Virtual Power Plant Project

DR21SDGE0002 Report

Prepared for:

Emerging Technologies Program
Customer Programs & Services
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Disclaimer

EXECUTIVE SUMMARY

As part of their Sustainability Strategy and commitment to reach net zero greenhouse gas (GHG) emissions by 2045, SDG&E launched a Virtual Power Plant (VPP) Project in 2021. The VPP was an initiative to strengthen community resilience and electric reliability in the unincorporated community of Shelter Valley in East San Diego County. This project took place about 12 miles east of Julian in the desert plains. The Shelter Valley community is prone to outages and public safety power shutoff (PSPS) events as they are at the end of the Julian transmission line. The goal of this study was to test the real-world impact of behind the meter (BTM) distributed energy resources (DER) on the SDG&E grid system in a traditionally hard-to-reach community. Data analysis and observation from this project will inform future VPP endeavors necessary to meet SDG&E's sustainability goals and to inform ongoing strategies for BTM resource management.

A VPP is a network of privately-owned or community DERs all interconnected and operating together to provide reliable power 24 hours a day. The DERs in this project include residential and commercial rooftop solar systems and battery energy storage systems (BESS) with smart load controllers such as well pump controllers, and smart thermostats which can be used by SDG&E to deliver electricity to the grid during periods of increased electricity demand. These devices were installed at eight single family homes and a community facility. All the devices were integrated into the Generac Concerto VPP software platform which served as a gateway controller for communications to these end assets. The assets were signaled to shed or shift their load during several simulated and actual demand response (DR) events.

Table-ES 1 shows the summary of demand reduction across all events of the VPP during the 2023 DR season (6/13/2023 – 10/5/2023). There were 16 DR events signaled, with 14 of them being 2-hours long and two events being 4-hours in duration. The baseline loads were calculated and adjusted separately for non-residential and residential customers for each event. The average residential baseline load was 13.5 kW for the 2-hour events, and 7.8 kW for the 4-hour events. The average demand reduction or impact of the residential sector of the VPP was 22.2 kW for the 2-hour events and 8.0 kW for the 4-hour events. For the non-residential customers, the average baseline load was significantly smaller at 0.4 kW for the 2-hour events and 0.6 kW for the 4-hour events. The demand reduction for the non-residential sector was 6.8 kW for the 2-hour events and 2.1 kW for the 4-hour events. This led to a total combined demand reduction of 29 kW for the VPP during 2-hour events and 10.1 kW for the 4-hour events.

TABLE-ES 1. SUMMARY OF VPP DEMAND REDUCTION

	AVERAGE RESIDENTIAL BASELINE LOAD (KW)	AVERAGE RESIDENTIAL DEMAND REDUCTION (KW)	AVERAGE NON-RESIDENTIAL BASELINE LOAD (KW)	AVERAGE NON-RESIDENTIAL DEMAND REDUCTION (KW)	AVERAGE COMBINED BASELINE LOAD (KW)	AVERAGE COMBINED DEMAND REDUCTION (KW)
2-Hour DR Events	13.5	22.2	0.4	6.8	13.9	29.0
4-Hour DR Events	7.8	8.0	0.6	2.1	8.4	10.1

ABBREVIATIONS AND ACRONYMS

AC	Air Conditioning
BESS	Battery Energy Storage System
BTM	Behind the Meter
CAISO	California Independent System Operator
CT	Current Transducer
DERs	Distributed Energy Resources
ET	Emerging Technology
DR	Demand Response
HVAC	Heating, Ventilation and Air conditioning
GHG	Greenhouse Gas
GW	Gigawatt
FTM	Front of the Meter
PSPS	Public Safety Power Shutoff
PV	Photovoltaic
CNS	Concerto Notification System
SOC	State of Charge
SDG&E	San Diego Gas & Electric
TOU	Time of Use
VPP	Virtual Power Plant

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INTRODUCTION

When energy demands are high during the summer, power plants ramp up often requiring the energization of peaker power plants to increase grid capacity and ensure reliability. These peaker plants generate electricity by combusting fossil fuels such as oil, coal, or natural gas, causing an increase in GHG emissions and contributing to global warming. Based on the CAISO grid emergencies history report from 1998 to present, there has been a substantial increase in alerts and warnings in the years 2020 and 2022. These alerts include: "Flex Alerts" to call consumers to voluntary conserve energy when demand for power could outstrip supply, "Restricted Maintenance Operations" that require generators and transmission operators to postpone any planned outages for routine equipment maintenance, "Energy Emergency Alerts" when day-ahead forecasting shows energy may be deficient, and "Transmission Emergency" alerts when an event may be threatening grid capabilities such as transformer overloads or loss.[1]

A VPP is a network of DERs in residential and non-residential buildings such as solar and battery systems – all working together as a single "virtual" power plant to provide reliable power 24 hours a day. A key feature of a VPP is its ability to combine the capabilities of various DERs and orchestrate support for the grid by putting energy back on the grid at the right place and right time. This allows a VPP to mimic or potentially replace a conventional power plant and help address distribution network bottlenecks with lower investment and operating costs as compared to the construction of a new power plant. Additionally, VPPs are a key resource to reduce GHG emissions by decreasing the use of fossil fuel based conventional power plants. They can also help reduce annual power sector expenditures by limiting peaker plant usage and thus decreasing overall energy costs.

Virtual power plants are a potential solution and a key resource to support varying grid needs and customer demand. One benefit of VPPs is that they are a cloud-based technology and do not require the significant physical space of a traditional power plant. The concept of VPPs has been around since the 1990s, but it has gained traction in recent years due to the increase in renewable energy generation, ongoing technological advancements, reduced conventional power plant approval/construction, and market driven transformation of the electricity grid.

By 2030, VPPs are expected to reduce peak demand in the United States by 60 gigawatts (GW). That number could grow to more than 200 GW by 2050. By avoiding generation buildout, decreasing wholesale energy costs, and avoiding or deferring transmission and distribution investments, VPPs can help reduce annual power sector expenditure by $17 billion in 2030 (Kevin Brehm, 2023).

SDG&E and AESC initiated this project by recruiting SDG&E customer participants located in the unincorporated community of Shelter Valley in East San Diego County. Shelter Valley is a traditionally hard-to-reach community based on its geographical isolation and demographics. Participating customers received no-cost energy efficient equipment such as smart thermostats, smart load controllers and/or a BESS. After the equipment installation, all the devices were integrated on a common platform and dispatched to test two use cases: peak load reduction (shed) and grid response (grid support). Figure 1 shows a schematic of VPP including DERs and smart controllers.

[1] https://www.caiso.com/informed/Pages/Notifications/NoticeLog.aspx

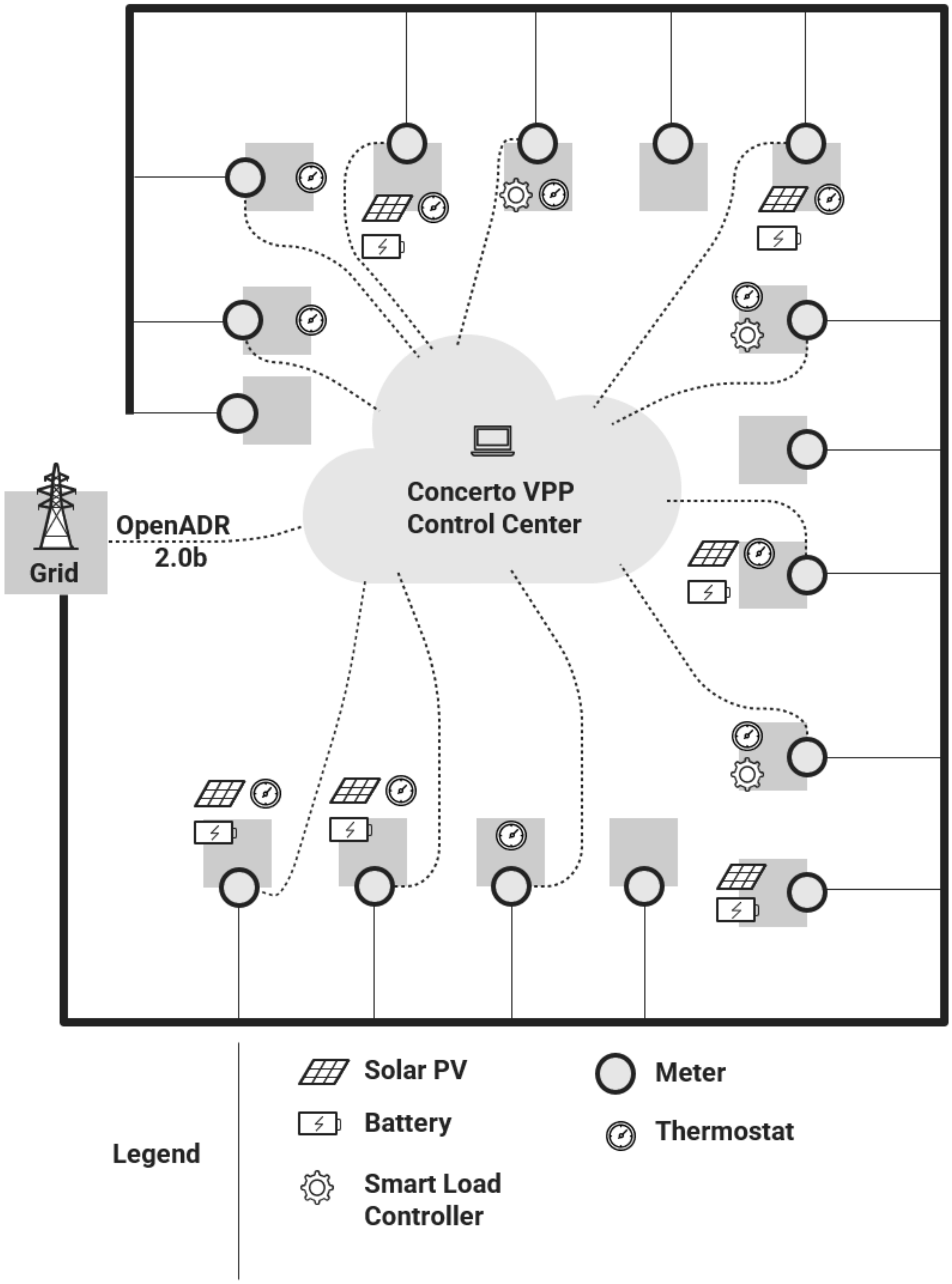


FIGURE 1. VIRTUAL POWER PLANT SCHEMATIC

BACKGROUND

As part of SDG&E's Sustainability Strategy and commitment to reach net zero GHG emissions by 2045, this VPP Project started in 2021 as an initiative to strengthen community resilience and electric reliability in the unincorporated community of Shelter Valley in East San Diego County. Shelter Valley is primarily residential, comprised of about 200 homes, a community facility, and a fire station. Over an 18-month period, the VPP project investigated how DERs such as smart thermostats, smart load controllers and battery energy storage function in real-world conditions, and how they can serve as a resource to help balance supply and demand on the grid.

