Pacific Gas and Electric Company®

Emerging Markets & Technology Demand Response Projects 2021 Q4 – 2022 Q1 Semi-Annual Report

March 31, 2022

Pacific Gas and Electric Company®

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I. Summary

Pacific Gas and Electric Company (PG&E) submits this semiannual report as directed in *Decision Adopting Demand Response Activities and Budgets for 2012 through 2014*, D.12-04-045, Ordering Paragraph (OP) 59 and continued per D.14-05-025 and D.16-06-029 adopting Bridge Funding for 2015-16 and 2017, respectively. The Demand Response Emerging Technologies (DRET) Program was also approved in the *Decision Adopting Demand Response Activities and Budgets for 2018 through 2022*, D.17-12-003.

PG&E's DRET program continues to explore new technologies and applications that have the potential to enable or enhance demand response (DR) capabilities and can include hardware, software, design tools, strategies, and services. Examples of some of the types of enabling technologies that have been investigated are advanced energy management control systems (EMCS), direct load controls, and advanced heating, ventilation, and air conditioning (HVAC) controls.

PG&E's DR Portfolio Strategy centers on addressing both customer and grid needs today and, in the future, taking into account Rule 24, and the enablement of DR integration into the ISO wholesale markets. In addition, PG&E acknowledges the rapid development of "smart" devices, storage, and other technologies that are seeing increasing customer adoption across sectors and have the potential to help customers better perform on DR programs.

PG&E, Southern California Edison Company (SCE) and San Diego Gas & Electric Company (SDG&E), collectively referred to as the Investor Owned Utilities (IOUs), share updates on individual projects, including project status and findings, at monthly DRET conference calls as well as via participation in the Emerging Technologies Coordinating Council (ETCC) quarterly meetings.

II. Projects Completed in Q4 2021 and Q1 2022

A. Residential Battery as Virtual Power Plant (VPP) Study

1. Overview

This study evaluated how BTM residential battery systems were being used to provide value to the customers and the grid during grid emergency. The study focused on customers with existing battery with solar.

The objective of the study was to evaluate:

1) What are the ex post load impacts using end-use battery data and premise data?

2) How do impacts using the end-use battery data compare with impacts at the household level?
3) Do the event calls lead to changes in consumption at the household level?
   a. Is there an increase in a household's net discharge to the grid during an event?
   b. Do residential batteries export to the grid during emergency events? Or are they used solely to offset the household's energy use?
4) What was the performance when consecutive events were called?
5) What is the full export (to the home and to the grid) capability?
6) What are the pros and cons of settlement of load impacts at the device (battery) level vs. premise meter level?
7) What is the customer experience when participating in this type of study?
8) How does the EM&V analysis compare with the settlement results?

2. Collaboration

The DRET team collaborated with the internal Distributed Generation team and the Integrated Grid Planning and Innovation Team to implement this study. PG&E hired a consultant to manage the EM&V for this DRET study and a third-party program administrator to support dispatch and calculation of customer compensation.

3. Results/Status

- Total number of customers enrolled with PGE VPP - 1367 Customers
- Total number of enrolled PGE VPP batteries - 2,506 batteries
- Total aggregate delivered MWh – 8.92 MWh
- Total aggregate delivered MW (1st hour) – 4.5 MW

Research Question	Findings
Do customers enroll in programs that allow the utility to use their battery for grid needs in exchange for payments?	1,300 of the 7,000 (18.6%) customers recruited into the pilot enrolled. All recruitment took place in the Fall of 2021 via push-notification over a compressed timeline. PG&E offered customers an incentive of $1/kWh for energy dispatched over their typical baseline, and customers were allowed to opt out of events.
What are the ex-post load impacts using end-use	The incremental impacts are estimated to be ~4.5 kW in hour 1, ~3.0 kW in hour 2, and less than 1 kW in hour 3.

