can't move air.

I would want more details on cost/benefit for battery backup systems, options for providers, and how easy monitoring system performance is.

I have purchased an eco flow battery for back up with solar charging however in the winter it may not charge. We have water, food, flashlights, batteries. Prolonged outages would be difficult. I believe that we all need to have a few days of survival supply as help may be prolonged in a major disaster

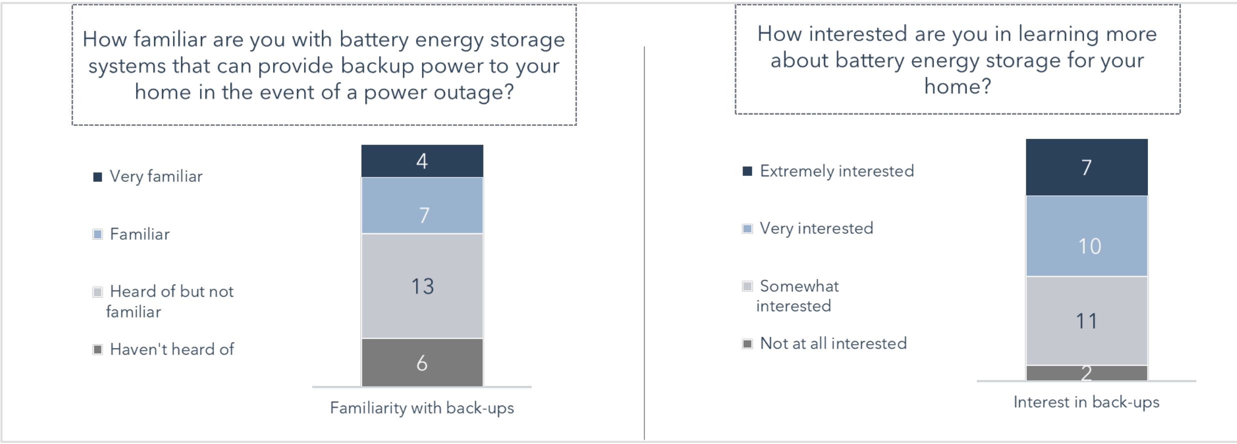
I feel like it is hard to prepare because you don't really know how long an outage might last. It is easy to be ready for a short amount of time, but anything longer than a few hours starts to present challenges when it comes to keeping food cool etc.

Nope, it's lower on the priority list of things to-do and based on the value-add to cost benefit it is hard to justify incurring a thousand or two in additional "band-aid" expenses when 1) I see infrastructure improvements all over the neighborhood, and 2) layouts of new green programs such as these being discussed.

The qualitative conversations were paired with some survey questions, however due to the small sample sizes these should be treated as qualitative data as well.

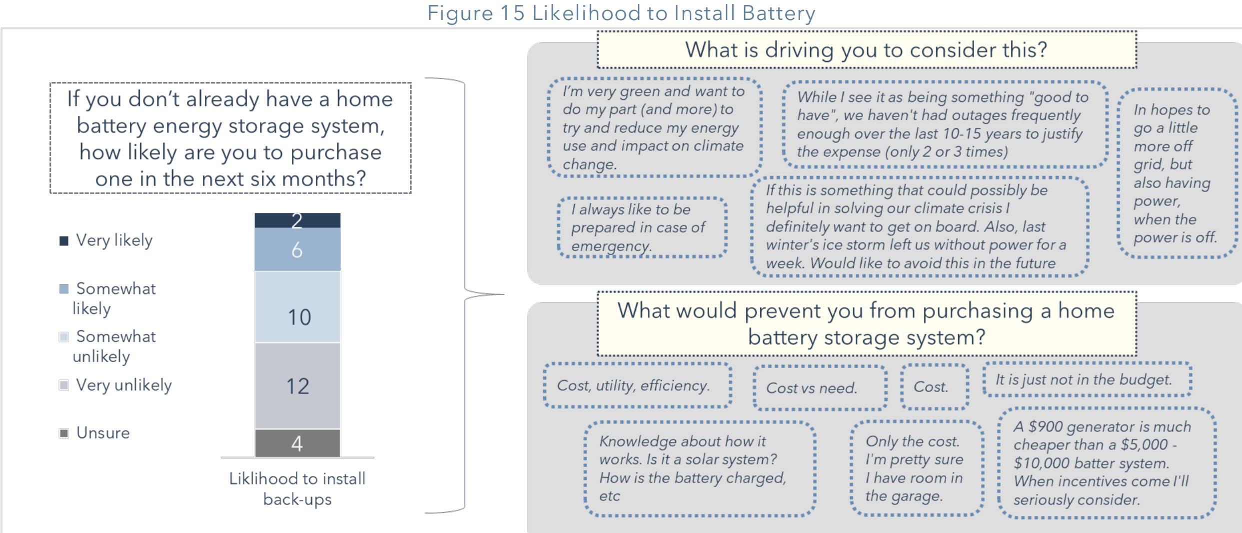
Current familiarity with back-up power options was low but most were at least somewhat interested in learning more about it.

Figure 14 Familiarity / Interest with Batteries



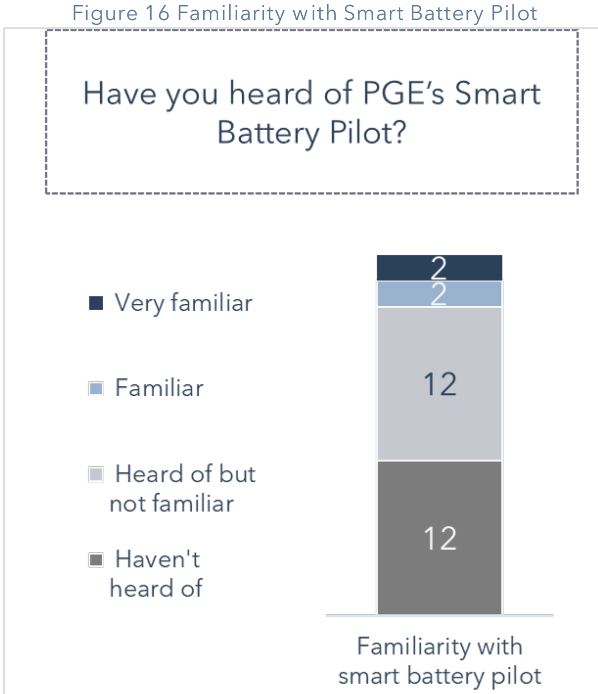
Only 8 respondents were likely to purchase a system in the next six months, while 22 leaned toward unlikely. Climate change and independence were the largest motivators, with cost being reported as essentially the only perceived major barrier.

Figure 15 Likelihood to Install Battery



Most respondents were unfamiliar with the Smart Battery Pilot.

Figure 16 Familiarity with Smart Battery Pilot



The conversation then turned to the Smart Battery Pilot, first just the concept without incentives shown. Customers agreed that it was an interesting project, but they simply needed more information, such as the specifics of the cost, technical questions about how they would work with solar, and concerns around safety.

Figure 17 Program Description Shown to Respondents

Save thousands on a home battery system

As we build a cleaner energy future and add more sustainable power like wind and solar, we're developing energy storage so we can make the best use of these more intermittent resources.

Because you are part of the PGE Smart Grid Test Bed, you can save thousands of dollars off the purchase and installation of a home battery storage system. And, if you take us up on our offer, we'll enroll you into the PGE Smart Battery Pilot.

This program gives you a monthly credit on your bill just for connecting your battery to our grid.

- Customers enrolled in the Smart Battery Pilot allow PGE to interact with and operate their battery. PGE can send energy to the battery to store and dispatch energy from it to add to the grid. In the event of a power outage, customers retain full usage of their battery for use as a power backup.

What can a battery storage system do for you? You might be surprised.

- You can rely on back-up power if there's an outage.
- You can earn monthly credits as part of the PGE Smart Battery Pilot program.
- If you also have solar panels, you'll get the value of that power storage solution.
  - A battery lets you store the energy you generate during the day.
  - You can then use that renewable energy at night.

These batteries will create a virtual power plant that is made up of small units that can be operated individually or combined to serve the grid, adding flexibility that supports PGE's transition to a cleaner energy future. In addition, the batteries provide you with a backup energy resource you can rely on in the event of a power outage.

Q: What is your first reaction to this program concept? Is the purpose of it clear to you? Please keep in mind that I'll present the incentives for the program to you in an upcoming activity. In the meantime, tell me what you think of the concept.

Figure 18 Customer Quotes- Smart Battery Response

Sounds great. Questions that come to mind are installation location, size, life expectancy of the battery, safety with pets or children.

I really like the idea and with the proper incentives it is something I would definitely be interested in

I think that it is interesting, but adds a lot of questions to if I would want to Inquire about it. It mentions solar panels, and that makes me wonder what would I have to do to verify I would qualify for those. Are those included in the set-up? What is the range of the credits? The initial flyer perks my interest and I think the program is cool idea once I know more information

The concept sounds great, but the devil is in the details. How much will the battery system cost? Like Amanda noted, if we're saving thousands we're likely spending thousands as well.

It's a great concept. Just depends on costs. I've seen offers for solar panels that have you finance them over many years, with the idea that you pay for them from your energy savings. It's all fun and games until you sell the house.

I'm very interested in the concept, as it would directly provide some of the backup we are interested in if there were a power outage, and I like the idea of contributing to a community-wide grid improvement project. The biggest question is COST, both up-front and long-term. I'm also curious about how the battery would be sized, since it probably won't be able to sustain an entire household for multiple days if there's no grid power

There is some distrust of PGE managing customer systems, but most acknowledge that it makes sense. Several participants mention not liking or needing more information about the ways in which PGE would be controlling their devices. However, most understand that if PGE is helping with the cost, it is appropriate the utility have some control.

Q: A component of the Smart Battery Pilot is PGE would occasionally manage your battery's charging and discharging to support more sustainable energy sources, reduce power outages to all customers, and keep electricity costs low? What do you think about this?

Figure 19 Customer Quotes - Managing Battery

It is not my favorite thing to have PGE involved in this, but since they would help pay for it, I think it would be okay and it may actually help the batteries laat longer.

Seeing that PGE is (partially) kicking in for the cost, I believe it makes sense that they have some control over the battery. They are, after all, using it for the benefit of the entire grid, thus they would need to charge and discharge as the grids needs it.

I like all concepts of this model but I'd like to fully understand all PGE's controls, authorities and usages of this system.

If PGE was occasionally managing my batteries charging and discharging that sounds ok but I would appreciate a schedule to know when this is taking place.

This is the whole advantage of the program: it adds a tremendous amount of decentralized capacitance to the grid. This makes the grid more flexible and resilient for all of us. The social contract is that PGE customers support the capital expense by installing the batteries on their end, in return for the use of those batteries during outages. It seems like a fair deal to me--although I would still need the economics to be valid for me as an individual customer, to participate.

I am curious as to how PGE will manage the battery. In particular, I wonder if PGE would ever charge our batteries from the grid and would this effect our tax incentive for installing the battery as part of our solar project. My understanding is that the battery must be exclusively charged from the solar panels. I do see the need for PGE to find creative ways to store energy if we are to ever move beyond fossil fuels.

The program financial incentives were then revealed to participants and asked more questions of them.

Similar to the last discussion, people liked the concept but lacked enough information to decide either way and wanted to see a clear and concise breakdown of the costs.

Figure 20 Program Incentives Shown to Respondents

You can take advantage of rebates and earn monthly bill credits for participating in the Smart Battery program:

- Earn $20 a month if your battery can only charge from your solar system. Earn $40 a month if your battery can charge from the PGE system and/or your solar.
- Because you live in the PGE Smart Grid Test Bed, you can also receive an instant rebate of $1,000 to $3,000 toward the cost of installing a battery.* Learn more.
- Up to 25 income-qualified customers will receive a $5,000 instant rebate toward the cost of installing a battery energy storage system when also participating in the Energy Trust's Solar Within Reach program.

Q: I'd like to get your first impression of the incentive structure for the Smart Battery program. If you have questions about the incentives, please feel free to ask.

Figure 21 Customer Quotes - Incentive Structure

There are lots of details that need to be further delineated in the incentive description. Why is there a range between 1-3k for the instant rebates? If we install an approved battery pack ourselves, are we still eligible for those rebates? What is the Solar Within Reach program? And what are the income qualifications for that program?

$20-40/month sounds like practically nothing, compared to the expense of installing a battery system. There's a pesky little asterisk on the second bullet above with no follow-up, but presumably including lots of important information on what to expect for the rebate offered.

The incentive structure is interesting, but having to contact PGE to understand the details is a roadblock.

I'd like to see a breakdown of the costs along side the incentives to see what the total cost would be

Honestly, It sounds expensive to put in both battery and solar. So if your using solar and the battery backup, you get 40 per month from PGE? But can you clarify if that's in addition to the extra savings from no to low electric costs? And does PGE then also buy back when your battery is full?

The rebates are nice but it's important to note that these aren't paid directly to the customer. Rather the solar / battery installer receives the incentive and it is a component of the overall price of the installed system. My very biased opinion is that some installers know the incentive you are eligible to receive and don't competitively price the system, rather the price reflects the additional money available.