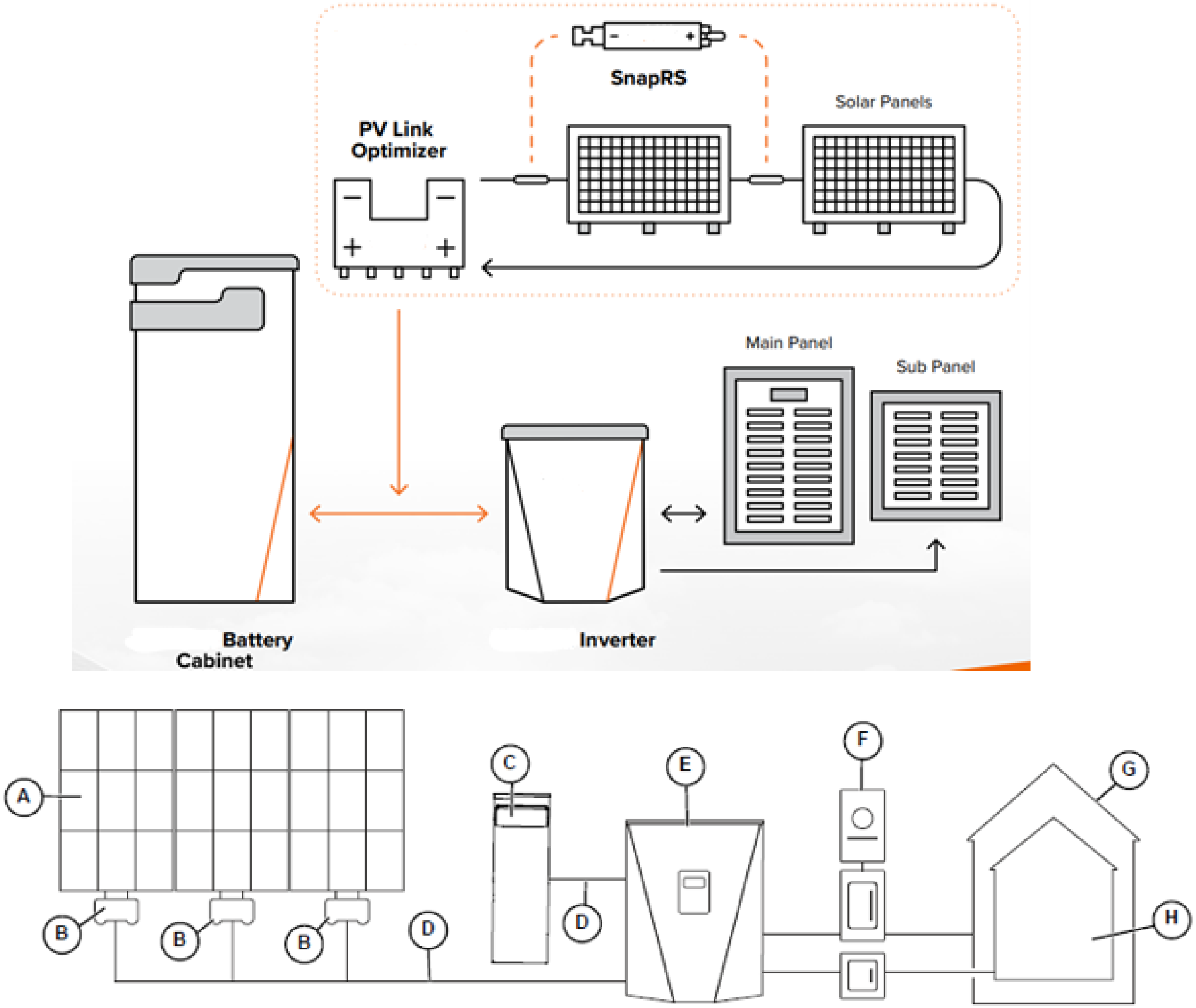
EMERGING TECHNOLOGY/PRODUCT

The technology that is being assessed in this project involves establishing a VPP in the Shelter Valley community. It consists of installation of various equipment like BESS, smart load controller and smart thermostats which are then configured into the Generac Concerto VPP software platform which acts as a gateway controller for communications to these end assets. During both simulated and actual DR events, these assets receive signals to either shed or shift their load.

BATTERY STORAGE SYSTEM

The battery storage and inverter system used in this project consists of six 3 kWh lithium-ion battery modules with a total storage capacity of 18 kWh. The inverter is rated at 7.6 kW, however the inverter can discharge at a higher rate for short periods of time to support the large inrush current required to start equipment. The inverter connects to PV Link optimizers[2] and batteries to form the grid-interactive solar and storage system.

[2] Part of BESS from manufacturer which provides substring level optimization for all connected PV modules



A Solar Panels
B PV Link
C PWRcell Battery
D REbus
E PWRcell Inverter
F Grid
G Loads
H Protected Loads

FIGURE 2. BATTERY SYSTEM CONNECTIVITY DIAGRAM (IMAGE FROM GENERAC GRID SERVICES)

BATTERY SYSTEM MODES OF OPERATION

The battery storage system has five different modes of operation, however for this project, the installed batteries were configured to only operate in Self Supply Mode, Priority Backup Mode, and Sell Mode.

On normal days, the system's default is Self Supply Mode, where the inverter prioritizes powering local site loads using solar and/or stored power first. Any excess solar production is used to charge the battery. In the evening, when solar production is less than the site load, the battery discharges to power the site load. Figure 3 and Figure 4 show energy flow matrices during Self Supply Mode.

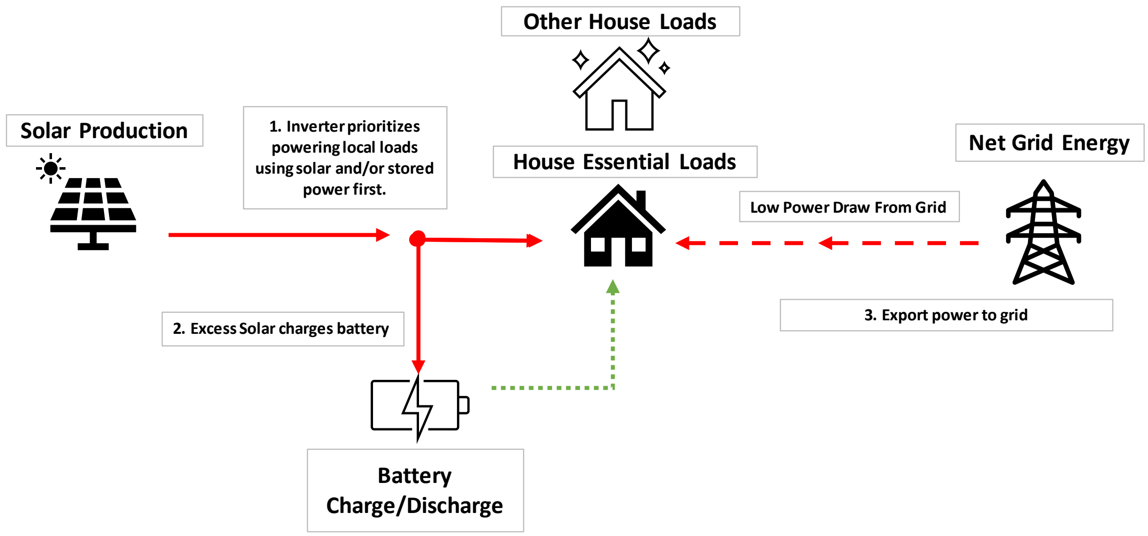


FIGURE 3. SELF-SUPPLY MODE (DAYTIME – CHARGING) ENERGY FLOW MATRICES

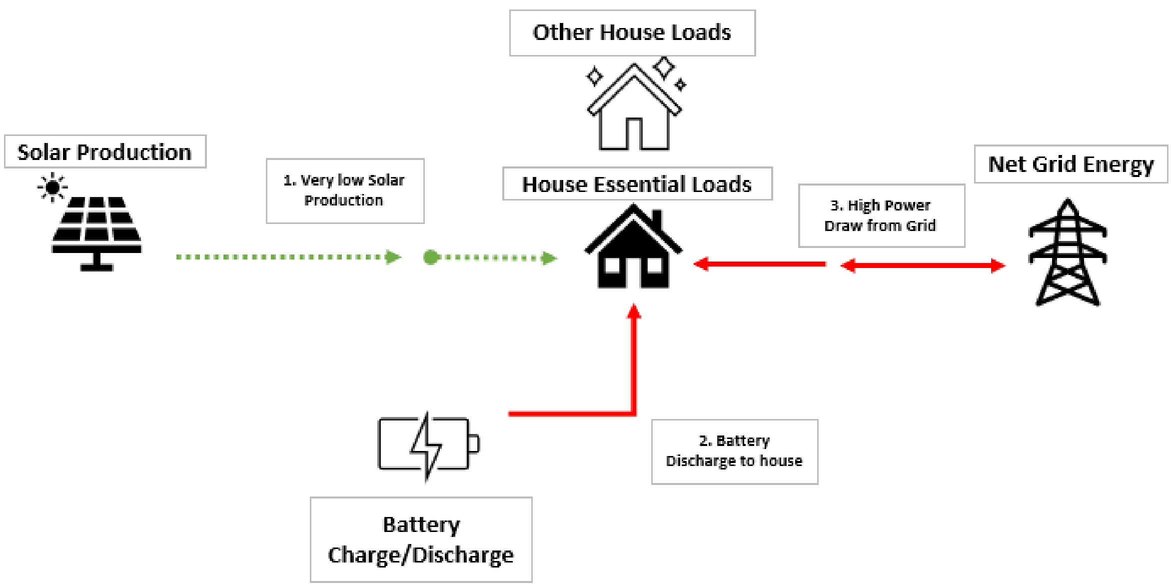


FIGURE 4. SELF-SUPPLY MODE (NIGHT/CLOUDY – DISCHARGING) ENERGY FLOW MATRICES

In Priority Backup Mode, the inverter prioritizes keeping the batteries charged using solar. This means the local site loads will be sustained by grid energy. The system was set to Priority Backup mode for a few hours before DR events.

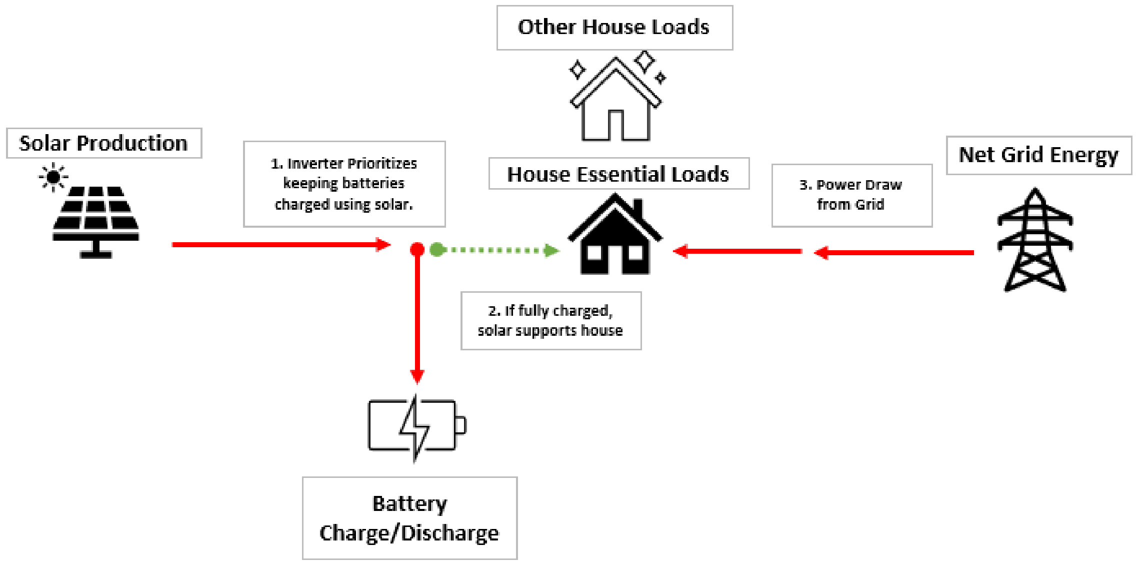


FIGURE 5. PRIORITY BACKUP MODE (BEFORE DR EVENT) ENERGY FLOW MATRICES

During a DR event, the battery system switches to Sell Mode. This sets the battery to discharge all available power to the grid until the minimum state of charge setpoint is reached.