battery data and premise data?	
Do the existing dispatch algorithms to deliver a flexible, controllable grid resource?	The current battery dispatch algorithms deliver all of the resources, all at once, until the available energy storage is exhausted. Currently, the algorithms cannot deliver a consistent level of demand reduction over the event, deliver a requested level of output, or sustain the resources over a longer event duration. The battery manufacturer is in the process of modifying its algorithms, so residential battery resources are more flexible and controllable for grid needs.
How do impacts using the end-use battery (sub-meter) data compare with impacts at the household level?	Load impacts estimated using household-level smart meter data were similar to those calculated using battery end-use data, with less than a 1% difference between the impacts on average.
Do the event calls lead to an increase in a household's net discharge to the grid during an event? And exporting of battery resources to the grid?	When dispatched for events, the batteries not only offset the household's energy use, but also exported energy back to the grid. Customers do not noticeably modify their energy use (of other end-uses) when the battery is used to support grid needs.
What was the performance when consecutive events were called?	The batteries delivered consistent dispatch across consecutive event days. However, events were called during mild weather conditions typically with ample sunshine. The dispatch consistency may change if batteries are discharged under more extreme weather conditions.
What is the full export capability?	On average, batteries were able to discharge 4.5 kW during the first hour for a full net export of 3.3 kW. However, this is not necessarily representative of battery export capability during peak system demand as batteries for this pilot were dispatched under moderate weather conditions.
How does the EM&V analysis compare with the settlement results?	For settlement with customers, the baseline usage is calculated as the same hour average over the past 10 days using battery end-use data. Any battery discharge above the baseline was considered the load impact. On aggregate, the impacts calculated using the settlement baselines are comparable to EM&V results, but were 5% higher on average.

4. Next Steps

This assessment ended on December 31st, 2021. PG&E is finalizing the report and it will be posted at the ETCC website in the 2nd quarter of 2022.

B. Develop a residential ADR incentive for EV Charging Controls

1. Overview

In 2019, the Automated Demand Response (ADR) Program conducted a Collaborative Stakeholder Process to identify and vet emerging residential ADR technologies for potential inclusion in the program. This process found that EV charging control (such as onsite charging station, or manufacturer's telematic) were an excellent fit for the ADR program, based on the rigorous criteria and stakeholder process employed in the study. However, surveys with the vendors and their respective control technologies indicate that they were not ready for full-scale rollouts at the time for various reasons.

In order to develop a residential ADR incentive for EV charging controls, this study will test EV charging controls in a field setting and measure the DR impact of such technologies. The study will:

- Identify relevant eligibility criteria for EV charging controls' participation in the field test, and more broadly, in PG&E DR programs.
- Identify EV charging controls and assess their DR impact in a field test.
- Characterize, to the extent possible, the average load management potential for identified residential EVs in PG&E territory:
    - Characterize load management groups of PG&E EV owners based on their EV's, TOU rates, and charging habits.
    - Document existing DR incentives available through PG&E programs (e.g., Smart Rate, Demand Response Auction Mechanism (DRAM) and Capacity Bidding Program (CBP)) to inform how the residential ADR program fits into the DR landscape and how ADR incentives for EV ADR controls should apply to these different DR programs.
- Assess potential ADR incentive designs and amounts for residential EV charging control technologies.

2. Collaboration

The DRET team collaborated with the internal EV team to implement this study. PG&E hired the same consultant that leads the ADR Collaborative Stakeholder Process to manage this DRET study.

3. Results/Status

Below are high level study results:

- Vehicle telematics and EV charger controls are both effective strategies for curtailing EV charging during DR events with minimal impact on participants
- EV ADR charging controls technology holds promise for mitigating overnight peaks
- The maximum resource from managing charging with no export potential for EV ADR control technologies is 9 MW to 13 MW during the peak period from 4:00 p.m. to 9:00 p.m. for the current population of 366,000 EV owners in PG&E service territory
- In alignment with the resource potential findings, almost half of PG&E EV owners regularly charge overnight and would be good targets for new type of EV DR programs that target this time period.
- EV ADR incentives should focus on customers who already own Level 2 chargers

4. Next Steps

This assessment ended on March 2022. PG&E is finalizing the report and it will be posted at the ETCC website in the 2nd quarter of 2022.