More cost information was provided to customers based on this feedback. Once they were given more incentive details, they were split on if it was a good idea. Several thought it was a good deal if you already had solar, but it wasn't worth the money if you had to do both at once. For many, the benefits do not outweigh the costs.

Q: Since there were so many questions about installed cost of a home battery system, I thought I'd post some estimated costs for you. I was able to chat with one of our program folks and they provided this estimate. The estimate includes the PGE incentives except for the income-qualified incentive. After taking a look at this, tell me how that changes your thoughts.

Figure 22 Customer Quotes – Incentive Impact

The incentives seem pretty good. The base cost of close to 17k is for a battery which doesn't have enough reserve to power many homes for more than a day, probably less. Ultimately I would want a system that could power my house for days, and in the winter when solar is minimal that seems like a pretty big set of batteries. I think the cost barriers for most folks are still too high. Hopefully the cost of batteries and solar will come down and we can make significant progress in cutting our carbon footprint.

Batteries clearly enhance a solar-electric solution. But for those without solar power, the value proposition isn't there as I see it.

With all of the rebates, $7k installed is not terrible if one already has solar panels and can power, for free, appliances running during the night.
Battery costs are constantly coming down too

This makes sense with solar panels, if you already have them. Kind of a hard pill to swallow if you have to add on the extra expense of adding solar panels to your home, at which point you're jumping from $17k gross to roughly $37k - $45k gross. I am not sure what solar panel incentives are left but from a pure financial cost-benefit analysis stand point this will be a tough sell.

Looking at the overall incentive I think also adding items like the pre-reqs required to support this system would be good as well. like what type wall space is needed. is it exterior or interior. can it be either or? I looked into solar at an old home and was going to have to pay an additional 15K to get the roof updated to support the panels. Are there some other hidden costs that we are missing?

PGE next turned to message testing to get feedback on some different marketing approaches and language. People were mostly negative toward this email, feeling that the costs are an immediate turn off and would discourage them from further pursuing information about battery energy storage.

> Q: Would this email encourage you to take action to find out more information about the program or enroll in it? Why or why not? What don't you like about the email?

Figure 23 Email Sentiment

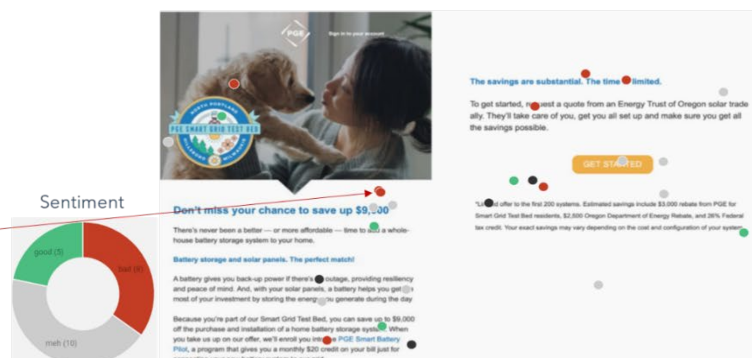
Clear easily understandable content.

The logo design is attractive and eye appealing to me.

I like the savings mentioned but I do not know the total cost for me after I receive this savings. I would need to know even more before I jumped into this. I would reach out for more information but not to enroll. This email needs more specifics.

This tells me that getting a battery system installed is much, much higher than $9k, and I know from the asterisk (before reading the fine print) I'd be unlikely to qualify for that much money off. So it's disheartening to realize how unattainable a battery system is.

A $20 monthly savings, on something that costs well over $9,000 almost sounds like a joke.



A letter was tested next with more verbiage and information. There was more positivity because it had more information for them; but cost is still an issue. People liked the emphasis on clean energy and that it is clear and direct with actionable steps to take. However, some still took issues with the phrasing and others felt the costs were being hidden.

Figure 24 Letter Sentiment

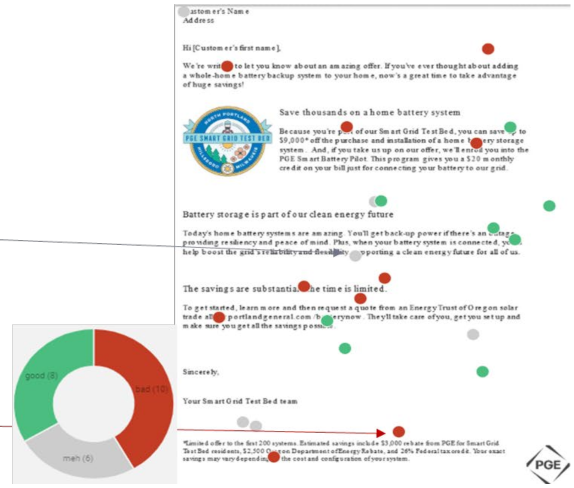
I like this mailer because it is to the point. gives me a website to visit and lets me know that there is a qualifier for the number of participants.

I appreciate the emphasis on clean energy and that is a positive step PGE is taking.

"supporting your community" is more specific than a "clean energy future" another option could be "supporting your community and protecting the environment"

I think people are sophisticated enough to be potentially turned off by the typical sales speech. I understand that it is best practice to have a call to action, but this looks like every sale pitch ever.

Doing the math here, you're estimating that a system will be ~$14k. Since most of us won't qualify for/get the largest incentives, that means we're spending a LOT of money ourselves.



Finally, a postcard was shared with customers for their feedback. Customers liked the visual design and felt the content was more helpful and relevant than that of the email. However, they again complained about the lack of specificity and consistency with the other items that they were exposed to.

Figure 25 Postcard Sentiment

Looks good and only add would maybe add in a range of potential overall cost of new battery system.

Slogan works for this program. It tells people why they care. This is so much better than the email.

Qualifying language. "up to $3000" what does that really mean

I think I would ask for an estimate. Somehow this doesn't feel as persuasive as the promotional letter for me to find out more information.

The other brochures said a $9,000 savings, and this one only says $3,000. I know this is specifically the rebate and not combined with the other offers, but it makes it look incongruent and less appealing.

These findings meaningfully informed the approach that PGE began to take moving forward to recruit customers and how to speak about the pilot. The most significant is the idea that the monthly payments and pilot incentives are not intended to provide a financial payback for the cost of the battery storage but are to encourage customers to participate in the Pilot and optimize their device's impact once they have made the investment decision. The customer conversation was also foreshadowing that the Smart Grid Testbed rebates were not high enough to induce action to purchase a battery if a customer was not already planning on doing so, which is a key reason why the Pilot was redesigned in 2023.

Quantitative Customer Survey

In April 2023 PGE surveyed customers about their awareness and experiences with the Smart Battery Pilot. Among the respondents 55 are current participants in the Pilot and 71 have a whole-home battery but are not currently participating in the Pilot.

Smart Battery Pilot Participants

Customers are overall highly satisfied with the Pilot and highly likely to recommend it to a friend.

Figure 26 Smart Battery Pilot Satisfaction

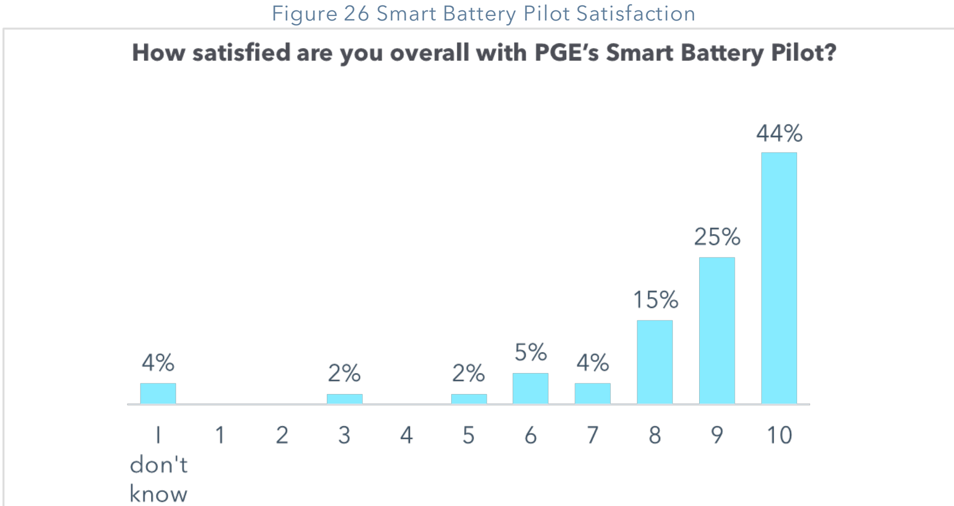
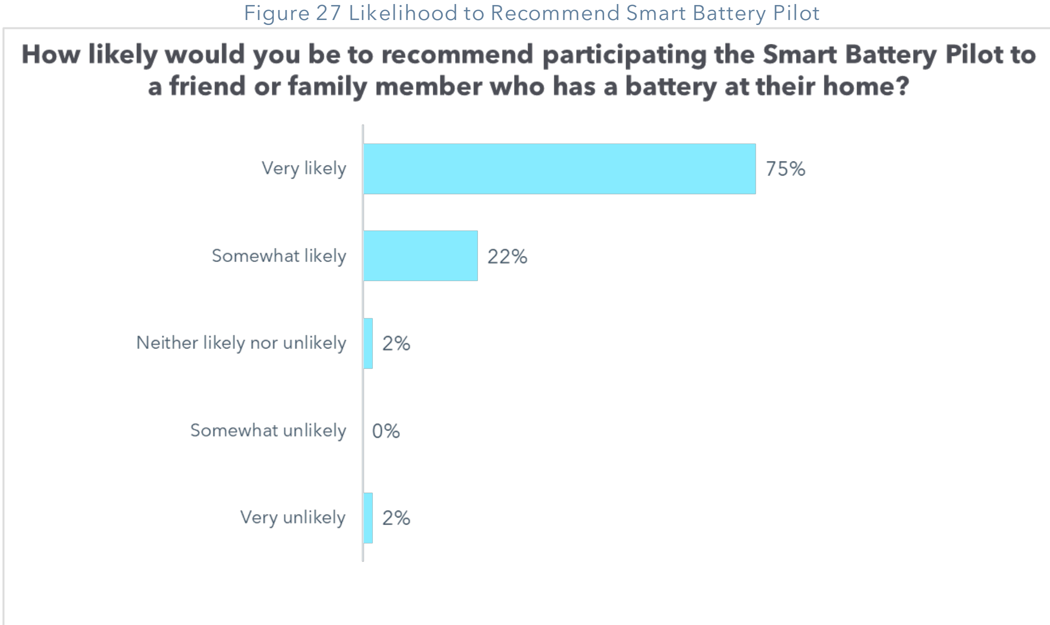


Figure 27 Likelihood to Recommend Smart Battery Pilot

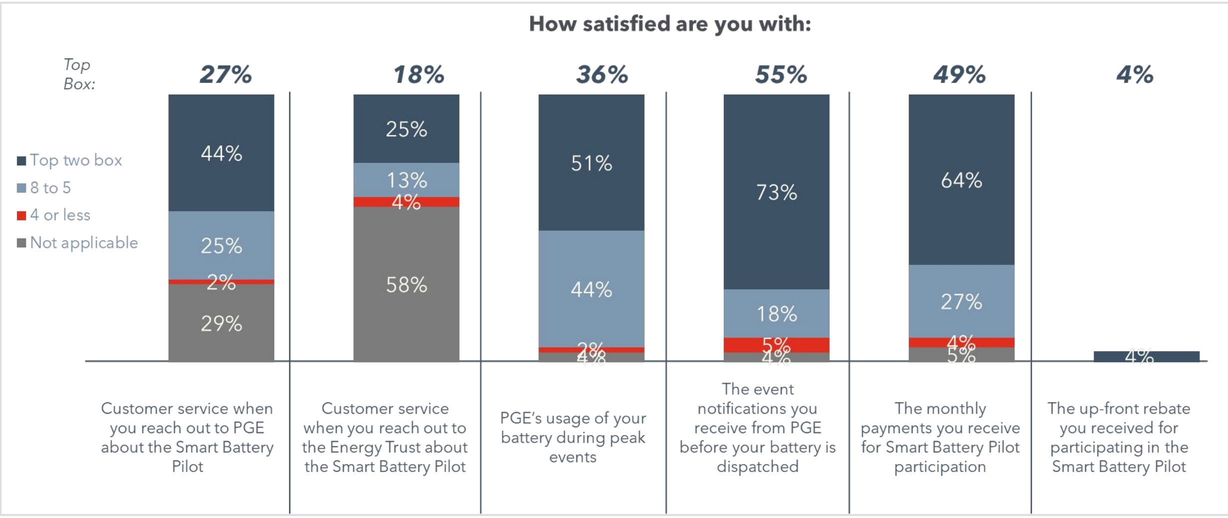


When it comes to the specifics of the program, customers are most satisfied with their event notifications and the monthly payments they receive.

While many had not reached out to Energy Trust customer service or PGE, among those that did, satisfaction is high with only 2% giving PGE customer service a 4 or less.