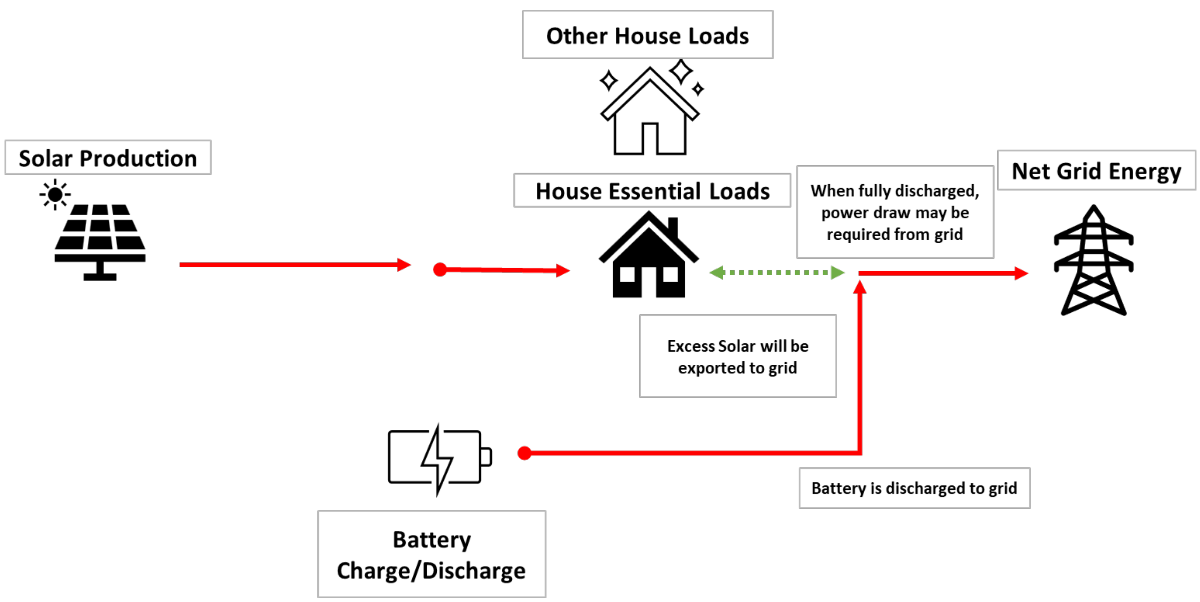


FIGURE 6. SELL MODE (DURING DR EVENT) ENERGY FLOW MATRICES

Smart Load Controller (Well Pump Controller)

A power control module was used in this project to control customer's well pump operation. The power control module consists of a line-voltage power relay module and a low voltage wireless control module. The power relay module is mounted either inside an electrical sub panel or in its own dedicated electrical box and has five dry-contact relays which can be scheduled to turn electrical loads on or off. The wireless control module has a wireless antenna used to bridge communication between the wireless mesh network and the power relay module installed at the site, linking the power control module to a Site Manager web application.

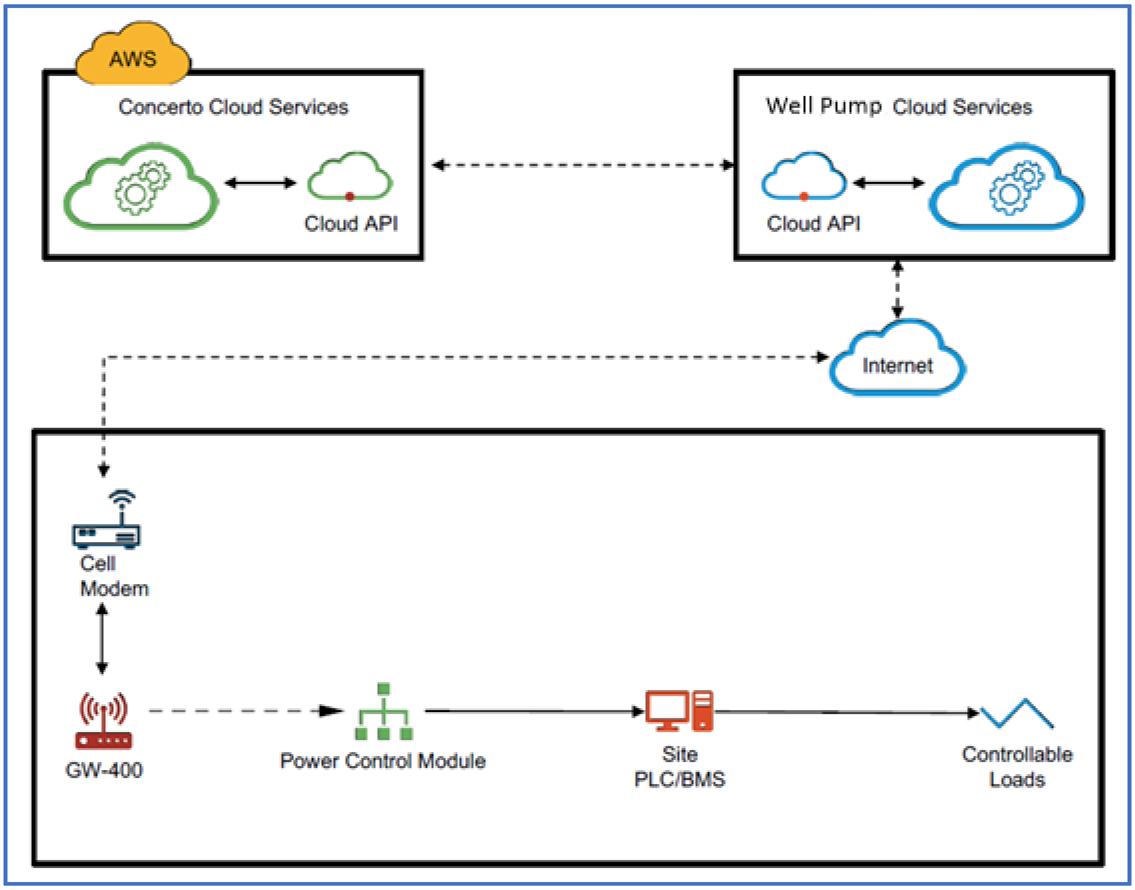


FIGURE 7. WELL PUMP CONTROLLER SYSTEM ARCHITECTURE (IMAGE FROM GENERAC GRID SERVICES)

The ground water lift pump fills a water storage tank and the recirculation pump circulates the water from the tank to the building. Hence, the storage tank can be filled before a DR event and the ground water lift pump can be turned off during the DR event to shed the electric load. If needed, an override switch on the pump controller could be used by the customer if they chose to no longer participate in the DR event. The well pump controller communicated with the Concerto platform using the customer's Wi-Fi. In the absence of customer Wi-Fi, a router was installed and used for communication.

THERMOSTATS

Smart thermostats were installed and connected via Wi-Fi to remotely control the air conditioning (AC) system through a phone app that provides several enhanced functions like smart recovery, fan dissipation, and a thermostat optimization platform to enhance the energy efficiency of residential HVAC systems with minimal user effort. The platform engages customers by prompting them to specify their preferred balance between comfort and savings.

For this study, the optimization platform was enabled and used to control the house temperature during DR events. When signaled, the thermostat lowered the cooling setpoint temperature by 4°F to precool the home for one hour before the DR event. At the start of DR event, the setpoint was increased 4°F from the original setpoint (or 8°F from the precool setpoint). Occupants were able to override the thermostat's setpoint at any time during the events and/or opt-out from the event.

All four thermostats installed at the sites were integrated into the Concerto Platform. Since the thermostat manufacturer only allows the dispatch of a group of devices, all four thermostats were aggregated into a Thermostat group asset type in Concerto.

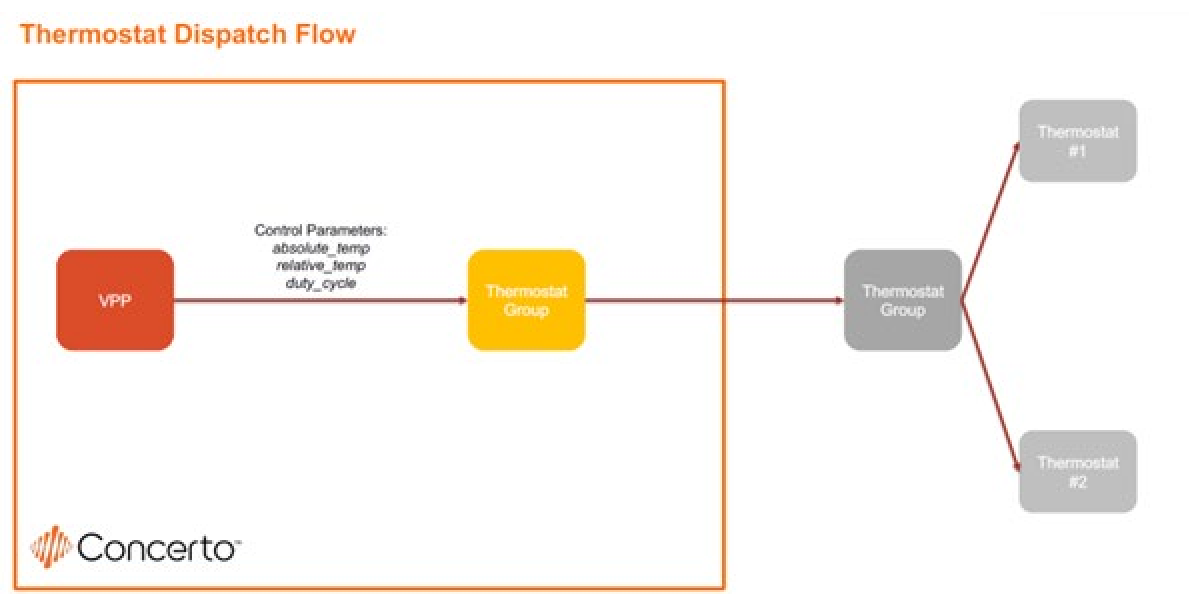


FIGURE 8. THERMOSTAT SYSTEM ARCHITECTURE (IMAGE FROM GENERAC GRID SERVICES)

WATER HEATER CONTROLLER SWITCH

A controller switch (an LTE communication device) was identified to manage the operation of residential hot water heaters. After the installation and activation of the switch, it is designed to connect automatically over a cellular network and be accessible for grid power management during DR events.