C. New DR Program/Rate designs for Agricultural customers

1. Overview

PG&E received direct feedback from major aggregators of agricultural customers whose customers have significant load to drop and are interested in an agricultural specific DR program. Existing demand response programs are not an optimal fit for some customers in the agricultural industry given their unique load patterns and energy usage. By creating an agricultural specific demand response program or rate that helps customers overcome these obstacles and optimize their unique resources, more customers will have the opportunity to participate in demand response and PG&E will be able to meet its goals of maintaining, growing, and optimizing DR megawatts (MWs).

The objective of this study was to collect data on new DR Program/Rate designs for agricultural customers during 2021 in order to create a draft DR program design for agricultural and irrigation customers to be filed by PG&E in its 2023-2027 DR funding application. Specifically, the study goal is to collect data that informs a new pilot program designed for agricultural customers to do the following (including but not limited to):

- Increase load reduction per agricultural participants in existing DR programs
- Increase number of agricultural participants
- Reliable load reduction: ability to deliver the amount of load reduction that is promised
- Higher customer and aggregator satisfaction than agricultural participants in existing DR programs
- Whether cost-effectiveness remains the same or better than other agricultural participants in existing DR programs

2. Collaboration

The DRET team contracted with a 3rd party vendor who are familiar with the agricultural industries and market to implement this DRET study.

3. Results/Status

The results of the conjoint choice experiment study are fundamentally a reflection of relative customer preferences for some program attributes over others: stronger preferences drive enrollment likelihood. The strongest respondent preferences included:

■ Performance-only participation terms (relative to terms with penalties): 3 to 5 fold relative preference, depending on the penalty magnitude

■ Earlier notification (24 hour v. 30 minute): 3 fold preference

Preferences within other attributes (incentive level, expected event frequency, or expected event duration) are documented below and more detailed in the final report:

RESEARCH QUESTION	KEY FINDINGS
What is the tradeoff relationship between program incentives and program rules for agricultural customers?	**A performance-only design is preferred three to five fold over a design with penalties**, depending on the penalty magnitude. Given the expected boost to enrollments, a performance-only design is therefore expected to yield greater MW load reduction and greater net benefits than a design with a penalty, even after factoring in assumptions for lower performance with a performance-only design.

RESEARCH QUESTION	KEY FINDINGS
How much notice should customers receive before being dispatched?	**Event notification is a key driver of enrollment likelihood, with one day ahead (24 hour) notification strongly preferred to day of (30 min) notification**.
How does the duration and volume of event dispatch impact enrollment likelihood for agricultural customers?	**Event duration and event frequency are not the primary drivers of enrollment likelihood**, though respondents preferred fewer event hours in general. Given that longer and more frequent events also deliver more avoided capacity value, moderate event duration (4 hour) and frequency (12 events) balance net benefits with dispatch flexibility.
Would alternative incentive units ($/hp) resonate better with Ag customers than usage based units ($/kW, $/kWh)?	**Horsepower (hp) is best understood by most agricultural customers**. When discussing peak load, water district customers were most familiar with kilowatts (kW), whereas all other agricultural customers were most familiar with horsepower (hp) as units.
How do preferences and load reduction potential differ by agricultural segment, e.g., small v. large firm?	**Smaller customers may be able to curtail a larger portion of their peak load. Program element preferences were directionally similar for small respondents (bottom 20% of peak load) compared to large respondents. The main difference is that small respondents were open to curtail a larger percentage of their peak load.** **Tree growers may be most able to curtail load. Barriers may exist for some water district customers. Nut and fruit tree growers were willing to shift a large portion of their peak load, significantly more than agricultural customers with other activities. In contrast, water/irrigation districts (often very large customers) were most likely to have peak loads that are manually controlled and left on all the time, though this was still a minority.**
What program design is likely to deliver the greatest net benefits to PG&E and society?	**A performance-only design with day ahead notification is expected to maximize MW load reduction and net benefits for PG&E (Utility Cost Test (UCT) perspective) and for society (Total Resource Cost (TRC) perspective). This was based on assessing costs and benefits for 108 design permutations tested.**

4. Next Steps

This assessment ended on December 2021. PG&E posted the final report at the ETCC website.