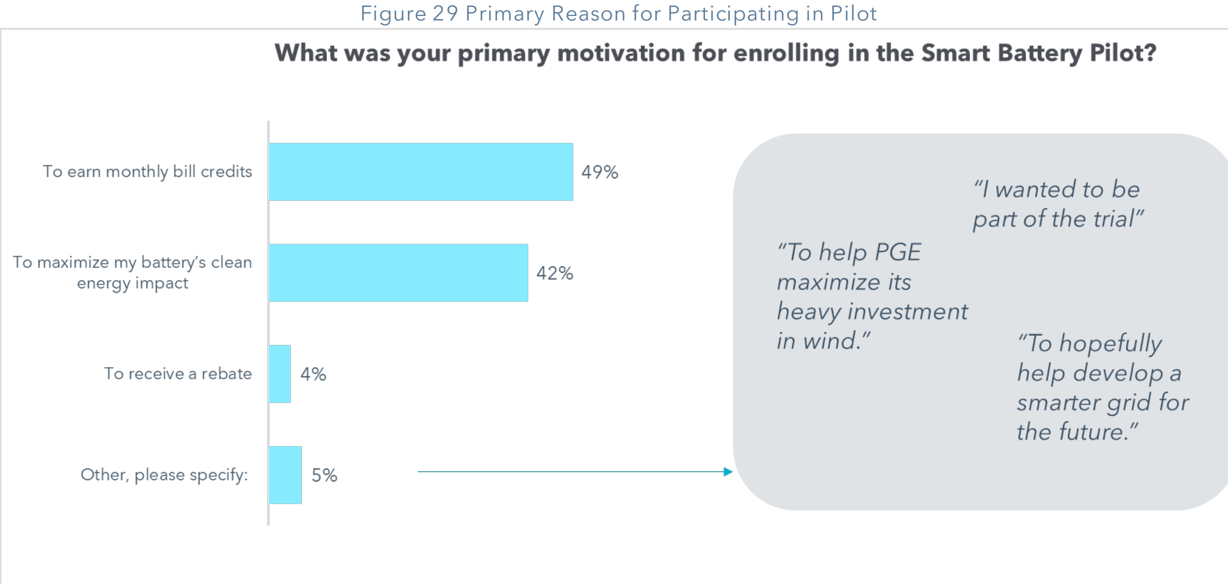
While only 4 participants responded who had received a rebate, they all rated their satisfaction with the rebate as a 9 or 10.

Figure 28 Satisfaction with Pilot Elements



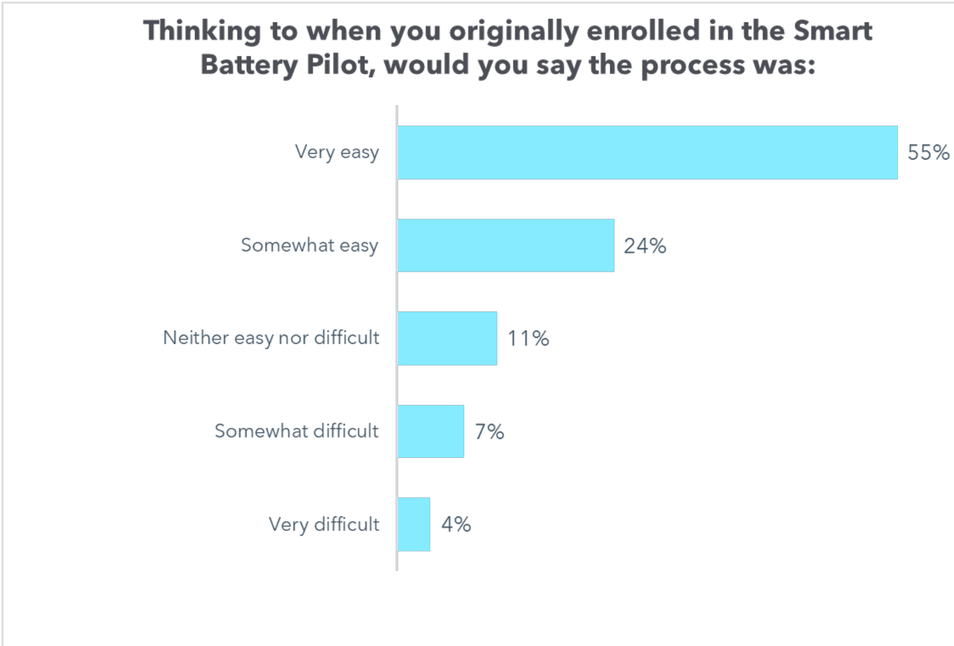
The primary motivation for participating in the pilot is split between financial and environmental reasons.

Figure 29 Primary Reason for Participating in Pilot



Most participants felt the program was easy to sign up for.

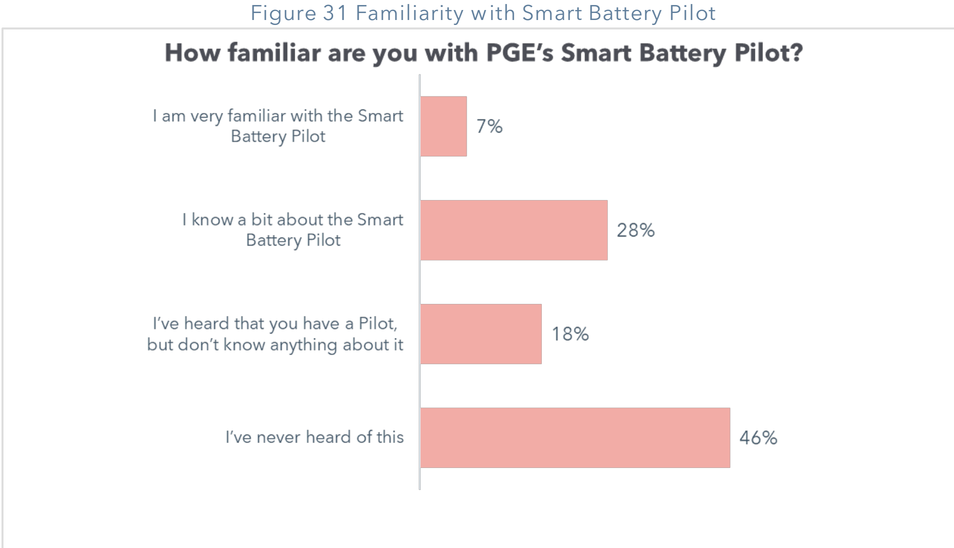
Figure 30 Ease of Pilot Enrollment



Non-Participants

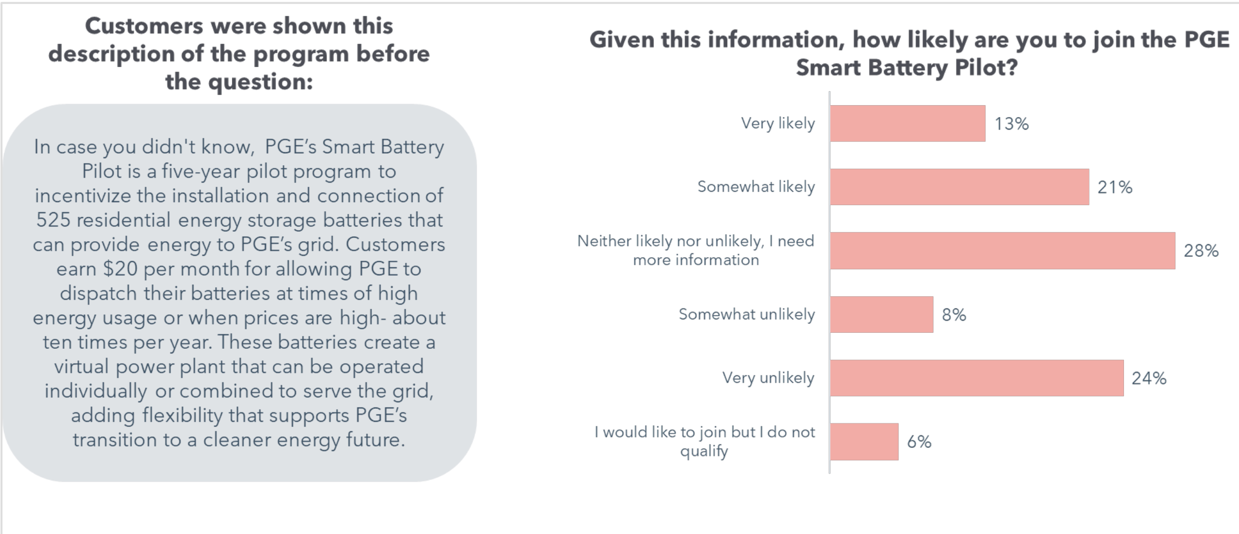
Among those who are not currently in the program, familiarity is low. Increasing awareness is likely to increase participation, and this is supported by what we see in the open-ended questions where many mention interest in the program, they just need certain questions answered or more information.

Figure 31 Familiarity with Smart Battery Pilot



After reading a short description of the pilot, 34% said they would be likely to join while 30% said they were unlikely to join. Based on the open-end responses, driving people to a source for their questions may increase enrollment.

Figure 32 Likelihood to Join Smart Battery Pilot



Customers both in the Pilot (blue box) and not participating (red box) had some positive things to say about PGE and the Smart Battery pilot.

Figure 33 Customer Quotes - PGE Satisfaction

PGE has been great so far! ***They have some of the amazing plans and customer service stands out to me!***

I really appreciate ***your efforts in transitioning to greener energy sources.***

We are one of the first to participate in this program! We're ***looking forward to getting set up on the program and helping PGE when we can.***

I've been impressed with PGE's innovation & many efforts to help accelerate the clean energy transition *- keep up the great work!*

PGE is great! *The City of Portland was a huge roadblock/delay in getting our solar system turned on.*

Please reach out to me with how to sign up for the pilot project. ***I'd be happy to make my battery available for these purposes.***

Excellent job of taking care of your customer's needs *- I've talked to MANY friends in other areas of the country - and they do not have the same options that PGE provides - so I am very appreciative of the job PGE is doing.*

Y'all are awesome <3
-Rebate

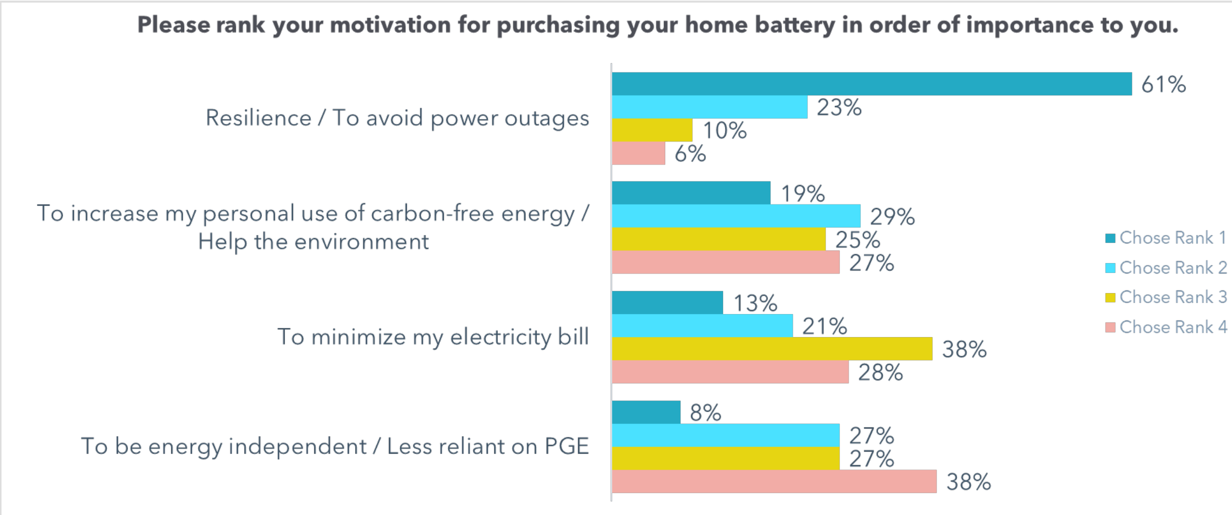
Thanks for the pilot and decarbonizing the grid!

Hoping to see this program become permanent

The survey next asked a few questions of all customers about their battery installation experiences.

Obtaining resilience and increasing the use of carbon-free energy were the most often ranked as the top two motivations for installing a battery, though resilience far outpaced the other options as the top motivator.