Unfortunately, the device was excluded from the study because the limited cellular coverage in Shelter Valley prevented the switch from connecting to the Concerto platform. Subsequent communication with the manufacturer revealed that the switch necessitates full LTE coverage for communication with the Concerto platform and does not function with home Wi-Fi.

AIR CONDITIONER SMART DEVICE

A smart device was identified to control split AC systems and window air conditioners. The device is compatible with more than 10,000 AC brands as long as the system has remote controlled thermostat. The device allows the customer to control AC from their smart phone and access features like; seven-day scheduling, geo-fencing, and also connect to smart home voice assistant. The device was not installed in the study as no participants expressed willingness to install it.

ASSESSMENT OBJECTIVES

The objective of this project was to test the real-world impacts of a VPP on SDG&E's grid and analyze its operational performance. The specific objectives are:

- Build out a VPP Project Team.
- Implement a standalone VPP providing a management solution for BTM resources.
- Recruit VPP participants and deploy the initial BTM resources in the field.
- Test the VPP with BTM resources in preparation for the DR season.
- Operate the VPP and send out DR signals based on test, simulated, or real DR events.
- Experiment with the VPP for other grid services such as varied start times and durations for DR events, and sustained battery discharge features.
- Analyze operational performance of the VPP and document results that can be used for future VPP endeavors.

To accomplish these objectives, AESC developed a test plan which is outlined in the following sections.

TECHNICAL APPROACH/TEST METHODOLOGY

SITE INFORMATION

The selected project sites are located in Shelter Valley, California in East San Diego County. Shelter Valley is a small and remote community with only one cellular tower in the area, making telecommunications difficult. The community is in an area that often has high wildfire risk, occasionally requiring power to be turned off during periods of high winds. This makes the VPP important for the community in the future, where resiliency is often tested by environmental conditions.

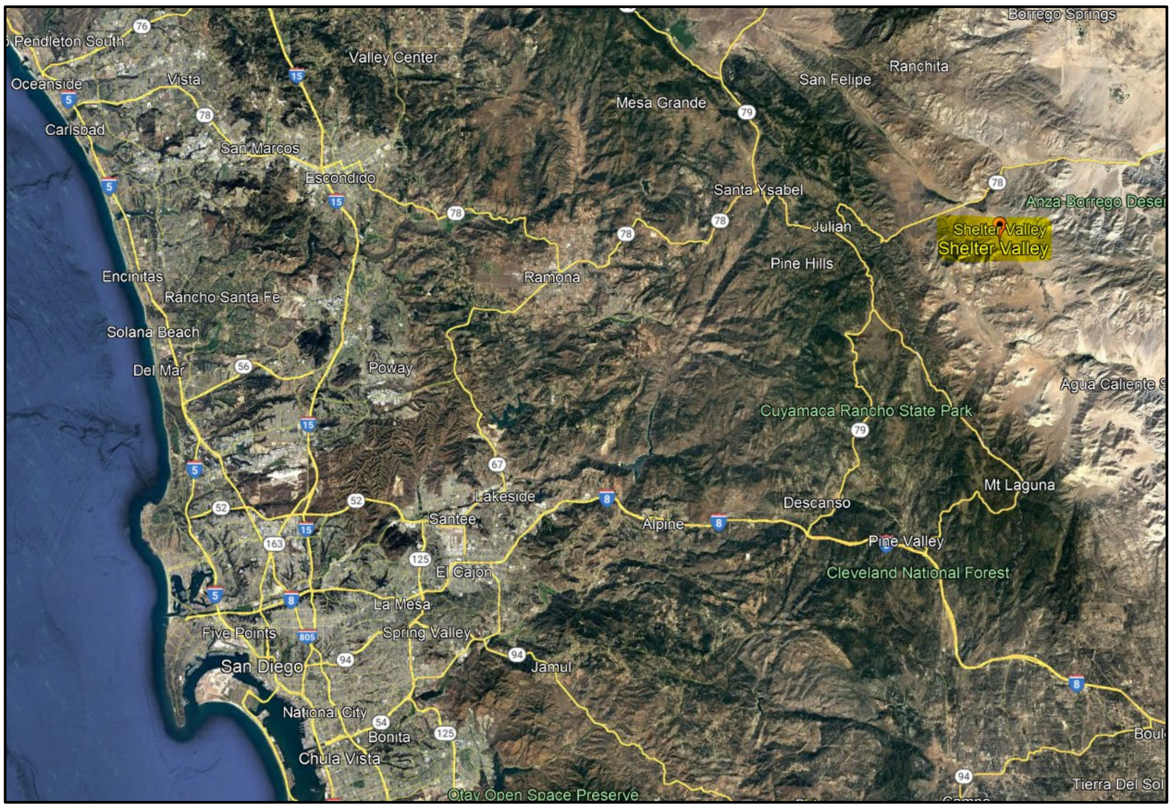


FIGURE 9. GOOGLE IMAGE OF SHELTER VALLEY COMMUNITY LOCATION

FIELD TESTING OF TECHNOLOGY

This project required residential customer participation to effectively test the operation of the VPP. Field testing of the technology was conducted at eight residential sites and a community facility in Shelter Valley to understand aggregated load reduction and net metering to the grid. A field study was chosen over laboratory testing because the technology performance needed to be evaluated in real-world conditions. The following section covers the participant acquisition, installation of the BTM resources, and testing procedures.

Customer Acquisition

In the Shelter Valley area, there are 212 SDG&E customers, primarily residential with one community facility and one fire station. SDG&E initially planned to recruit approximately 30 customers for this study. To accomplish this goal, AESC and SDG&E's marketing team implemented several recruitment strategies and started creating marketing materials which included a VPP project fact sheet, an informational VPP webpage, community event flyers, and email/letter content. AESC also created an enrollment webpage for customers to sign up for this project with an option to view in Spanish to be accessible for the Hispanic community. The community outreach and recruitment process started in March 2022 by hosting community events like coffee events, food drives, and board meeting presentations to promote the project and encourage residents to participate in this project. Approximately 20 customers participated in these community events and 16 participants agreed to move forward with the next steps.

To engage residents who did not participate in community events and increase response rates, AESC also initiated a postal mail campaign, urging all customers to sign up through AESC's enrollment webpage. Despite these efforts, a considerable number of customers remained unresponsive. In a final attempt to boost enrollment rates, SDG&E sent out a mass email to all customers in the community. Twelve customers signed up through the webpage as the result of postal mail and mass email communication. Direct contact via phone was also made with two Medical Baseline Allowance Program customers to explore the possibility of installing a BESS. Figure 10 shows the number of customers enrolled through different recruitment strategies. To view the different marketing material used during the recruitment process, refer to Appendix A.

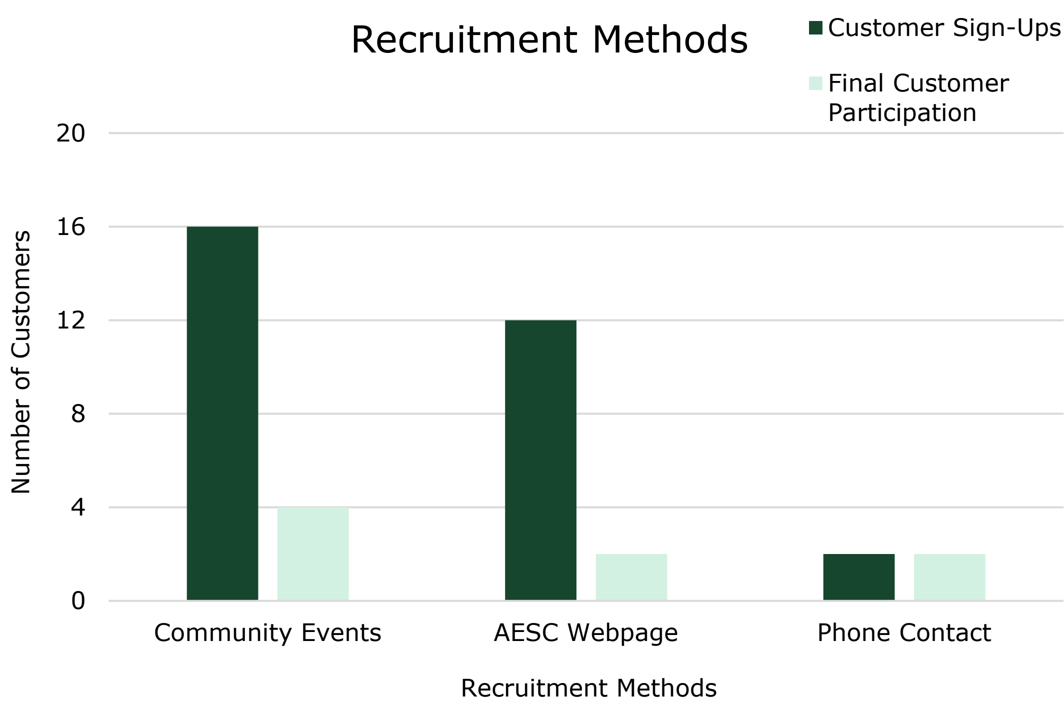


Figure 10. Number of Customers Enrolled

Certain criteria were established for the customers to be eligible to participate in the study. Participants must be an SDG&E customer located in Shelter Valley and meet at least one of the following requirements:

- Own a functioning central AC or heat pump system or a portable terminal window AC unit; and allow AESC to adjust temperature settings thru the study period, until the end of 2023.
- Have an electric water heater or well pump.
- Be willing to let AESC monitor their energy usage thru the study period, until the end of 2023.
- Battery energy storage system only for selecting existing solar PV customers; priority to Medical Baseline Allowance Program and Access and Functional Need (AFN) customers.

After the initial screening, AESC reviewed the interested participants' interval data to further filter acceptable candidates. Sites which were not occupied during the summer or were in the process of renovation were not allowed as potential candidates. The shortlisted interested customers were contacted and notified of the subsequent following steps that were expected of program participants.

- Allow an AESC engineer/contractor to visit their home and assess the property layout and equipment for eligibility.
- If selected, sign a field demonstration agreement (FDA) as required by SDG&E.
- Allow a project engineer and a certified electrical/mechanical contractor to install the necessary equipment and/or control devices.
- Allow the contractor to run a diagnostic test on their heating and cooling system for about 10 minutes to confirm everything is installed and working correctly.
- Receive a $50 gift card after equipment installation.
- Allow a follow-up site visit and/or answer follow-up questions after installation, if required.
- Be willing to participate in the VPP signaling events and let AESC monitor their energy usage thru the duration of the study.
- Complete a final survey and receive another $50 gift card.
- Determine whether to keep the equipment after the study or have their home restored to its original configuration.