D. TOU optimization study with smart technologies

1. Overview

The objective of this study is to evaluate if residential smart technologies, such as smart thermostat, can optimize TOU customers HVAC energy use in order to shift customers energy usage from peak to non-peak and potentially result in customers' bill saving. In the study, the technology

should provide a "set it and forget it" experience for the customers. The study should analyze performance of smart thermostats, including:

- Enrollment rates for all three smart thermostat manufacturers, regardless of recruitment method, by recruitment mechanism
- TOU sign-up rates with email and push notification by vendor
- Estimate load impacts for each event overall and by smart thermostat manufacturers, TOU status, and TOU auto-programming
- Estimating the load impacts for each event called
- Estimate the TOU impacts on non-event days overall and by smart thermostat manufacturers, TOU status, and TOU auto-programming
- Estimate the enhanced energy savings for different smart thermostat manufacturers
- Compare DR load impacts for all three smart thermostat manufacturers
- Compare effectiveness between vendor's TOU optimization versus smart thermostat manufacturer's TOU optimization
- Comparison of automation capabilities for smart thermostat manufacturers to understand potential for load flexibility, shed, shape, and shimmy

2. Collaboration

The DRET team contracted with a third-party vendor who is familiar with residential smart technologies, manufacturers, and the market to implement this DRET study.

3. Results/Status

During the first and second quarters of 2021, the study recruited 13,350 customers to enroll in the pilot. The study also called six DR test events to measure the load impact from pilot participants. Below are high level results of this study:

- Sites that signed up for automated TOU response reduced 4-9 pm loads by ~0.20 on a daily basis, with some variation by temperature

- For sites with automated TOU response, the full event impact is the daily TOU response plus the event day impact

- Cooling loads peak around 4 pm and start declining (though household load peaks in the evening)

- Air conditioner loads are less coincident with CAISO net loads than with PG&E and CAISO gross loads
- The reductions for hotter temperature days exceeded 1.0 kW but decayed for later event hours.
- The biggest drivers of event response are weather, the event hour, and daily automated response to TOU later event hours

4. Next Steps

This assessment ended on December 31st, 2021. PG&E is finalizing the report and it will be posted at the ETCC website in the 2nd quarter of 2022.

III. Project Initiated in Q4 2021 and Q1 2022

There were no new project initiated in Q4 2021 and Q1 2022.

IV. Ongoing DRET Projects

A. Evaluate 3rd party aggregator and vendor interest on residential digital rate

1. Overview

The objective of this study is to evaluate third-party (example: Integrated Demand Side Management aggregators and smart energy vendors/manufacturers) interest in receiving residential digital rate in order to help residential customers to be successful when enrolling in a dynamic rate such as time of use (TOU), electric vehicle (EV) and Smart Rate. Below are the proposed scoping topics for this study:

- Defining what is a digital rate
- Determining the format of the dynamic rate
- Scoping information technology (IT) architecture design that can be scaled in the future
- Documenting third parties' preferences on the channels and different type of rates
- Testing different channels that can provide digital rates to third parties
- Testing the elasticity of different type of rates (dynamic, tier and non-tier, etc.)

2. Collaboration

PG&E's DR Emerging Technology and Share My Data teams jointly designed and will implement this Emerging Technology assessment. Internal stakeholders would include the Pricing Product and IT Team. A consultant was hired to lead the digital rate development.