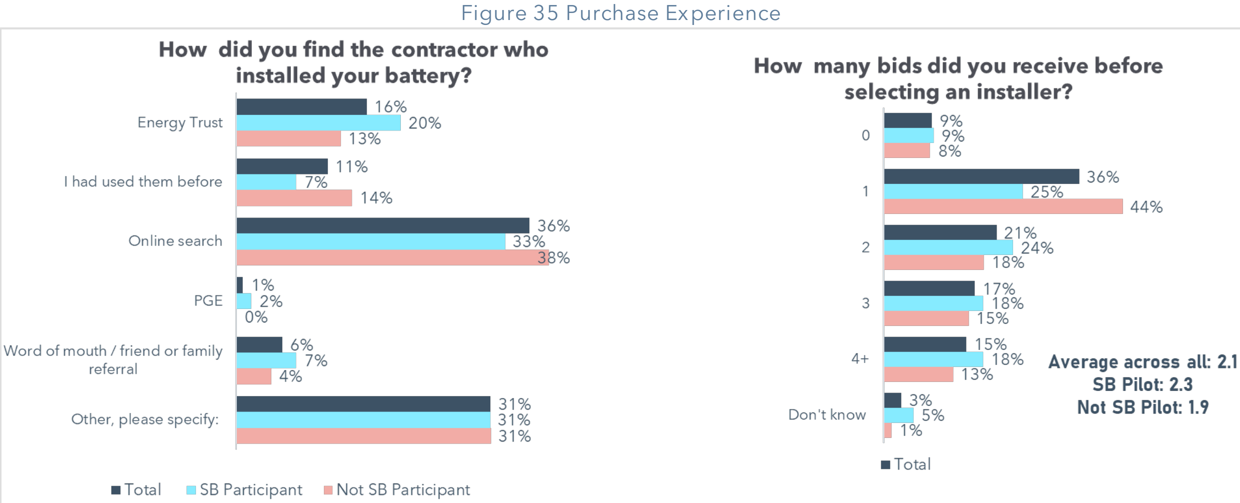
Figure 34 Motivation for Purchasing Battery



When asked how the customer found the contractor who installed their battery, responses were evenly split between an online search or were connected by Tesla (the vast majority of the "other" responses).

On average, customers received around 2 bids before selecting, but some received as many as eight. Almost half in the non-participant group received only one bid before selecting.

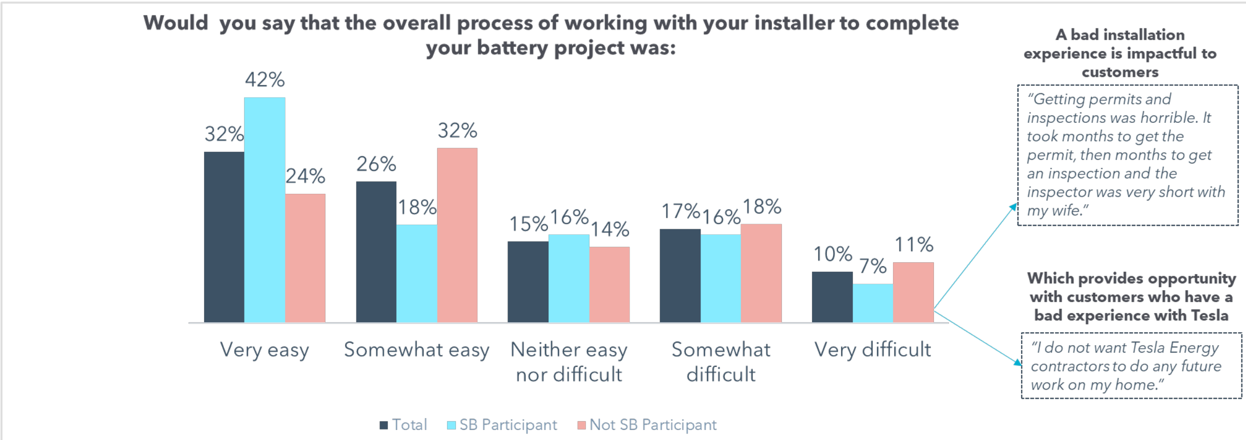
Figure 35 Purchase Experience



Customers generally found the process of installing their battery to be easy, however, there is an opportunity to improve these scores as 27% of customers found the process to be difficult.

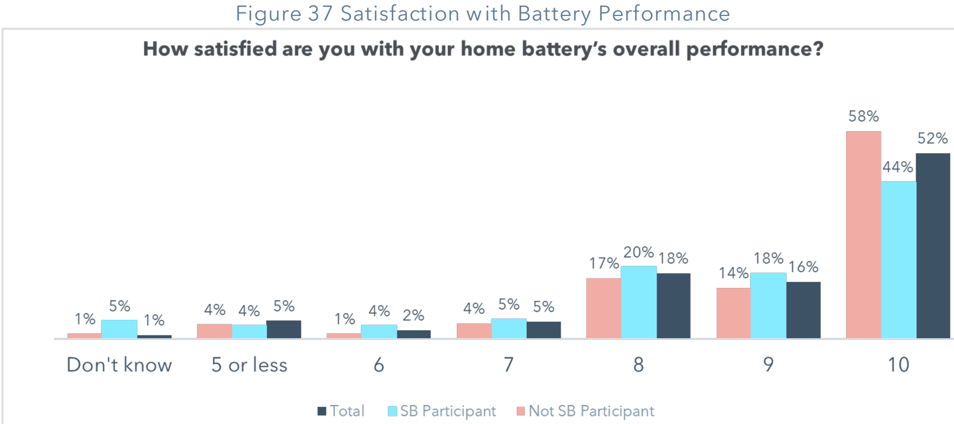
More Smart Battery participants said that it was very easy compared to non-participants.

Figure 36 Ease of Working with Installer



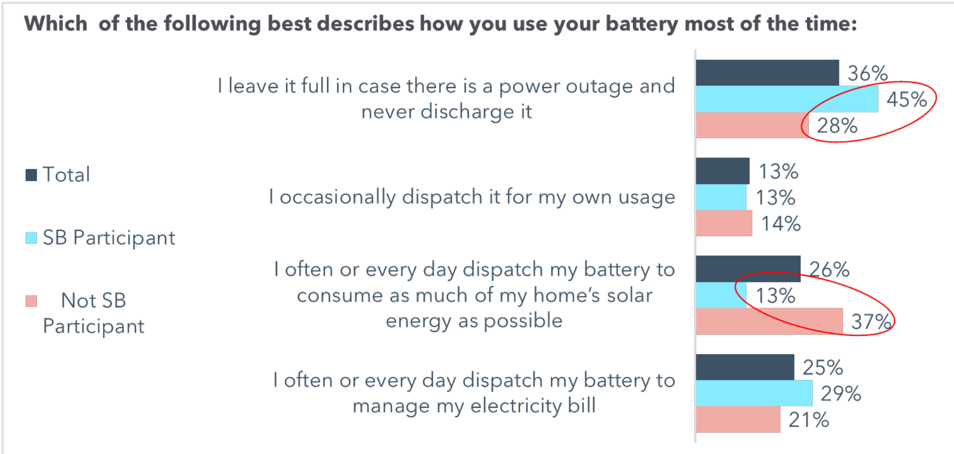
Customers are overall very satisfied with their home battery's performance, with 68% of customers choosing a nine or ten and only 13% of customers giving their battery a score of less than seven.

Figure 37 Satisfaction with Battery Performance



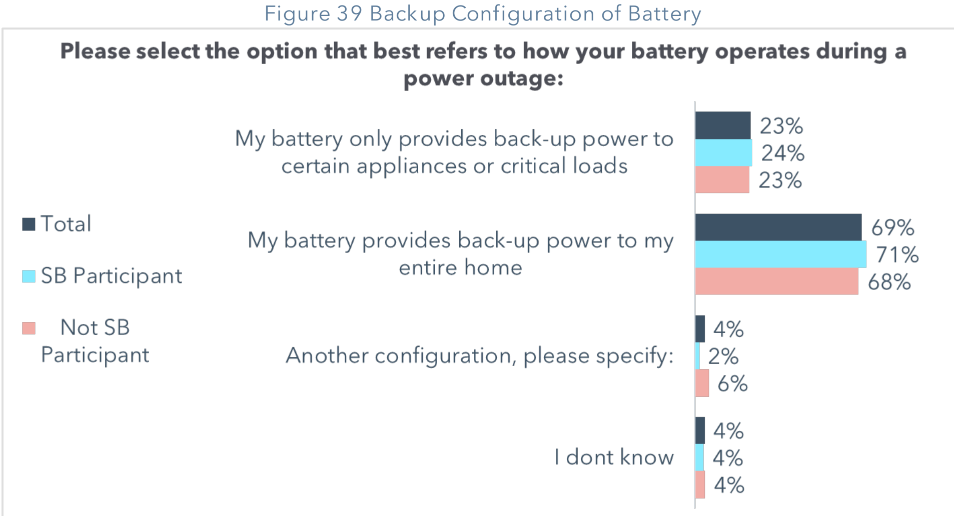
Participants in the Pilot are significantly more likely to leave their battery full in case of an outage compared to non-participants, who are more likely to dispatch it every day to maximize their solar generation.

Figure 38 Typical Usage of Battery



During an outage, most participants are using their backup batteries to power their entire home, while less than 25% are using it just for certain appliances or critical loads.

Figure 39 Backup Configuration of Battery



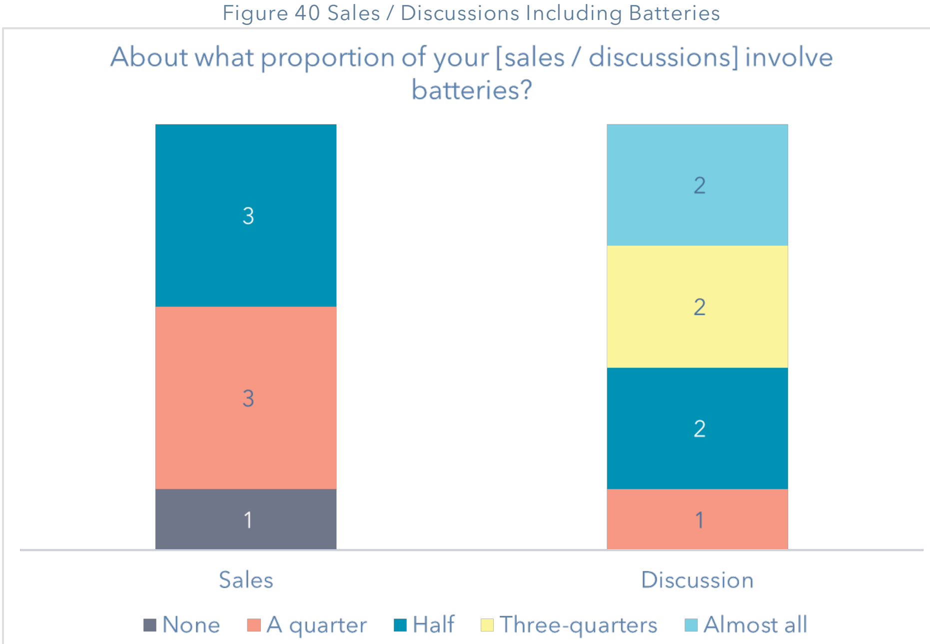
Vendor & Trade Ally Research

Trade Allies

In April 2023, PGE conducted a survey with battery energy storage vendors to better understand their experiences with the Pilot and any suggestions for improvement. With only 6 responses, the sample size does not allow for statistical significance, however PGE did receive useful feedback regarding vendor experience to help improve the customer experience in the future. The survey was conducted via the Medallia survey platform and was sent to vendors who have worked with PGE on the Smart Battery Pilot.

Only one trade ally reported that they do not typically sell batteries, while the others reported that around one-quarter to one half of typical residential sales include batteries. All trade allies reported having discussions with customers about batteries at least some of the time. Trade allies report that customers initiate about half of the conversations around battery storage.

Figure 40 Sales / Discussions Including Batteries

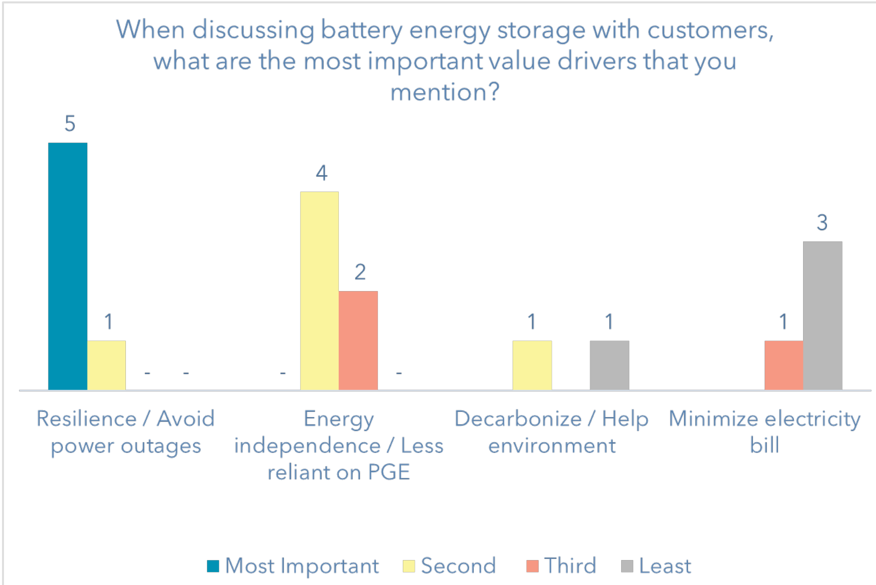


The most important value drivers that vendors mention while discussing energy storage with customers were ranked as (in order from most important to least important):

1. Resilience / to avoid power outages.
2. To be energy independent / to be less reliant on PGE.
3. The ability to minimize your electricity bill.
4. The ability to increase the use of carbon-free energy / Help the environment.