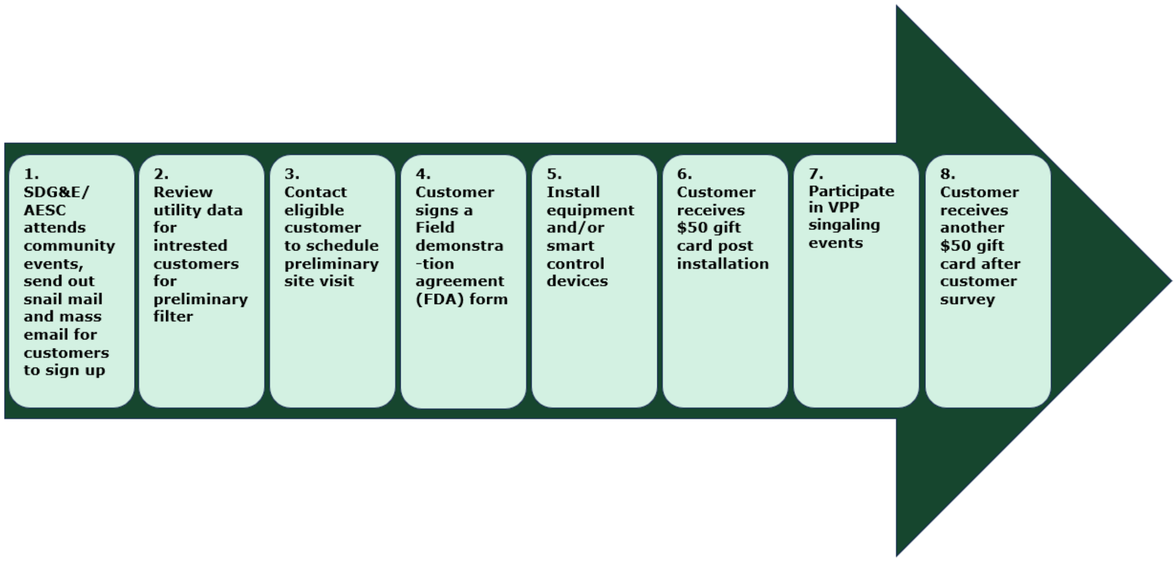


FIGURE 11. VPP PROJECT STEPS

BEHIND THE METER RESOURCE INSTALLATION

Once the residents were identified, the equipment and/or control devices were installed at the customer sites. All the control devices and battery storage systems were provided by SDG&E at no cost to the customers. An independent contractor was hired by SDG&E to install the batteries and control devices. The installation times varied for different components with thermostats and well pump controllers typically taking two to three hours while batteries required a couple of days. However, BESS installations required additional steps such as obtaining City permits, interconnection agreements, and acquiring permission to operate from SDG&E, making the overall process between three and four weeks. Once the thermostats and well pump controllers were installed by the contactor, AESC integrated them into the Generac Concerto platform. The batteries were integrated into Concerto by other project partners. For communication, the batteries and smart devices utilized customer Wi-Fi and in cases where customer Wi-Fi was not available, a router was provided to connect to the Concerto platform. Table 2 below shows different site, equipment and means of communication for each device.

Numerous challenges, including poor Wi-Fi signals and changes in customers' internet service providers, were identified during the testing period. Consequently, the communication mode for all batteries was eventually switched to cellular SIM cards towards the project's conclusion. At Site 8, a router was replaced to ensure a more reliable internet connection.

TABLE 2. PARTICIPATING EQUIPMENT AND MEANS OF COMMUNICATION

SITE ID	PARTICIPATING EQUIPMENT	MEANS OF COMMUNICATION
Site 1	Battery	Router/Cell Card
Site 2	Battery	Customer Wi-Fi/ Cell Card
	Well pump controller	Customer Wi-Fi
Site 3	Battery	Customer Wi-Fi/ Cell Card
	Thermostats (2)	Customer Wi-Fi
Site 4	Battery	Customer Wi-Fi/ Cell Card
Site 5	Battery	Customer Wi-Fi/ Cell Card
Site 6_Community Facility	Battery (2)	Cell Card
	Well pump controller	Customer Wi-Fi
Site 7	Well pump controller	Customer Wi-Fi
	Thermostat	Customer Wi-Fi
Site 8	Thermostat	Router
	Well pump controller	Router
Site 9	Well pump controller	Customer Wi-Fi

TEST PLAN

A test plan was developed to help achieve the assessment objectives. The plan included field testing of the technologies at eight residential sites and a community facility in Shelter Valley, CA. The test plan is outlined in the following subsections.

SCENARIOS

A test plan was developed for the three different scenarios described below and tabulated in Table 3. However, only scenario 2 (peak load reduction) was tested in this project.

1. Normal Operations Optimization – Shift normal grid electricity consumption to reduce overall electricity costs and GHG emissions.
2. Peak Load Reduction – When a DR event occurs, immediately shed the net metered load, and reduce the peak demand usage.
3. Resilient Operations – During an emergency event, shift and shed the critical loads to operate for an extended period during a power outage.

TABLE 3. SCENARIO LIST

SCENARIO NAME	#	USE CASE NAME	LOAD IMPACT	GOAL	TRIGGER	TEST TYPE
Normal Operations Optimization	1.1	Load Flex Costs	Shift	Minimize Costs	Normal Operations	Actual
	1.2	Load Flex Emissions		Minimize GHG		
Peak Load Reduction	2.1	DR Event	Shed	Reduce Peak Energy	Planned Event	Actual/ Simulated
Resilient Operations	3.1	Wind Event Warning	Shift/ Shed	Resiliency	Unplanned Event	Actual/ Simulated

USE CASES

1. Normal Operations Optimization (Shift)
   a. Load Flex Costs – This use case focuses on shifting the usage pattern of household equipment from peak periods to non-peak periods to reduce overall electricity costs. Examples included:
      i. Operate household equipment such as dishwashers and washing machines, before 4 p.m. or after 9 p.m. (outside of SDG&E's most expensive peak demand hours).
      ii. Charge the battery (first and then export to the grid) during periods of solar generation and use this stored energy from the battery during peak hours when the electricity price is highest.
      iii. Pre-cool the home before 4 p.m. and raise the temperature setpoint by 4° F from 4 p.m. to 9 p.m.
      iv. Reduce hot water usage during peak periods.
      v. Lock out the well pump and only operate the booster pump during peak periods.

   b. Load Flex Emissions – The main goal of this use case is to minimize GHG emissions. Given that the demand peak is aligned with the highest marginal emission rates, the following was recommended:
      i. Charge the battery during periods of solar generation and use this stored energy during peak hours or based on a GHG emission signal.
      ii. Pre-cool the home before peak hours and raise the temperature setpoint by 4°F during peak periods.
      iii. Reduce hot water usage during peak periods.
      iv. Lockout the well pump and only operate the booster pump during peak periods.

2. Peak Load Reduction (Shed)
   a. DR events – This use case aims to avoid energy use during DR events. Customers were notified the day before the event, typically 24 hours ahead. Actions include:
      i. Solar power prioritizes charging the battery first and the charge is retained until DR event (excess solar generation is exported to the grid). Discharge the battery to the grid during the DR event.

ii. Pre-cool the building before the event and raise the cooling temperature setpoint by 4°F during the event.
iii. Fill the water storage tank prior to the event and turn the well lift pump off during the event.
iv. Minimize or eliminate hot water usage during the event.

3. Resilient Operations (Shift/Shed)

   a. Wind Event Warning – This use case was intended to create a low power operating mode to test the community's ability to operate for an extended period in island mode during a power outage. Customers would be notified a day ahead of the event day. Customers would:

      a. Charge the battery (if available) from solar ahead of the event and discharge the battery during the event.

      b. Raise the cooling temperature setpoint to 80-82°F during the event.

      c. Reduce the temperature setpoint of the water heater or eliminate the usage of hot water during the event.

      d. Fill the water storage tank prior to the event and turn the well lift pump off during the event.

Tarriff Schedule

The different tariff schedules at the Shelter Valley sites are TOU-DR1NME, TOU-DR1NM, TOU-DR1, TOU-ANM, DR-SESNM and DR-NM.

Site Weather and Insolation

Shelter Valley is in Climate Zone 15 and is characterized by extremely hot and dry summers and moderately cold winters. The average summer temperature in Climate Zone 15 is much higher than any other zone in California. The humidity is below the comfort range much of the year, which results in a large diurnal temperature range and very cool nights. The winters are short and mild and can bring short frosts.

Participating Equipment

Depending on the test site, a variety of equipment was chosen to include in the VPP. The list of sites and their participating equipment is tabulated in Table 2.

Depending on the eligibility of the customers described in the Customer Acquisition section, smart thermostats, smart load controllers, and BESS were installed at eight residential sites and a community facility. Table 4 lists the equipment installed in Shelter Valley as a part of this project.

TABLE 4. EQUIPMENT LIST

EQUIPMENT TYPE	NUMBER OF EQUIPMENT
Battery Storage System	7
Battery Inverter	7
Smart Load Controller	5
Smart Thermostat	4

For selecting sites for BESS installation, customers with existing solar PV were shortlisted and priority was given to Medical Baseline Allowance Program and Access and functional needs (AFN) customers. Out of the five residential sites selected, two customers were enrolled in Medical Baseline and the other three customers were selected based on the size of their solar system and usage profile throughout the year. The community facility was selected since it serves as a community support service location and cool zone during extreme heat, and hosts several events like food drives, community coffee/potluck events and church services.

The well pump controllers were installed at four residential sites and the community facility. The eligibility criteria for the well pump controller installation were that the site should have a ground water lift pump, a recirculation pump, and a water storage tank.

To control the central HVAC systems, smart thermostats were installed at three residential customer sites with one site receiving two thermostats.

SCHEDULE

The VPP testing started in December 2022 after initial equipment was installed at the first few sites. The first five test events were scheduled from December 2022 to April 2023 with an additional 20 simulated or actual events from May 2023 to November 2023. Most of these events were two or four hours long and the start times varied for each event. At times, SDG&E's AC Saver program's DR events were leveraged for VPP signaling to reduce the total number of SDGE's events for the customer in a week. Table 5 shows the summary of all the scheduled events. The test schedule leveraged a combination of real-world DR events called by SDG&E's Demand Response Programs[3] and simulated events. For all these events, customers were notified a day before the event, typically 24 hours ahead via email and/or text using the Concerto Notification System (CNS).