3. Results/Status

CPUC Energy Division staff has suggested to PG&E to put this DRET study on hold due other priorities, such as the Reliability Order Instituting Rulemaking (OIR). PG&E delayed the deployment of this DRET study until the end of second quarter 2021 and is restarting the study in the 3rd quarter of 2021.

4. Next Steps

PG&E hosted three webinars to enroll third parties into the study. Three companies have submitted a registration form to show interest in participating in the study. PG&E is in the process of finalizing the vendor participation agreement and expects to start working with these vendors in second quarter of 2022.

B. Voice automation technology for load management study

1. Overview

PG&E started to default residential customers to TOU rate in April 2021. Therefore, PG&E will expand the existing tools and technologies offered on PG&E's website in order to help customers to be successful in these new time varying rates. The objective of this DRET study is to leverage residential voice assistant technology (such as Amazon Alexa) to educate residential customers on energy usage and bill forecast, rates and Time-Of-Use automation/optimization, and notification of utility events.

Customer Engagement through Voice Assistants require the customer to have access to Amazon Alexa via speakers, display and/or mobile app. Information is collected and processed from PG&E's internal rate engine and Share My Data (SMD) to 3rd party system. The customer would then interact with a third- party system (Energy Expert) through smart speakers, smart display, and mobile devices. The Energy Expert will advise the customers to optimize energy use based on the customer's rate schedule. In addition, the app will provide customer notification such as Smart Days and PSPS events.

This study has two phases. Phase 1 of this program will target 5-10 employees (combination of PG&E employees and friends of PG&E employees). Phase 2 will target up to 5,000 customers.

2. Collaboration

The DRET team is partnering with the internal customer care Pricing Pilot and Marketing teams to develop frequently asked questions (FAQs) that relate to TOU and load management. PG&E hired a third party to develop a smart speaker application (a voice automation skill named Energy Expert) for this study.

3. Results/Status

The DRET team is in the process of performing small scale User Acceptance Test on the Energy Expert skill. Below is list of sample questions that are supported by the Energy Expert skill in Phase I:

- What's my bill? (As of yesterday)
- What's my energy usage? (As of yesterday)
- What is my current rate?
- What other rates are available?
- Am I on the right rate?
- What's a good time for to run appliances?
- When are prices the lowest? (For both Smart Rate and non-SR customers)

4. Next Steps

The DRET team worked with Amazon to leverage the notification function for Smart Days and PSPS and successfully completed Phase 1 of the study. This study is preparing to release this product to residential customers through the Apple and Android app stores for up to 5,000 participants.

C. Heat Pump Water Heater barriers and mid-stream solution study

1. Overview

As CA policy focuses on reducing GHG emissions, residential natural gas use is one of these sources of GHG emissions in the state that warrants attention. The majority of existing single family and low-rise multifamily buildings use natural gas for some or all of the following end-uses: space heating, water heating, cooking, clothes drying, fireplace and pool heating.

The State has allocated funding from several different sources for residential electrification efforts targeting space and water heating equipment. As the market is developing and initial programs have launched to support these efforts, several challenges have been identified that could significantly delay market transformation.

Converting existing gas water heaters to heat pump water heating equipment across the state will require a comprehensive effort across the entire industry, including education for homeowners and equipment manufacturers, enforcement personnel, distributors and installers. Initial efforts have identified several challenges that inhibit selection and installation of Heat Pump Water Heaters (HPWH), including, but not limited to:

- Insufficient panel capacity
- Location of existing equipment (e.g., most HPWH require 240V supply, no electricity (or only 120V) at equipment location)
- Permitting (both electrical and plumbing)
- Familiarity with technology (both for homeowners and contractors)
- Equipment not locally stocked

As most water heater replacements are triggered by equipment failure with the majority resulting in emergency replacements, the objective of this DRET study is to identify potential solutions to these barriers, with a focus on leveraging mid-stream channels such as contractors, distributors, and retailers to increase adoption of this technology.