This is in line with the customer surveys we conducted, customers stated that obtaining resilience and increasing the use of carbon-free energy were the most often ranked as the top two motivations for installing a battery.

Figure 41 Sales Drivers for Batteries



The trade allies were then asked if there are any other important value drivers not listed above that are discussed with customers when promoting energy storage. The two responses both mentioned time-variable rates as an additional value driver for energy storage.

> "Discussing time-shifting grid use and time-of-use tariffs. These go with minimizing the electricity bill, but it is an involved process. It's also a confusing one because it does not apply, or cannot be done to a financial benefit, when the monthly generation is more than the use and the bill is at $0."

> "TOU net metering"

When discussing barriers to storage installations, vendors note many of the same concerns that customers do, with cost being the primary issue. Two installers also mentioned the challenges of recouping the investments of energy storage through TOU rates as well as through this Pilot.

Figure 42 Trade Ally Quotes - Barriers to Installing Energy Storage

What are the primary barriers that prevent residential customers from installing battery storage?

"Cost primarily. Complexity of installation. Safety concerns re: fires."

"Expense of the upfront investment. Inability to benefit from energy arbitrage unless their solar system is sized for less than 100% annual energy offset. Insufficient number of smart battery events from which to benefit from the investment."

"Cost and lack of opportunity to gainfully use the battery. Without TOU arbitrage, self-consumption doesn't have a lot of value so it is almost entirely peace of mind for backup power that is motivating clients."

"Cost, manufacturer delays, lack of diverse options in the market"

When asked what additional information trade allies were hoping for to sell more batteries, a few asked for additional information and details on the Pilot (PGE created a one-pager targeted at trade allies during their sales process after receiving this feedback). Others again referenced TOU and supply chain and/or cost challenges.

Figure 43 Trade Ally Quotes - Information Desired to Sell Energy Storage

What types of resources or information would help you more effectively sell battery energy storage to residential customers?

"Info on TOU and battery rebate/direct dispatch info. We don't necessarily understand it that well, or can explain everything clearly."

"Better TOU tariff structures that allow for earning bill credits for avoiding on-peak consumption when monthly solar generation is such that credits are being banked on the bill."

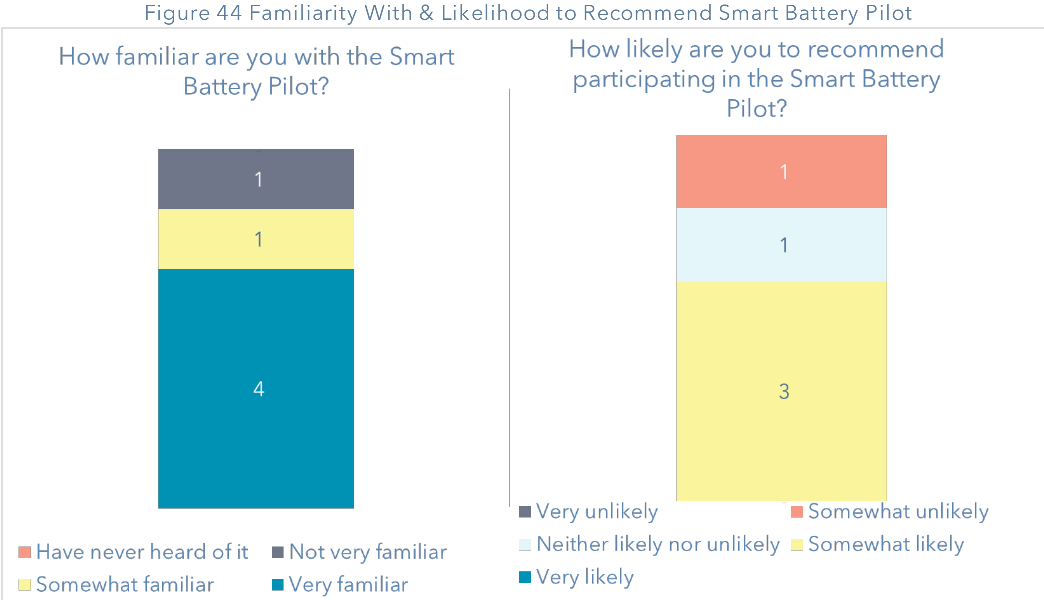
"Explainer of the new smart battery pilot that has concrete dollar amounts clearly stated as well as some more details and what/why/how of the program. More incentives would help as well. of course."

"Place to point customers for more local, current information, such as interactive grid maps, and statistics showing how battery is currently benefitting homeowners and the grid."

"Better/ longer battery outage supply at a reasonable price."

Turning from energy storage in general to the Smart Battery Pilot, all but one trade ally were somewhat or very familiar with the Pilot. Among those that were familiar with the Pilot half of the trade allies were somewhat likely to recommend the pilot, one was neutral, and one was somewhat unlikely to recommend the Pilot. The Pilot had very recently transitioned to the new structure when this survey was conducted, and PGE understands why trade allies would have preferred the selling ease of a $40 monthly credit over the more variable pay for performance structure. PGE will continue to monitor the trade allies' feedback with regards to customer experience and has already taken steps to provide more information and streamline the enrollment process. Nonetheless, satisfaction with the Pilot and likelihood to recommend are lower than we would like, and PGE will seek to improve this relationship with trade allies.

Figure 44 Familiarity With & Likelihood to Recommend Smart Battery Pilot



Streamlining the application process and providing additional information are two actionable suggestions for improvements PGE can seek to make to improve these scores.

Figure 45 Trade Ally Quotes - Reason for Satisfaction with Smart Battery Pilot

Why did you give that score as your satisfaction rating?

"Not a lot of helpful documentation to share with project managers, clients, installers. Generally, we set them up to participate, but its up to them to manager their PGE account."

It's a good idea but the incentives are now unpredictable based on participation in unpredictable events. The VPP programs in California seem to be structured better but it's a hard comparison to make without having first-hand experience with California VPP, just news reports. To put it another way... the ROI for the battery investment is difficult to calculate and almost impossible to sell to a customer because we have no minimum ROI that we can point to, which was one major advantage of the $20/$40 flat-rate incentive to participants."

"There hasn't been much information made available to clients regarding the program, how it works, what exactly would be happening with their battery, etc. On top of that the payment that were initially promised are now being reduced and the new offering is less attractive. For $10 per event or whatever it is now, there isn't a lot to be gained from installing a specific brand and model and giving PGE access to it, with no guarantee that it won't affect warranty or performance when the client needs it."

"Very long and demanding application process (signature forms, separate ETO application, plus net metering application). Would save contractor time and money to simply have the battery pilot application as part of the net metering application. Very complicated incentive/pay back structure applied to customer's bill."

"Not well versed in the program."

Opt-Outs

In addition to the qualitative information on customer experience PGE examined the propensity of customers opting out of Pilot events to understand quantitatively how customers are responding. PGE began including opt-out links in notifications in April 2022, prior to which it was suggested that participants opt out through manual adjustment (or opting out was not mentioned).

Customers received an opt-out link on 6 out of 29 events. Excluding events with no link, the total opt-out rate was 1.9%, or 11 out of 578 commands.

Table 14 Opt-Out Notifications

Event Time	Command(s)	Email Option	SMS Option	Devices Contacted	Opt-Outs
04/13/22, 19:00	Dispatch	Link	Manual	70	0
04/25/22, 19:00	Dispatch	Link	Manual	70	0
08/30/22, 15:00	Dispatch	Link	Link	102	1
09/06/22, 16:00	Dispatch	Link	Link	103	1
12/15/22, 17:00	Dispatch/Charge	Link	Link	117	0
12/21/22, 17:00	Dispatch/Charge	Link	Link	116	9

Of the 11 opt-outs that occurred in 2022, 9 were in response to the dispatch and charge events that took place on 12/22/22. On this date there was a travel advisory for below freezing temperatures, wind gusts and snow and it is likely that customers opted out to preserve their resilience in the event of a power outage – behavior PGE encourages.[9] PGE believes that due to the low number of opt outs and complaints the dispatched events are appropriate and well received by participants.

Outages

The resilience provided by customer batteries is not directly tied to the Smart Battery Pilot but is an important reason for customers' purchase of their battery. PGE sought to quantify the resilience provided by batteries and their effectiveness at mitigating outages, and created a metric dubbed "Mitigated Customer Minutes of Interruption (MCMI).[10]" This metric represents the number of minutes during outages that power was available from the battery back-up system. To show outage performance before batteries reach minimum capacity, the MCMI of the first hour of each outage was also evaluated.

Outage start and end times from PGE's Outage Management System (OMS) were paired with a collection of metrics from Virtual Peaker. PGE ran current participants through OMS to determine when a grid outage was detected, then pulled up the same dates in Virtual Peaker. The duration of back-up power provided by the customer's battery was calculated as P_{house} $P_{battery}$ P_{solar} 0.2kW, where a negative $P_{battery}$ P_{solar} values indicate power output.

MCMI was defined as the number of minutes during the outage with non-negligible power use and no power from the grid.

Table 15 shows the total Customer Minutes of Interruption (CMI) and Mitigated Customer Minutes Interrupted (MCMI) in 2021 & 2022. The MCMI is a representation of the amount of time during outages that houses were powered by battery storage. CMI refers to the total

[9] City of Portland. "Travel Advisory: Get ready! Snow, freezing rain could cause hazardous road conditions Thursday afternoon through Saturday" (Dec 21, 2022)
[10] CMI, or Customer Minutes of Interruption is a utility reliability metric calculated as the number of minutes of outage duration multiplied by the number of customers affected. The batteries generally do not reduce CMI because the outage has still occurred, rather they "mitigate" the outage as experienced by that customer.

outage length, found by comparing OMS data to data acquired from Virtual Peaker. Each percentage indicates the corresponding field's ratio to CMI.

In February 2021 the Portland-metro region was hit with a catastrophic ice storm that caused much higher than typical CMI, with Smart Battery participants experiencing over 38,000 minutes of outages for the year. The customers batteries provided back-up power to 58% of the outage minutes total, and 85% of outage minutes in the first hour of the outage. 2022 experienced far fewer minutes of outages and mitigated two-thirds of the minutes. However slightly fewer minutes during the first hour of the outages were mitigated, at 79%.

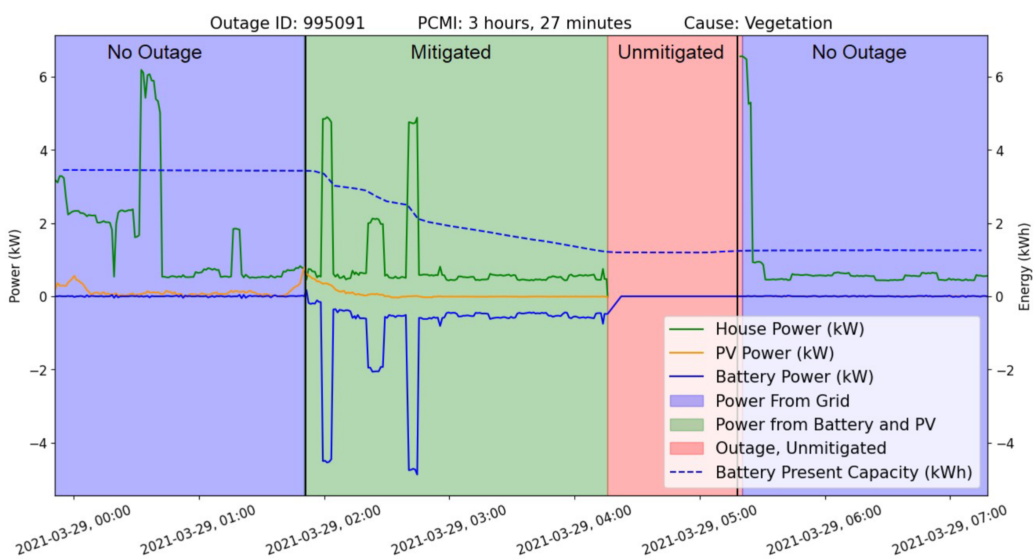
Table 15 Mitigated Customer Minutes Interrupted (MCMI)

Year	CMI (Minutes)	MCMI (% Of CMI with back-up power)	1st Hour MCMI (% of CMI)
2021	38,475	58%	85%
2022	13,760	67%	79%
Total	31,630	61%	81%

In a visual inspection of 10 outages lasting over 1,000 minutes in length, all devices demonstrated the ability to dispatch and recharge from solar power appropriately.

In an inspection of 20 randomly selected outages during which CMI was not completely mitigated, 17 (85%) of houses lost power due to batteries reaching their minimum capacity after operating correctly. One of these outages is shown below. Black lines indicate the start and end times of the outage. All power metrics are plotted on the left y axis, while battery capacity is plotted on the right.

Figure 46 Example of a typical plot of data during an outage



Devices performed similarly in 2021 and 2022, despite 2021 having a much higher average outage length. This, along with a visual inspection of a random sample, indicates that batteries are performing correctly during extended outages.