[3] SDG&E's AC Saver Day-Ahead Residential Program and CBP DA 1 – 9 p.m. Program

TABLE 5. SUMMARY OF EVENTS

EVENT NO.	DATE	EVENT START	EVENT DURATION (HOURS)	EVENT TYPE	AVERAGE EVENT TEMPERATURE (°F)	MAX TEMPERATURE (°F)[4]
1	12/8/2022	2:00 PM	2	Test	64.1	64.4
2	1/26/2023	3:00 PM	2	Test	64.7	66.2
3	2/28/2023	4:00 PM	2	Test	56.9	62.6
4	3/23/2023	1:00 PM	2	Test	65.0	66.2
5	4/27/2023	6:00 PM	2	Test	90.8	98.6
6	5/18/2023	5:00 PM	2	Simulated	97.1	98.6
7	5/31/2023	6:00 PM	2	Simulated	69.2	80.6
8	6/13/2023	7:00 PM	2	Simulated	83.9	95.0
9	6/29/2023	4:00 PM	2	Simulated	102.8	104.0
10	7/13/2023	5:00 PM	2	Simulated	105.8	111.2
11	7/20/2023	7:00 PM	2	Actual	105.2	116.6
12	7/25/2023	7:00 PM	2	Actual	104.6	114.8
13	7/26/2023	7:00 PM	2	Actual	103.4	114.8
14	7/27/2023	7:00 PM	2	Actual	106.7	113.0
15	8/10/2023	5:00 PM	2	Simulated	94.7	110.4
16	8/15/2023	5:00 PM	4	Actual	102.8	111.2
17	8/16/2023	5:00 PM	4	Actual	103.1	109.4
18	8/29/2023	6:00 PM	2	Actual	107.3	114.8
19	8/30/2023	6:00 PM	2	Actual	104.6	109.4
20	9/12/2023	6:00 PM	2	Simulated	89.9	102.2
21	9/14/2023	5:00 PM	2	Simulated	96.8	100.4
22	9/26/2023	6:00 PM	2	Actual	89.3	100.4
23	10/5/2023	6:00 PM	2	Actual	84.8	96.8
24	10/17/2023	7:00 PM	2	Simulated	77.3	98.6
25	11/1/2023	6:00 PM	2	Simulated	64.7	82.4

CUSTOMER NOTIFICATION

For all these events, customers were notified using the Concerto Notification System (CNS). The CNS configures notifications as per participants' preference (email, phone, and/or text). The platform sent text messages and email notifications to participants before each DR event, as well as a secondary reminder notification a few hours before each event, and when the event started and ended. The Concerto

[4] Data from Mesowest website - Borrego Valley Weather Station

platform and the CNS are linked by the common Remote ID of the sites. Figure 12 below shows Concerto and CNS Topology.

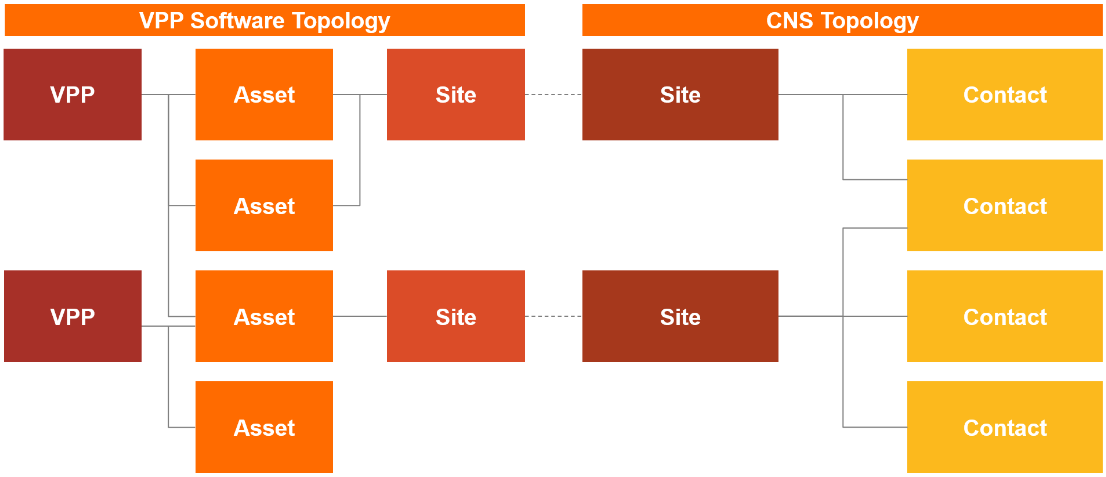


FIGURE 12. CONCERTO AND CNS TOPOLOGY (IMAGE FROM GENERAC GRID SERVICES)

SIGNALING PLATFORM

The technology was tested using Generac's Concerto platform for signaling DR events (https://www.generacgs.com/concerto/). When DR events were executed, the platform provided information regarding any opt outs, as well as the timeseries power data for each event. See Figure 13 for a sample view of the Concerto platform.

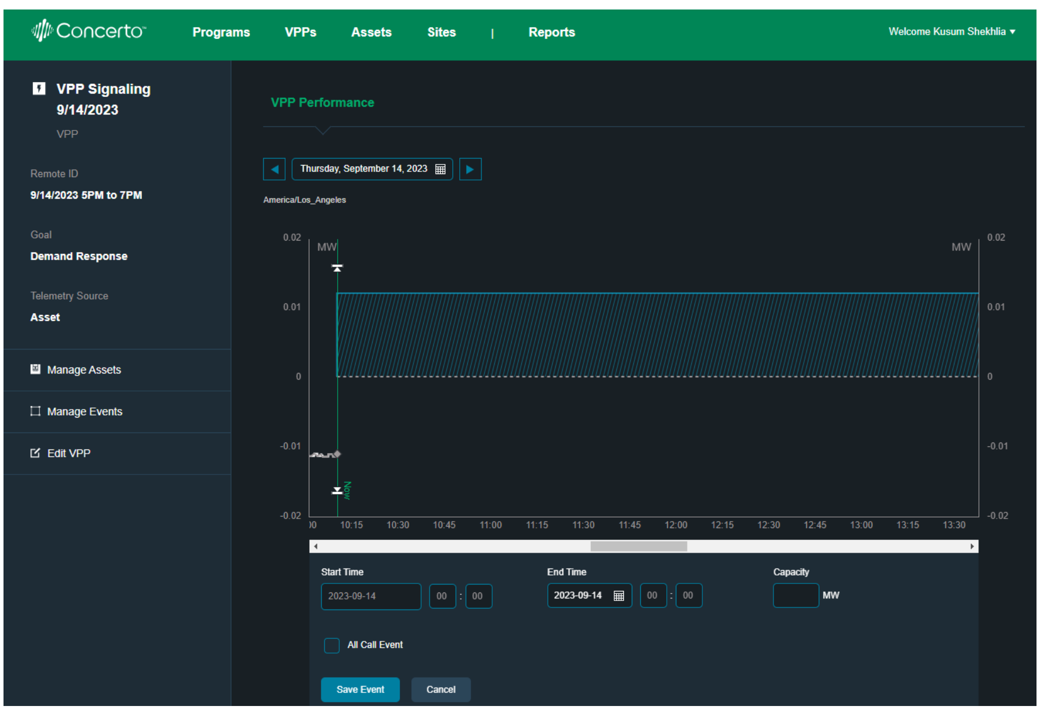


FIGURE 13. CONCERTO PLATFORM

Test Processes

All devices were signaled through the Concerto platform. A new VPP was created in Concerto and all the batteries, well pump controllers, and the Shelter Valley group of four thermostats were added as assets to the VPP. On an event day, an event was scheduled in Concerto for the event's time period. During the event, all the batteries exported power to the grid until they reached their minimum state of charge, the well lift pumps were turned off, and the thermostat temperature setpoints were offset by 4°F. After the event, all the devices were restored to their original modes; the batteries went back to Self Supply Mode, the well pumps were turned on, and thermostat setpoints went back to original values.

Instrumentation Plan

Following the IPMVP Option C approach, whole site energy usage was used to determine demand impact. Utility meter data, solar production data, battery charge and discharge data were collected throughout the baseline and DR event day periods.

To understand the well pump baseline behavior and power usage, current transducers (CTs) were attached to the pump motors to monitor their current draw. With the nameplate voltage rating of 230V, the power and energy usage were calculated. Thermostat reports and battery power and energy data were downloaded from the thermostat portal and Concerto, respectively. The community facility solar production data was available from Concerto. However, to monitor the solar production at all five residential sites, energy meters and CTs were installed and integrated into Concerto. The data was stored in the cloud and was downloaded periodically for analysis. The hourly ambient air temperature from the nearest weather station, located at the nearby Borrego Valley Airport weather station, was also used for analysis. Table 6 shows logging instrumentation details.

Table 6. Logging Instrumentation Details

Data Points	Measurement	Instrument	Logging Interval	Provided by
Utility Metered Data	kWh	N/A	15 Minutes	SDG&E
Batter Power / Energy	kW and kWh	N/A	5 Minutes	Concerto
Community Facility Solar Power	kW	N/A	5 Minutes	Concerto
Residential Solar Power	kWh	Energy Meter/ CTs	15 Minutes	Concerto
Well Pump Current	Amps	Data Logger/ CTs	5 Minutes	AESC
Space Temperature and Humidity	°F	N/A	5 Minutes	Thermostat
Space Setpoints	°F	N/A	5 Minutes	Thermostat
Outdoor Air Temperature	°F	Nearest weather station[5]	Hourly average	N/A

[5] Data was obtained from Mesowest website for Borrego Valley Weather Station

DATA ANALYSIS AND RESULTS

BASELINE DEVELOPMENT

To develop an accurate and robust baseline and account for day-to-day variances, the baseline was developed for each DR event and customer type. Advanced metering infrastructure data was used to collect information on the net meter for each VPP customer. The following methods were used to develop the baseline.

RESIDENTIAL

The baseline for residential customers was developed by aggregating and averaging the net meter readings for the five highest energy usage days within the 10 eligible weekdays immediately preceding the DR event. Other event days, CAISO holidays, award days, and outage days were not considered eligible and excluded from the 10-day period. The averaged baseline was the "unadjusted baseline". To determine the adjusted baseline, a same-day adjustment was applied to the unadjusted baseline. The adjustment was based on the adjustment ratio calculated during adjustment hours (See Equation 1). For residential customers, adjustment hours were defined as two pre-event hours and two post-event hours, each with a two-hour buffer from the event. The buffer period is to avoid adjustments to the baseline based on variances in behavior before and after the DR events. For example, if an event is called from 5 p.m. to 7 p.m., the pre-event and post-event adjustment hours will be 1 p.m. to 3 p.m. and 9 p.m. to 11 p.m., respectively. Post-event hours that spill into the next day are excluded from baseline adjustment windows. The inclusion of a buffer period mitigates the risk of contamination by enabling pre-cooling and snapback to take place in the hours immediately before and after the event. This ensures that these hours are not utilized to adjust the baseline. An example of the defined time periods in relation to a DR event can be seen in Figure 16. If, during the adjustment hours, the baseline is less than the actual load, it is adjusted upward. Similarly, if the baseline is higher than the actual usage, it is adjusted downward. To adjust the load, the unadjusted baseline is multiplied by the adjustment ratio, which is calculated as:

EQUATION 1. ADJUSTMENT RATIO

$$\textit{Adjustment Ratio} = \frac{\textit{Total kWh during Adjustment Hours}}{\textit{Unadjusted baseline kWh during Adjustment Hours}}$$

The ratio was capped at 1.4 (up) and 1/1.4 (down) and was applied to the unadjusted baseline resulting in the adjusted baseline used to calculate the net impact during the DR event. An example of the adjusted and unadjusted baseline and the highest five in 10 weekday constituents can be seen in Figure 14.