2. Collaboration

This study is a joint Energy Efficiency (EE)/DR Emerging Technology Study. PG&E is planning to hire a third party to lead this research project. The third party is responsible to partner with other initiatives that are related to heat pump water heater such as Technology and Equipment for Clean Heating (TECH) and Building Initiative for Low Emissions Development (BUILD).

3. Results/Status

The implementer developed a Midstream Heat Pump Water Heater Study and Field Test SharePoint extranet site. The extranet will provide contractors and distributors access to the Resource Library which is a searchable catalog of materials on the study. The implementer developed different marketing materials and marketing plans. HPWH contractors and distributors were recruited for the study. In addition, the implementer also

interacted with the major heat pump water heating manufacturers like AO Smith, Bradford White, Rheem, and Nyle.

4. Next Steps

The study is targeted to focus on the following tasks in the next two quarters:

- Completion of the PG&E Midstream HPWH Study and Field Test: Supply Chain Market Study
- Work with PG&E WE&T team, PG&E Code Compliance, and BayREN Code Training on the best pathway for knowledge sharing from the Supply Chain Market Study to help support their existing efforts on HPWHs
- Recruit more distributor into the Field Test.

D. BTM Battery for Load Management Study

1. Overview

This study evaluates how behind the meter (BTM) residential battery system can be used to provide value to the customers and the grid when the battery is optimizing under different dynamic rates (e.g. TOU and real time pricing (RTP)[1]) and DR events. The study will focus on two groups of customers, customer with existing battery and customer purchasing a new battery.

PG&E will have collected data that informs the below program enhancement goals:

- Determine how best to leverage battery storage technologies for TOU, DR, RTP, load following, and load shaping.
- Increase number of customers with DER technologies participating in DR programs
- Reliable load reduction: ability to deliver the amount of load reduction that is promised
- Meaningful load reduction: identify when and how DERs can provide value to the grid in DR programs
- Speed of response: measuring the speed of distributed battery storage response.
- Load building capability: the ability to increase minimum load and thus decrease ramping capacity needs and increase hosting capacity

[1] RTP as represented by the CAISO IFM Day Ahead LMP PGAE DLAP price

- How to remove significant barriers for battery storage aggregators and their customers to use DER technologies when participating in DR programs
- Cost-effectiveness: DR Programs remain cost effective with these enhancements

This study will collect data - such as customer load performance and effectiveness of different algorithms during 2021 and 2022 - to inform optimal program design for aggregators and customers with a BTM battery, which could then inform future DR funding applications.

2. Collaboration

The DRET team is collaborating with the internal Distributed Generation and Pricing Product team to implement this study. PG&E hired one consultant to manage the implementation and Evaluation, Measurement and Verification (EM&V) for this DRET study, and another consultant for TOU, DR and RTP signals dispatch.

3. Results/Status

PG&E completed the scope for the study and contracted with one battery manufacturer and two energy platform implementers for the study. The study also developed a customer participation agreement and websites for customer recruitment. As of March 2022, the DRET study recruited 70 customers to participate in the study.

4. Next Steps

The study will continue to recruit more customers and start sending TOU, DR and RTP signals to customers' battery in the 2nd quarter of 2022.

V. Budget

The following is a breakdown of the total expenditures for PG&E's 2018-2022 DRET budget. These values are based on accruals made each month. Values do not reflect commitments for projects, including those described in this report, which have been scoped and contracted for, but not yet executed.

At the time of the filing of this report PG&E had over committed its DRET budget. In response, PG&E is planning to fund shift a portion of the ADR funds to the DRET Program in 2022. Because the fund shifting amount will be less than 50% of the ADR budget, it will be reported in the monthly DR ILP report.

Approved 2018-2022 Budget	$7,230,000

Budget Spent as of February 28th, 2022	$6,137,023
Budget Committed as of February 28th, 2022	$1,627,977
2018-2022 Budget Remaining (estimated)	$0