The 81% first hour MCMI indicates that the majority of unmitigated CMI is caused by reaching minimum battery capacity after extended use. This is the expected and intended behavior of batteries during outages.

Objective 4: Program Design

Organization and Roles

The Pilot is operated and managed out of PGE's Energy Storage & Resilience Customer Solutions team, managed by Audrey Burkhardt. Francisco Rosales acts as the Program Manager, with day-to-day support provided by PGE contingent project coordinators.

Manny Obi, PhD acts as the principal technical engineer and performed or oversaw the technical demonstrations and experiments described within this assessment.

PGE has contracted with the Energy Trust to provide implementation support. This includes managing the contractor network, managing and paying program rebates, and performing initial quality assurance and safety audits on the first customer devices to enroll in the Pilot. PGE's primary contact at the Energy Trust for Pilot implementation is Jeni Hall.

Dispatch of the battery fleet is handled by a third party Distributed Energy Resource Management System (DERMS) called Virtual Peaker. Virtual Peaker is a cloud-based software-as-a-service (SaaS) that manages the dispatch of the batteries for grid services. The dispatch of the batteries is typically determined by PGE power operations, in alignment with PGE's other flexible load resources portfolio. The devices are also dispatched according to pilot or experimental needs. The PGE program manager schedules the dispatch within Virtual Peaker.

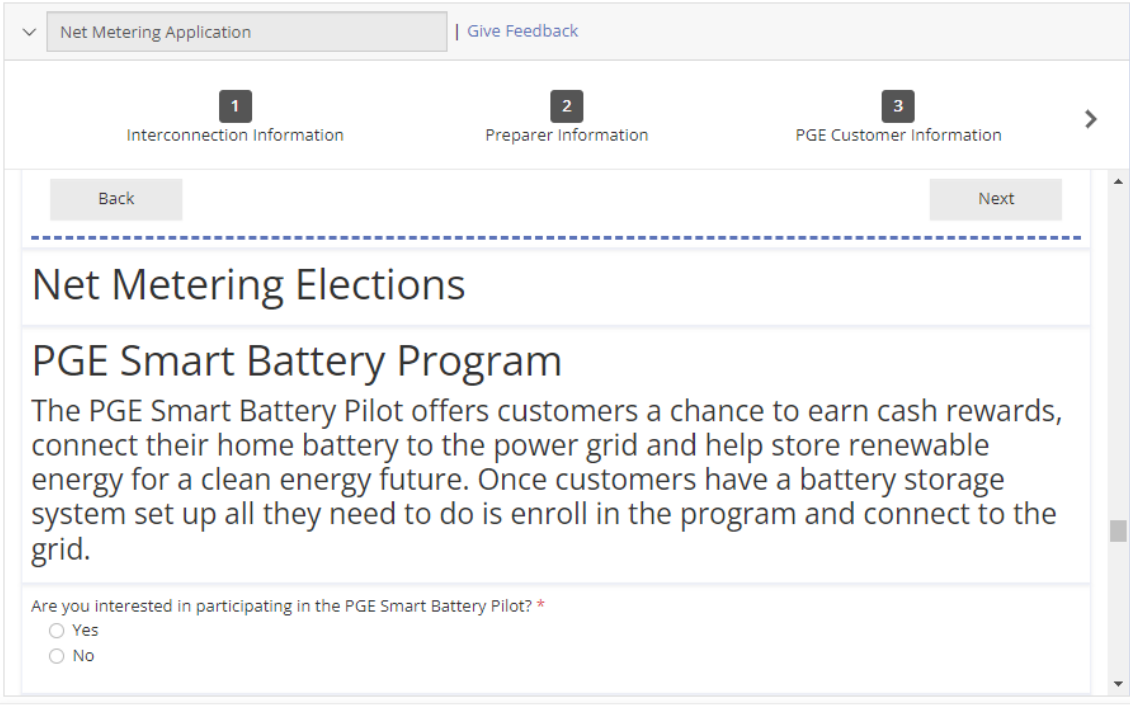
Customer Outreach

To launch the Pilot PGE pre-identified all customers with a qualified energy storage device already installed at their home and invited them to enroll in the Pilot.

On an ongoing basis there are two primary paths for a customer to enroll in the Smart Battery Pilot: a customer may indicate interest during the installation and interconnection process and be automatically prompted to sign-up when the project is complete ("trickle enrollment"), or through periodic outreach that occurs to customers who PGE knows to already have an eligible battery (campaign enrollment).

To enable the "trickle enrollment" approach, PGE added a button to the interconnection application form as seen in Figure 47, asking whether the customer was interested in the Smart Battery pilot. When a customer whose project installer clicked that button receives "Permission to Operate" from PGE interconnection an automated email is sent inviting them to sign-up. This strategy has a very high success rate of converting prospects to participants. One suggestion PGE will investigate for improvement in this is to have all customers with a qualified device receive an invitation to sign-up for the Pilot upon receiving Permission to Operate, and not just those whose installer indicated interest on the interconnection.

Figure 47: Interconnection Interest



The other enrollment process is to reach out to pre-identified customers who have a battery installed to invite them to participate in a scheduled campaign. These customers' installer may not have clicked the button to opt into the trickle enrolment process or may not have completed the enrollment, or possibly had a battery installed before Smart Battery Pilot launched.

PGE has conducted multiple outreach events to educate and invite customers to learn about the pilot, the benefits of energy storage systems and the rebates available to customers. Marketing materials sent to customers are included in Appendix A.

PGE also has information about the program on its website at portlandgeneral.com/smartbattery. The website provides details about the incentives and the on-bill rewards available to all customers with an email contact if the customer would like to enroll. Finally, the website provides a link to the Energy Trust of Oregon's website for customers interested in installing a battery system. Customers can submit a request to receive a bid from any of the trade allies. Between July 1 to September 30, 2023, the website received over 2,000 visits, 700 of these were mobile access, and 1,400 were desktop access. These numbers include repeat visitors.

Enrollment

Customers invited to participate or who receive an enrollment link sign-up directly on PGE's DERMS, Virtual Peaker. The sign-up portal is seen in Figure 48. They provide their contact information, agree to the terms & conditions of the Pilot, and complete the digital handshake (Figure 49) to allow for PGE dispatch of the customer battery.

Figure 48 Virtual Peaker Sign-Up Page

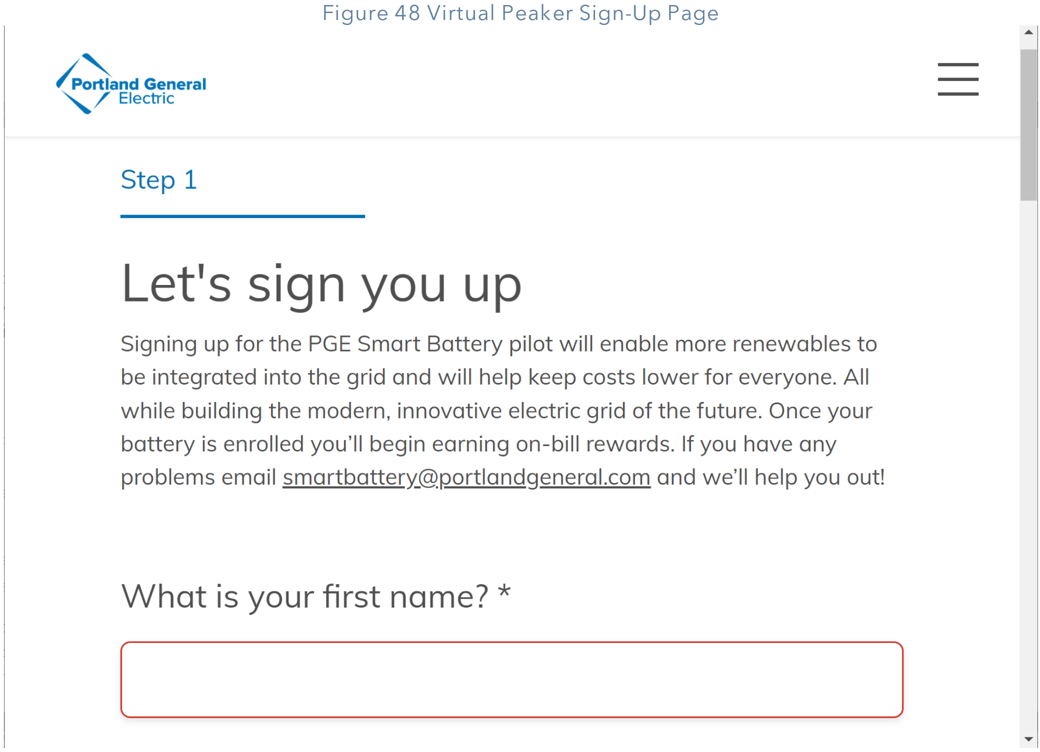
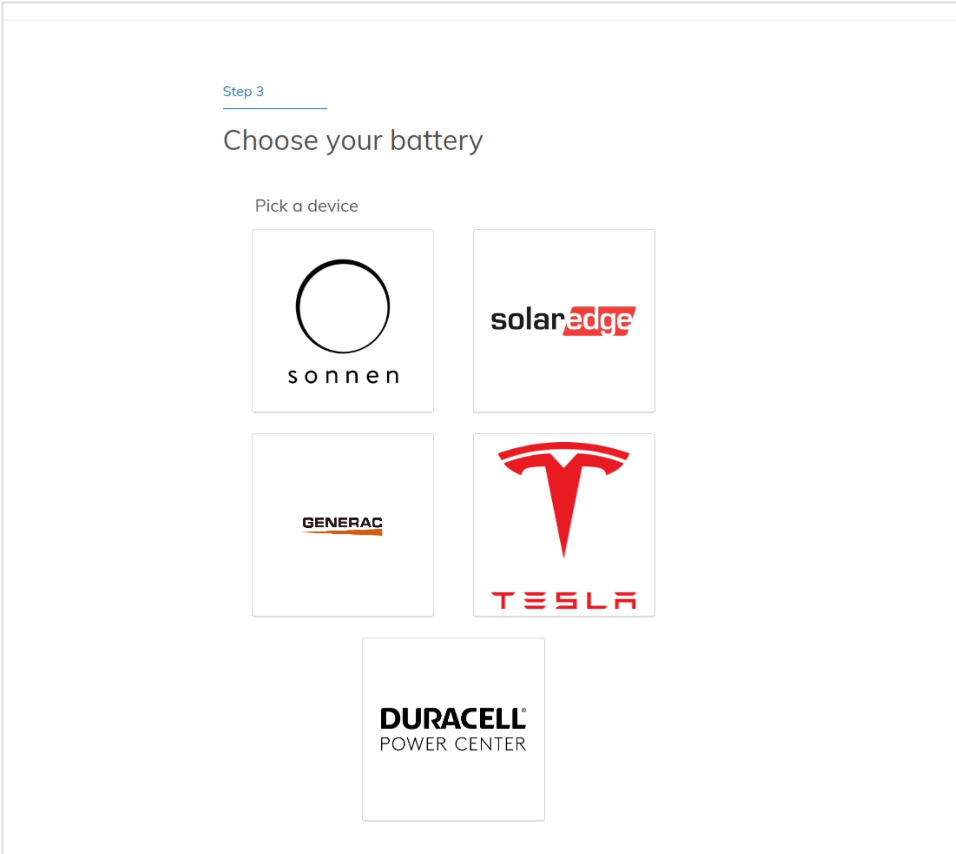


Figure 49 Digital Handshake



The customer signs into their battery app and completes the digital handshake that allows for the DERMS to send signals to the battery. After sign-up the customer shows up as a "pending house" in Virtual Peaker. PGE reviews and approves the house, also inputting them into the customer management system to activate the on-bill payments.

It takes from a few days to two weeks for the battery OEM to approve the connected device in Virtual Peaker. After approval the device becomes fully dispatchable by PGE.

Customers reported in PGE's research that the program is easy to sign up for, with 79% of respondents feeling as though it was a very or somewhat easy process.[11]

Rebates

For customers receiving an up-front rebate, the process is slightly different. Customers must work with an Energy Trust qualified solar trade ally for their project and indicate in their interconnection application that they are interested in receiving a rebate. The interconnection application is the point at which the customer rebate is "claimed" by the customer and funding is reserved for nine months.[12] In the first tariff filing the reservation

[11] Portland General Electric, "Smart Battery Pilot Evaluation" (2023)
[12] Portland General Electric "Advice No. 21-32 docketed as 1333" (November 8, 2021) https://edocs.puc.state.or.us/efdocs/UAA/uaa165751.pdf

period was six months[13], but PGE extended the duration to account for supply chain delays and installation challenges caused by the Covid-19 pandemic.

The Energy Trust trade ally partner is required to present any up-front rebates as an on-bill reduction in the customer's total installed cost. After installation of the battery and after the customer enrolls in the Pilot the contractor submits paperwork to Energy Trust for reimbursement of any solar rebates and energy storage rebates paid to customers. The Energy Trust re-pays the contractors through ACH, and PGE re-pays the Energy Trust via invoice.