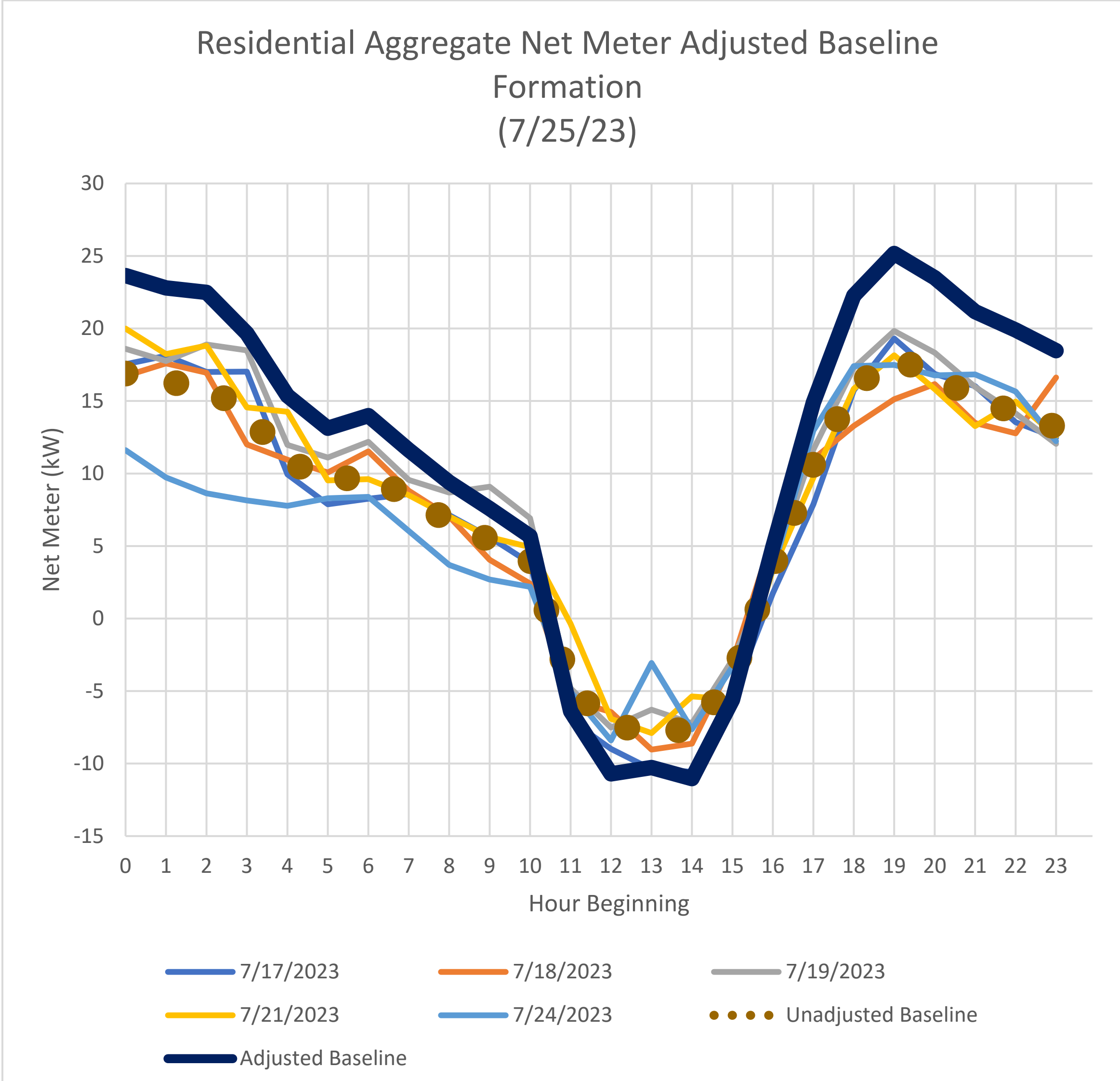


FIGURE 14. RESIDENTIAL AGGREGATE NET METER BASELINE FORMATION (07/25/2023)

NON-RESIDENTIAL

For the non-residential customer (the community facility), a different baseline was formed by averaging the highest 10 days in the 10 weekdays prior to the event. As with Residential, other event days, CAISO holidays, award days, and outage days were excluded. A day of adjustment was applied to this unadjusted baseline using the adjustment ratio calculated during the adjustment hours. For the non-residential sector, adjustment hours were defined as three hours prior to the event period with a one-hour buffer. The buffer period is to avoid adjustments to the baseline based on variances in behavior before the DR events. An example of the defined time periods in relation to a DR event can be seen in Figure 17. The adjustment ratio was calculated according to Equation 1. However, the cap for non-residential customers was set at 1.2 (up) and 0.8 (down). An example of the unadjusted baseline and the 10 weekday constituents can be seen in Figure 15.

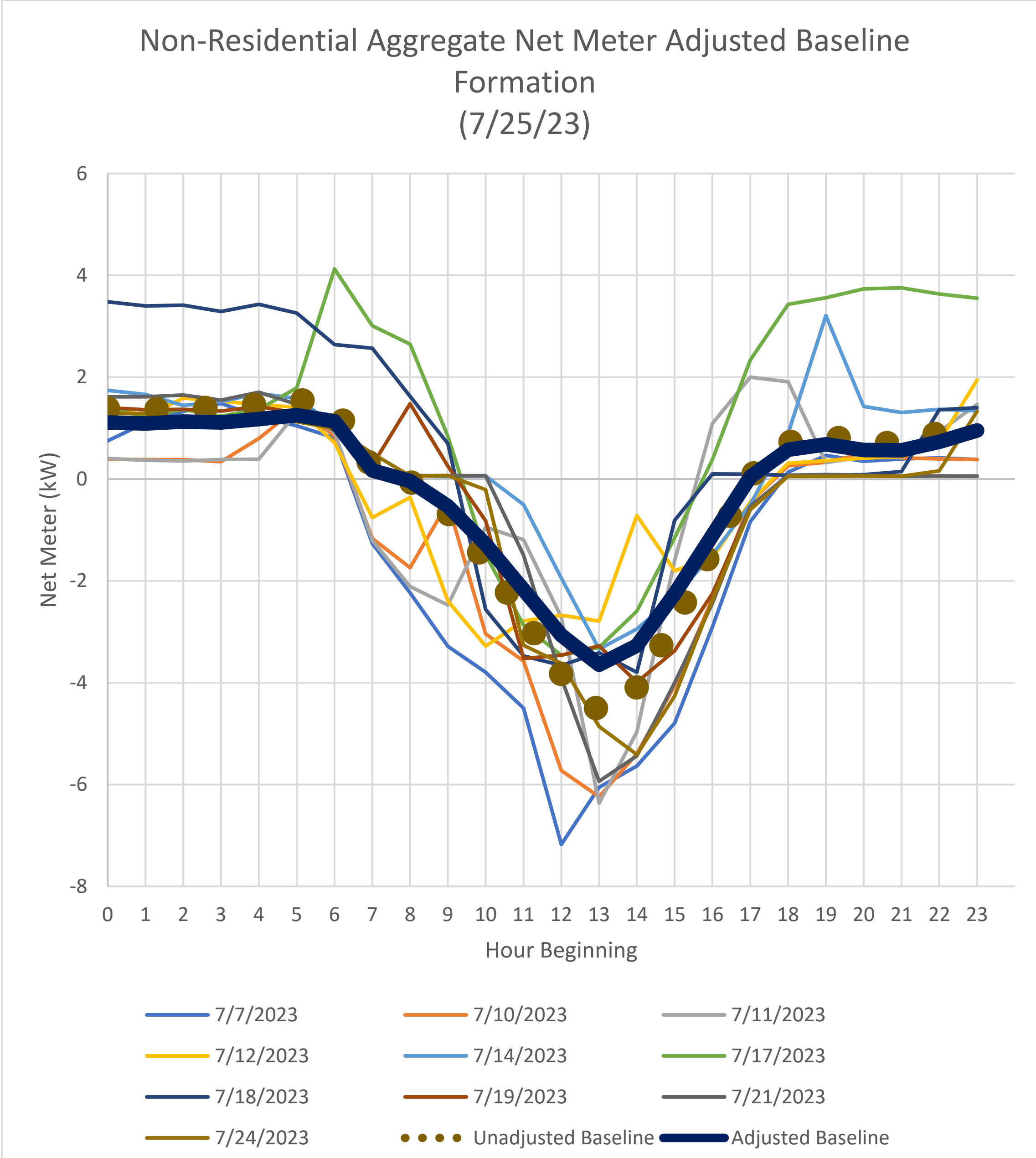


FIGURE 15. COMMUNITY FACILITY NET METER BASELINE FORMATION (07/25/2023)

NET METERING IMPACTS

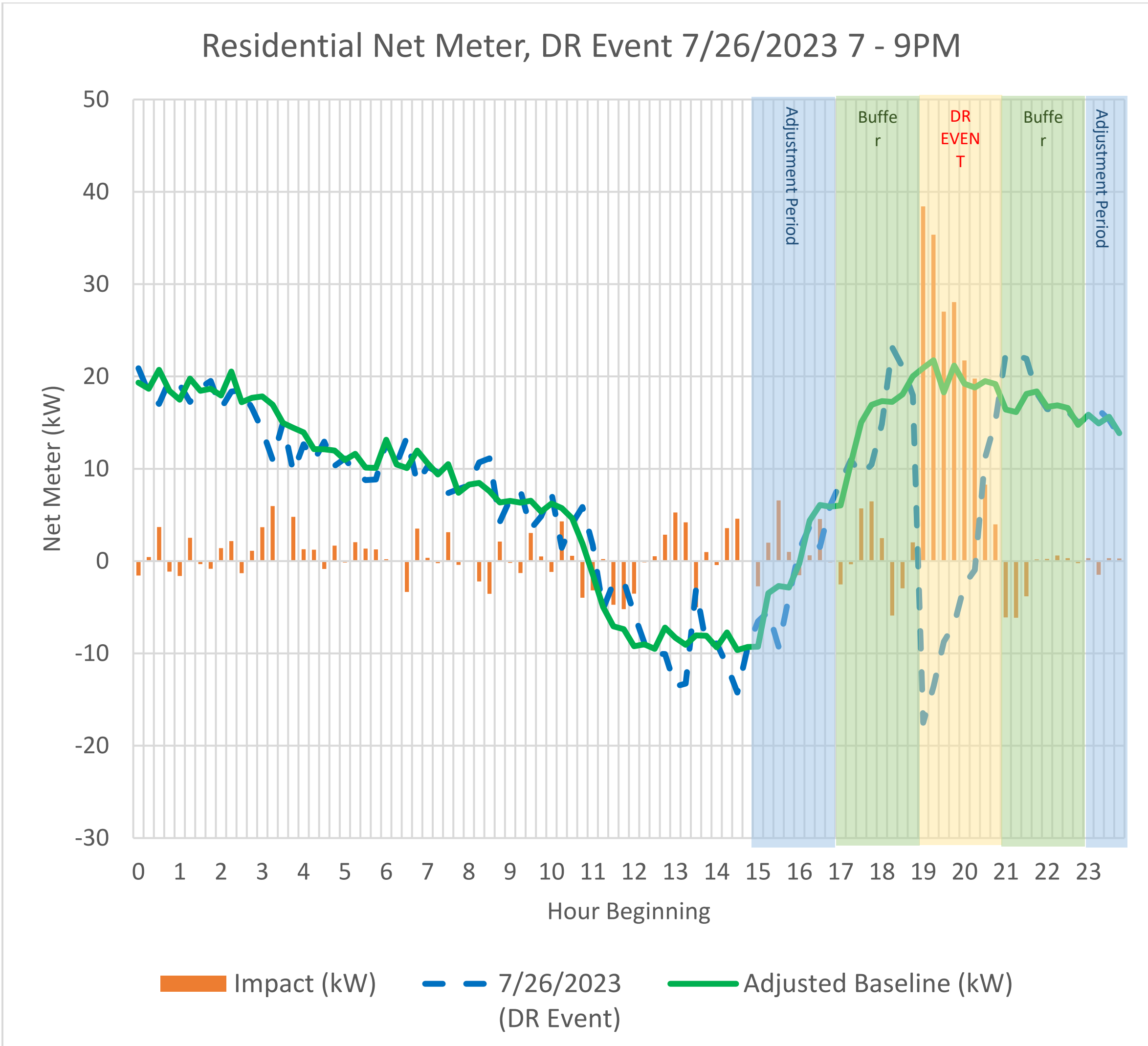
To calculate the average demand impact of each DR event, the baseline net metered demand calculated above was applied to the Equation 2.