Income-Qualified Rebates

The Pilot included a $5,000 up-front rebate for the first 25 income-qualified customers, defined as those eligible for the Energy Trust's Solar Within Reach offering. PGE designed the eligibility this way to utilize the stricter vendor relationships of Solar Within Reach and have more protections in place for vulnerable customers, as well as to enable "categorical income qualification" and remove PGE from the process of asking customers for sensitive income information and making them complete additional forms. Categorical income qualification is the process by which if a customer has shown documentation to be enrolled in one program or offering, they are automatically qualified to enroll in another.

This offering proved to be popular, with the rebates being fully claimed by March 22, 2022. As of September 14, 2023, 23 of the customers who received the rebate had completed projects and two were still in progress. All but one of the customers with completed projects has completed enrollment in the Smart Battery Pilot. The one customer who has not completed enrollment is missing a component of their application. PGE is working directly with the customer to resolve this, upon resolution, the rebate will be released.

PGE was surprised at the fast uptake of the income-qualified rebates versus the very slow uptake for the Smart Grid Testbed ones, and suspects that the narrow geographic restriction intended to induce geographic density is the culprit. When the rebate is available service-territory wide there is sufficient demand, even among a more narrowly defined customer base, but if PGE wants to encourage customers who otherwise are not planning on installing a battery to do so, more than $3,000 is needed.

PGE has cost information from 18 of the 25 customers who applied for an income-qualified rebate.

- 16 installed both solar and storage, and two added a battery to an existing solar array.
- The highest gross system cost was $109,551, which included solar and storage, and the lowest gross system cost was $13,248 for a battery only.
- The average gross cost was $56,129.

[13] Portland General Electric "Advice No. 20-08 docketed as 1111" (April 21, 2020) https://edocs.puc.state.or.us/efdocs/UAA/uaa1570.pdf

- The net cost to customers, inclusive of tax credits, Energy Trust rebates and PGE rebates ranged from $8,248 - $50,874.
- The largest total discount through incentives was $36,625 while the smallest was $5,000 – the rebate from PGE on a battery install only.
- The average total discount was $20,358.50.
- Twenty customers installed one battery, while three installed two batteries, and one apiece installed three and four batteries.

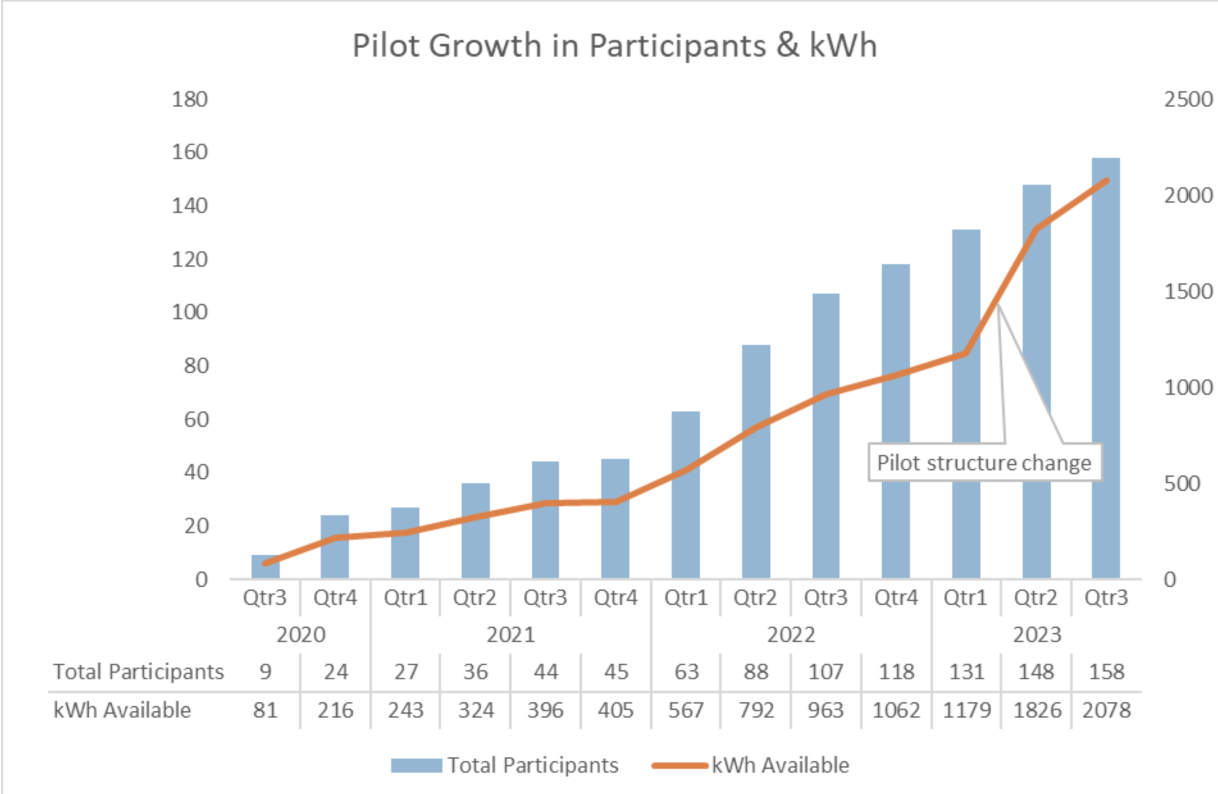
Device Dispatch & Participation

Participants receive both a text message and email about a day prior to any scheduled dispatches of their battery device, programmed through Virtual Peaker. While not a program requirement, PGE strives to keep customers informed of activity with their battery and keep customers informed of pilot activity.

A customer does not need to do anything to participate in an event, the DERMS software will send a signal to dispatch the battery to provide the requested amount of power at the scheduled time. The customer's local settings, however, will always take precedence over a PGE signal during an event. For example, the customer may opt out of an event through their battery's app, override the signal manually, or if the battery does not have enough capacity to fulfill the request the device will automatically cease dispatch when it hits the pre-set limit of reserved energy.

In the first iteration of the Pilot PGE was typically dispatching 3 kW for 3 hours, for a total of 9 kWh for each peak time event. Even though some customers had larger devices and more available capacity, the Pilot was structured to compensate every household the same and ask for the same capacity during events. As such the Pilot chose an amount available from the smallest device participating in the program since there was not the built in sophistication to dispatch and compensate customers for differing amounts. A key update that the Pilot made in the second iteration was to allow for customers with more capacity to participate at a higher level, which as previously discussed and illustrated in Figure 50 unlocked significant additional Pilot capacity.

Figure 50 Pilot Growth



	2020		2021				2022				2023		
	Qtr3	Qtr4	Qtr1	Qtr2	Qtr3	Qtr4	Qtr1	Qtr2	Qtr3	Qtr4	Qtr1	Qtr2	Qtr3
Total Participants	9	24	27	36	44	45	63	88	107	118	131	148	158
kWh Available	81	216	243	324	396	405	567	792	963	1062	1179	1826	2078

In the first iteration of the Pilot customers received recurring monthly bill credits regardless of their event participation. In the new version PGE reviews customer performance after each event and provides a log to the customer billing team to process bill credits that reflect actual performance. This has resulted in increased customer engagement with their battery's performance, correcting configurations that did not allow for full participation.

Energy Trust Partnership

On April 3, 2023, PGE conducted an in-depth interview with the partner administrator at the Energy Trust. This interview was conducted by a PGE employee who does not have direct involvement with the Smart Battery Pilot. The partnership was designed to serve the customer and the vendor throughout the process of enrolling in this Pilot and to ensure customers were receiving all possible incentives for their installation.

The Energy Trust noted that "when [the partnership] is working well…the contractor is applying for Energy Trust solar incentives at the same time as the PGE solar incentives" which streamlines the process for all parties involved. The process is designed so that the inventive check is sent to the installer with both incentives included, rather than the customer needing to go between two organizations to reconcile their funds.

Furthermore, this Pilot was designed from the outset with the Energy Trust which "has been a learning experience all around. Designing from the ground up, having a single point of contact…on the PGE side is tremendous." There is a division of labor between the two parties that includes collaboration across systems which translates to good customer experiences. “There doesn’t seem to be additional confusion for customers regarding when to talk to PGE versus when to talk to the Energy Trust.” Together the two teams have been successful at “creating customized customer experiences for those coming to either partner” which has been a “great experience and is a great model for solar plus storage for the Energy Trust to work off of in the future.”

A drawback to this newly built relationship between the two organizations, as observed by the Energy Trust’s administrator, is that there is no formal structure in place between the two teams. “The process is dependent on relationships, so if one employee left tomorrow [there is a risk that] the program would disappear.” Codifying the processes and ensuring there is a systematic relationship built, rather than one centered on relationships, will be necessary for the long-term health of the Pilot.

In terms of program design, the Energy Trust manages the vendor network on behalf of PGE. This is a service provided to PGE with the goal of providing a high-quality Trade Ally Network at a cost-effective rate. Furthermore, utilizing Virtual Peaker to run the Pilot has allowed PGE to remain relatively tech agnostic, which allows customers to bring any device to the Pilot, “versus choosing winners…which is what other utilities have done.”

Looking forward, the Energy Trust notes that ensuring that both organizations are “using the same language to describe things” and continue to work to ensure that the “incentives from PGE And the Energy Trust are complementary” is essential. This Pilot has allowed the Energy Trust to test out the up-front rebate programming model, something that they plan to take learnings from and potentially use for future programming. Overall, “this model of partnership is working, and is going in the direction it should be.”

One area of improvement between the two organizations is creating a more streamlined experience via Virtual Peaker. Currently, the customer is responsible for getting their battery system enrolled into the Virtual Peaker cloud system, the Energy Trust noted that they would like to “see this shift to the contractor to support, rather than have this burden on the customer.” If the vendor was gathering all the information needed for commissioning at the time of installation and inputting this to Virtual Peaker, it would avoid what currently “feels like a huge lag for the customer” between the arrival of the battery and receiving permission to operate from PGE.

Finally, a larger challenge that faces PGE in nearly all programming is the ability to share data quickly and efficiently across outside partner organizations. It is no different for this Pilot, the Energy Trust noted that the overarching agreement between the two organizations make it difficult to share resources that pertain to customer data, while this protects customer information, the practical impact of this is it can increase processing time for customers.

Since the Covid-19 pandemic, supply chain has been a major challenge for customers installing battery storage. While these challenges have improved over time, the Energy Trust noted that obtaining devices quickly for customers has “been a major challenge, but because

PGE and the Energy Trust are a little bit more flexible [than other organizations], we've been able to support vendors" when they have faced supply chain challenges.

Beyond supply chain, delays for processing new trade allies were identified by the Energy Trust as an opportunity for improvement. "Right now, the rebate is provided up front, so there is no financial incentive for the Trade Ally to turn in the paperwork" this results in the Trade Allies focusing on the next sale rather than completing the required documentation in a timely manner. This can result in delays for the customer and has been noted as an opportunity for the Energy Trust to improve the overall turnaround time of this process.

The Energy Trust is working to identify ways to better communicate across the vendor network. They are working to develop new collateral and communications designed to give vendors the information they need but also provide them with information to pass to the customer to ensure consistency across everyone involved. The Energy Trust's Administrator noted that "there is always something changing [in relation to the Pilot], whether it's grants, incentives, or program options" so ensuring that the vendors and customers have the most up-to-date information has been a challenge.

Furthermore, vendors have reported to the Energy Trust that simply having the word "Pilot" in the title of the Smart Battery Pilot has made them "uncertain of the program, and they want to protect their customers. They're not going to push it too hard unless they can count on it sticking around and remaining consistent." PGE expects that with the future transition of this Pilot to Program status, this issue should be resolved.

Future Pilot Considerations

The Pilot has an expiration date of July 31st, 2025, and at that time it can either apply to be extended, sunset, or transition to a program with the same or updated structure. At this time, it is PGE's hope and intent that the pilot will be replaced with a scalable and cost-effective structure and will continue to pursue learnings in the next two years that will inform this transition.

Increasing Energy Storage Adoption & Pilot Enrollment

There are two primary barriers to increasing Pilot uptake: the first is simply the number of customers with a battery installed at their home, and the second is encouraging eligible customers to enroll in the Pilot once their battery is installed. There are just over 800 batteries installed in PGE's service territory, representing about 0.1% of all customers. Seventy-five percent (75%) of all batteries installed are qualified for the Smart Battery Pilot however, and almost a quarter (24%) of those eligible are currently participating in the Pilot.

For the first issue, batteries remain quite expensive and forecasts that battery storage systems would drop in price since first being introduced to the residential market have not materialized. Cost is listed as the primary barrier among potential participants, and even with incentives the up-front costs of these systems are not low enough to sway customers who would not otherwise seek out a battery storage system.[14]

Vendors and PGE's key partner, the Energy Trust, cite that supply chain challenges presented significant barriers to adoption during and shortly after the COVID-19 pandemic. Customers who wanted battery systems were unable to procure them or faced extensive wait times for delivery.[15]

When the Pilot tried to encourage adoption of energy storge with the Smart Grid Testbed upfront rebates we found that the $3,000 offer was not enough funding to induce a purchase, so the Pilot will try again with a revamped rebate structure of $405 per kWh, in the hopes that this restructured incentive and a comprehensive outreach campaign in collaboration with the Energy Trust will encourage adoption for locational density.

Additionally, customers cite the importance of ease of installation. While many do say that their installation was very or somewhat easy, there are still 27% of customers that found it difficult. This impacts the way they talk about the battery device to others. PGE is reliant on the Energy Trust to manage this installer network and has limited control over the customer experience with this phase of the process. Likewise, installers report lower levels of satisfaction and likelihood to recommend the Pilot to customers. There appears to be an opportunity for improvement for PGE to partner closer with the trade allies to ensure they have the desired information about the Pilot and to improve their willingness to recommend installing a battery and participating in the Pilot to their customers.

As we continue to see weather events that highlight the need for home resilience products, PGE expects to see an increase in customer interest and adoption of home battery backup systems. The customers who currently participate in the Pilot cite that obtaining resilience (61% rank resilience as their top motivator) and increasing their use of carbon-free energy are the top two motivations for purchasing a BESS.[16]

Generally, customers participating in the Pilot are satisfied and highly likely to recommend it to others, with 75% saying they are very likely and another 22% saying they are somewhat likely.[17] The best way to enroll a customer appears to be right when they have installed their device, and PGE will consider adjusting the process for sending the automated enrollment email to all qualified customers versus only those whose installer has opted them in.

Among those who are not currently in the program, familiarity with the Pilot is low. Despite a lack of familiarity, customers do express interest in enrolling when presented with details of the Pilot. This suggests that with marketing materials designed to address specific questions around cost, installation, and pilot details, additional customers may choose to enroll. [18] PGE has done many marketing campaigns to perform outreach to customers with a qualified

[14] Portland General Electric, "Smart Battery Pilot Evaluation" (2021)
[15] Energy Trust of Oregon Interview, Portland General Electric (April 3, 2023)
[16] Ibid
[17] Ibid
[18] Portland General Electric, "Smart Battery Pilot Evaluation" (2021)

battery to make them aware of the Pilot, and continues to explore new means of communications other than email, including a new bill insert in late 2023.

Another suggestion for a future iteration to ensure all qualified customers to participate is to allow customers other than Rate Schedule 7 to participate in the Pilot who have a qualified device. Currently the tariff limits the Pilot to Schedule 7, however there are residential customers on Schedule 32 with, for example, a shop or garage who are not able to participate due to the tariff language and cannot enroll their battery in Peak Time Rebates since they are not on Schedule 7, nor Energy Partner since they are residential. Other entities that may benefit from expanding the eligibility of Smart Battery are non-residential customers who have a residential scale battery. PGE has customers such as synagogues & churches, vineyards, and other small businesses that are being encouraged to enroll in Energy Partner, however we believe that Smart Battery may be a better fit for those small, directly dispatchable devices. This will be explored in the next iteration of Smart Battery.

Cost-Effectiveness

Should the Smart Battery Pilot seek to expand into a Program in the next iteration PGE will endeavor to make it scalable and cost-effective. The Pilot's goal has been to optimize learnings while in this early phase and to enable the integrations and investments in backend infrastructure necessary to support the pilot, and any transitions to the next phase.

Distributed customer-sited batteries like those in the pilot are expected to play an increasing role in providing a zero-emission capacity resource. PGE is developing a Virtual Power Plant (VPP) that can utilize various DER connected to the distribution system and provide reliable grid services that typically are provisioned by centralized power plants. The current Smart Battery pilot design has focused on early operational learnings on how to communicate with, remotely dispatch, and validate performance of the battery fleet, and therefore has not evolved into fully optimized dispatch and integration with other DERs. For example, most event calls have coincided with system-wide capacity calls during resource adequacy periods, which is an important value stream but is not reflective of the full flexibility from batteries capable of dispatching for daily energy optimization and load shifting purposes. PGE plans to model more robust optimized dispatch scenarios to inform future cost-effectiveness evaluation and program design considerations.

As this pilot matures and number of participants increases, careful consideration of the balance between customer incentives and grid service value will be important. Although the pilot design was geared at a small sample to test the technology, communication needs, and participant behavior, these learnings are expected to translate into a more robust program design capable of leveraging larger scale procurements and enrollment targets that can help buy-down per-unit integration costs. These strategies can be expected to result in reduction of program delivery costs and combined with the inclusion of more optimized dispatch for grid services, will help the pilot on the way to becoming cost-effective.

Appendix A: Customer Communications

PGE Smart Battery Pilot

PGE

Making the most out of a home battery system

Launched in 2020, PGE's five-year Smart Battery pilot studies the best ways to connect batteries at your home to PGE's grid. During Peak Time Events, we'll charge or discharge your battery to either store or provide energy to the grid. In return, you'll receive bill credits for participating.

Gain resilience
You can rely on back-up power if there's an outage.

Choose your savings
Save on your bill based on the amount of battery capacity you choose to contribute.

Optimize your solar
A battery lets you store the energy you generate from solar panels.

New this year - a tiered reward structure

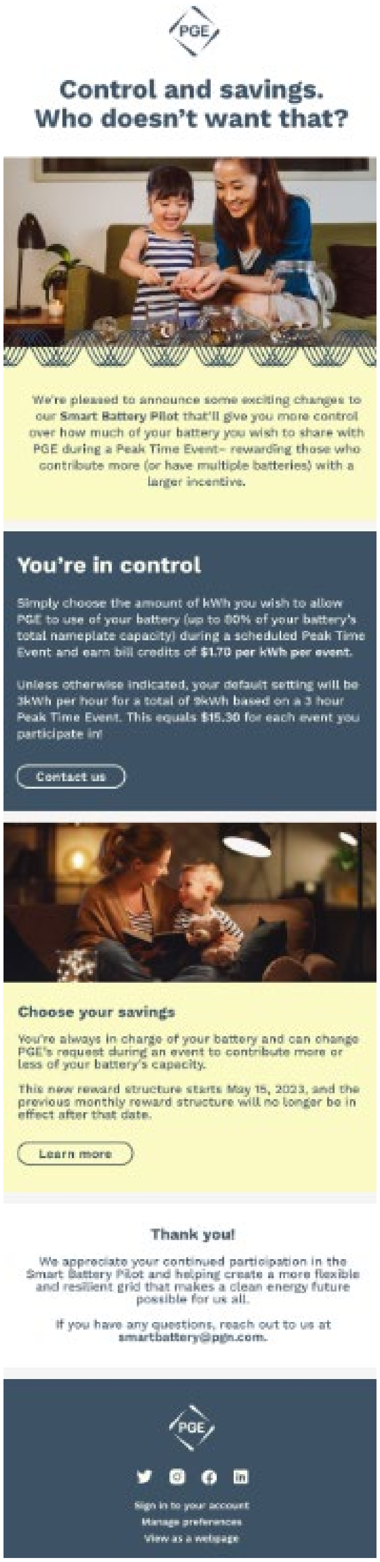
Recently we changed our incentive structure to give you more options. Now, you can choose the amount of kWh you wish to allow PGE to use of your battery during a scheduled Peak Time Event and earn bill credits of $1.70 per kWh per event. This allows participants more options when it comes to optimizing resilience based on their own comfort level. Each tier is based on a percentage of your battery's total nameplate capacity:

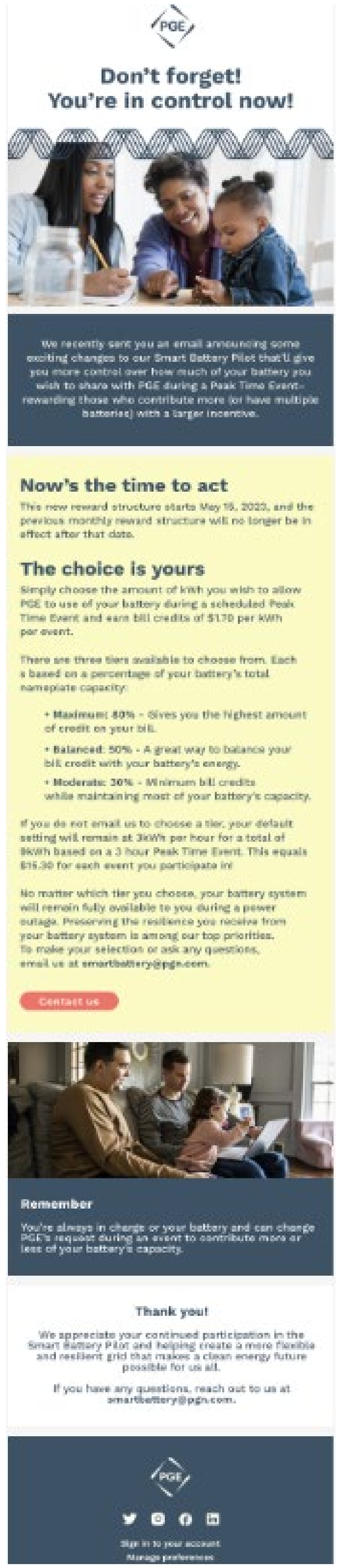
Maximum	Balanced	Moderate
80%	50%	30%
Gives the highest amount of bill credit	A great way to balance between bill credit and the battery's energy	Minimum bill credits while maintaining most of the battery's capacity

Remember, you're always in control. You are always in charge and can change PGE's dispatch during an event to contribute more or less of your battery capacity. Batteries are not dispatched when outages are most likely and remain fully available to you during a power outage. Preserving the resilience you receive from your battery system is among our top priorities.

For the latest information on the PGE Smart Battery Pilot and how to sign up visit: **portlandgeneral.com/batteryinfo**

Smart Battery one pager providing program overview and benefits to be used at events where PGE has a presence.





Emails sent to customers informing them of upcoming changes to the Pilot structure and encouraging them to share their desired capacity in Spring and Summer of 2023.

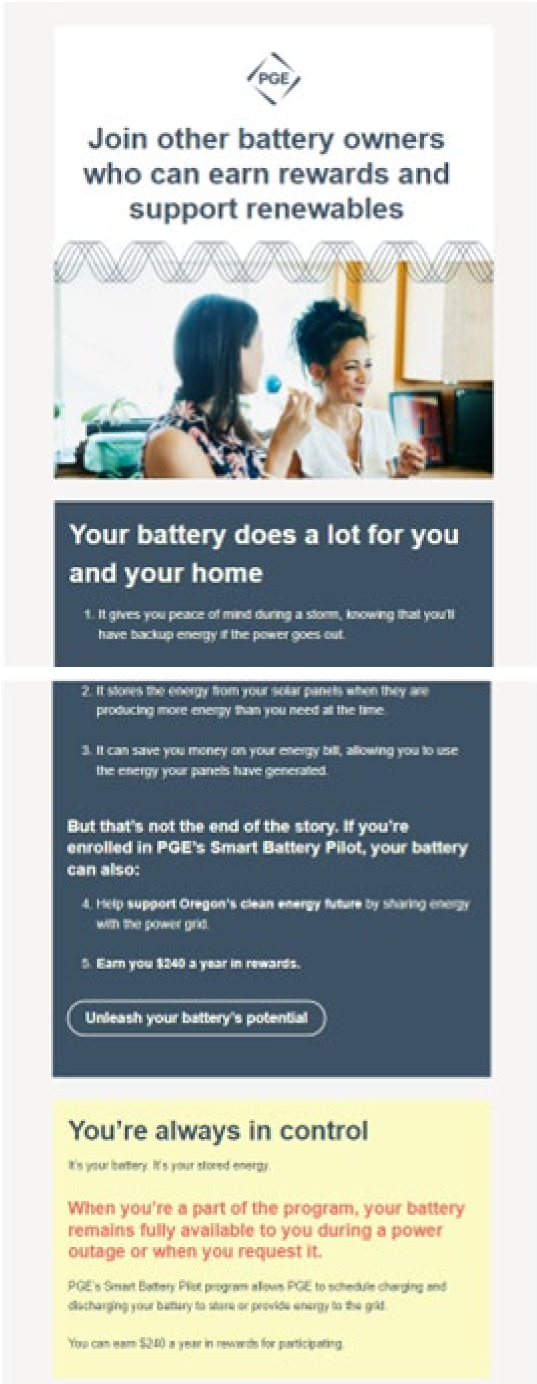
Why should EVs get all the love?

Modern day batteries are the magical ingredient in today's EVs. But they also can work their magic in homes, too. With a home battery storage system, you'll get back-up power that can outlast many types of outages, providing you with resiliency and peace of mind.

What's in store at your home? How about energy!

Because you're part of our Smart Grid Test Bed, you can save up to $9,000* off the purchase and installation of a home battery storage system. When you take us up on our offer, we'll enroll you into the PGE Smart Battery Pilot, a program that gives you a monthly $20 credit on your bill just for connecting your new battery system to our grid.

Excerpt of an email sent to Smart Grid Testbed customers without an existing battery in 2022.



Email sent to customers with an existing battery in 2022.

Front and back of postcard sent to customers with existing battery storage in 2022.