EQUATION 2. IMPACT CALCULATION

$$\begin{aligned}&\mathit{Average\ Demand\ Impact\ (kW)}\\&\qquad= \mathit{Average\ Adjusted\ Baseline\ Net\ Metered\ Demand\ (kW)}\\&\qquad- \mathit{Average\ Event\ Day\ Net\ Metered\ Demand\ (kW)}\end{aligned}$$

Residential VPP Impact

Figure 16 illustrates an example of net metered aggregated residential loads on a single DR event day. On this day, the adjustment ratio of 1.14 was applied and a significant average demand reduction of 21.2 kW was seen during the event. Due to battery discharge, the VPP was able to cover the residential building demand with a net export to the grid during most of the event duration.



*Impact defined by Equation 2

Figure 16. Aggregated Residential Customers' Net Meter During DR event on 7/26/2023, 7 – 9 PM

Due to the nature of the adjustment ratio calculations described in Equation 1 and the timing of the DR events, there were cases where the 'Total kWh during Adjustment Hours' were negative or close to zero due to the high amount of solar production. This led to a very high or low baseline adjustment ratio as shown in the results in Table 7 and Table 8. The duration of the DR event also had an impact on calculations, as the demand reduction was averaged over a longer period of time, lowering the average impact calculated. Therefore, the four-hour DR events had significantly lower impacts calculated compared to the two-hour DR events.

Out of all the events shown in Table 5, this project analyzed the demand impact on DR events during the DR season (6/13/2023 – 10/05/2023). The results are shown for the residential customers in Table 7. The maximum aggregated residential demand impact was calculated to be 35.4 kW during a two-hour DR event on 8/10/2023. The minimum aggregated residential demand impact was 6.8 kW on 8/16/2023. This can be attributed to the occurrence of a thunderstorm on a hot cloudy day, impacting both solar production and battery charging. The average impact across all two-hour DR events for the residential sector was 22.2 kW with an average baseline load of 13.5 kW, while the average impact across all four-hour DR events was 8.0 kW with an average baseline load of 7.8 kW.

TABLE 7. CALCULATED AGGREGATED RESIDENTIAL CUSTOMER IMPACTS DURING DR EVENTS

Event Start	Event Duration (Hours)	Calculated Residential Impact (kW)	Calculated Baseline Adjustment Ratio	Applied Baseline Adjustment Ratio
6/13/2023 7:00 PM	2	15.7	1.1	1.1
6/29/2023 4:00 PM	2	17.3	0.3	0.7
7/13/2023 5:00 PM	2	32.0	22.7	1.4
7/20/2023 7:00 PM	2	24.7	1.4	1.4
7/25/2023 7:00 PM	2	27.7	1.5	1.4
7/26/2023 7:00 PM	2	19.5	0.9	0.9
7/27/2023 7:00 PM	2	26.0	1.6	1.4
8/10/2023 5:00 PM	2	35.4	-2.1	0.7
8/15/2023 5:00 PM	4	9.2	-0.5	0.7
8/16/2023 5:00 PM	4	6.8	-0.8	0.7
8/29/2023 6:00 PM	2	19.4	15.8	1.4
8/30/2023 6:00 PM	2	20.8	21.2	1.4
9/12/2023 6:00 PM	2	19.8	2.9	1.4
9/14/2023 5:00 PM	2	20.6	0.9	0.9
9/26/2023 6:00 PM	2	15.0	2.8	1.4
10/5/2023 6:00 PM	2	16.5	14.1	1.4

NON-RESIDENTIAL VPP IMPACT

In Figure 17, the net metered demand of the community facility using the adjusted net meter baseline is shown compared to the net meter during a DR event. The applied adjustment ratio on this day was calculated as 1.2 and a significant average demand reduction of 10.7 kW was observed during the event.

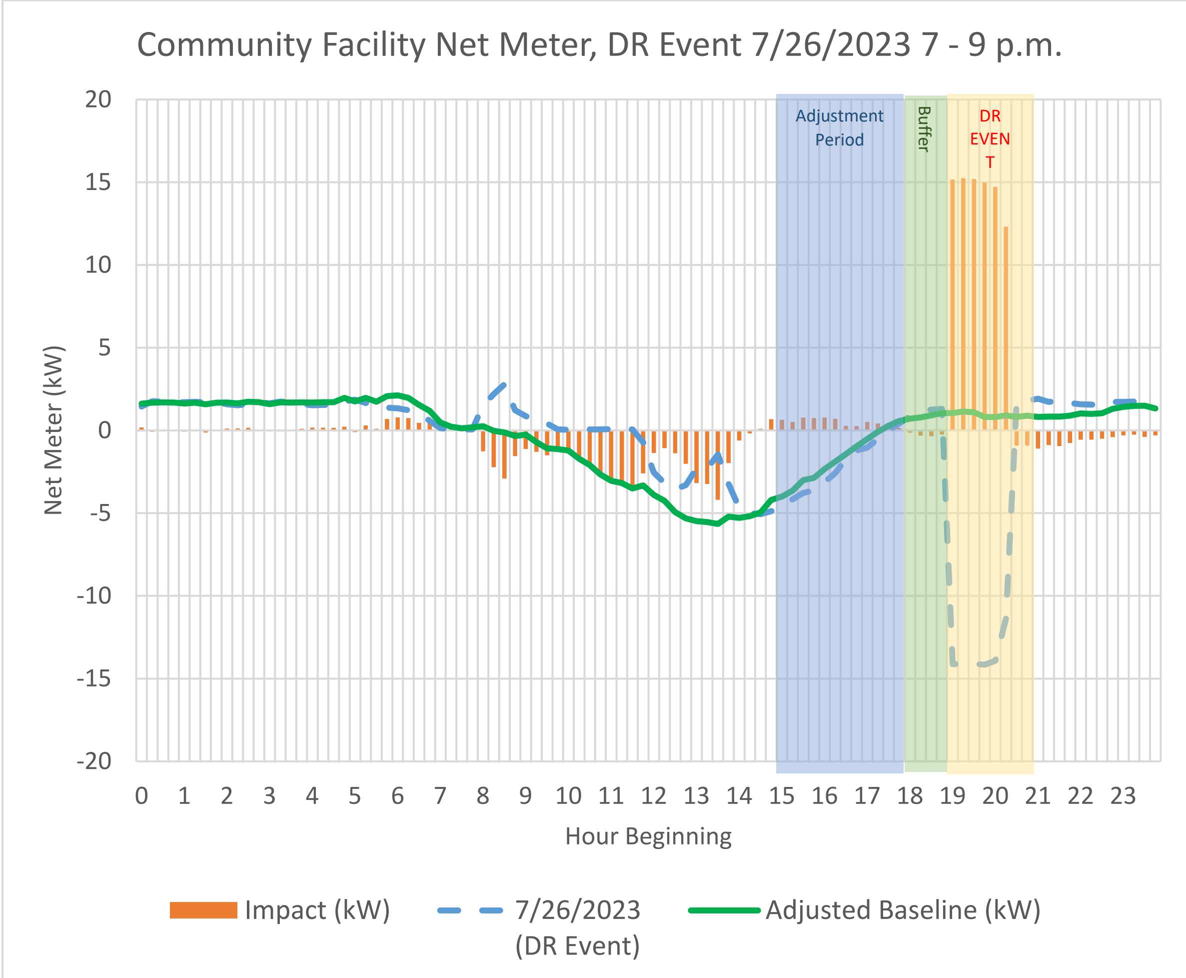


FIGURE 17. NON-RESIDENTIAL (COMMUNITY FACILITY) NET METER DURING DR EVENT ON 7/26/2023, 7 – 9 P.M.

The non-residential impacts recorded at the community facility during DR events are shown in Table 8. The maximum impact was calculated to be 10.7 kW during a two-hour DR event on 7/26/2023. The minimum non-residential impact was 0.26 kW on 9/26/2023. The low impact is attributed to the fact that neither of the two batteries installed at the site were deployed during the event, due to inverter issues associated with both batteries. The average non-residential impact across all two-hour DR events was 6.8 kW with an average baseline load of 0.4 kW, while the average impact across all four-hour DR events was 2.1 kW with an average baseline load of 0.6 kW.

TABLE 8. CALCULATED NON-RESIDENTIAL IMPACTS DURING DR EVENTS

EVENT START	EVENT DURATION (HOURS)	CALCULATED NON-RESIDENTIAL IMPACT (KW)	CALCULATED BASELINE ADJUSTMENT RATIO	APPLIED BASELINE ADJUSTMENT RATIO
6/13/2023 7:00 p.m.	2	4.4	0.5	0.8
6/29/2023 4:00 p.m.	2	1.1	0.9	0.9
7/13/2023 5:00 p.m.	2	7.3	0.6	0.8
7/20/2023 7:00 p.m.	2	10.3	-1.9	0.8
7/25/2023 7:00 p.m.	2	10.0	-1.8	0.8
7/26/2023 7:00 p.m.	2	10.7	1.6	1.2
7/27/2023 7:00 p.m.	2	10.4	-1.6	0.8
8/10/2023 5:00 p.m.	2	6.5	1.2	1.2
8/15/2023 5:00 p.m.	4	3.9	0.0	0.8
8/16/2023 5:00 p.m.	4	0.3	0.3	0.8
8/29/2023 6:00 p.m.	2	5.7	1.4	1.2
8/30/2023 6:00 p.m.	2	10.1	0.7	0.8
9/12/2023 6:00 p.m.	2	9.4	1.5	1.2
9/14/2023 5:00 p.m.	2	4.0	0.9	0.9
9/26/2023 6:00 p.m.	2	0.3	2.8	1.2
10/5/2023 6:00 p.m.	2	5.1	14.1	1.2

COMBINED VPP IMPACT

Calculated impacts of both non-residential and residential sectors of the VPP are combined in Table 9 and Figure 18. There was an average of 29.0 kW in demand impact across all two-hour DR events, and 10.1 kW in combined demand impact for the four-hour DR events. The maximum combined demand impact was 41.9 kW on 8/10/2023 and the minimum combined demand savings was 7.1 kW on 8/16/2023.

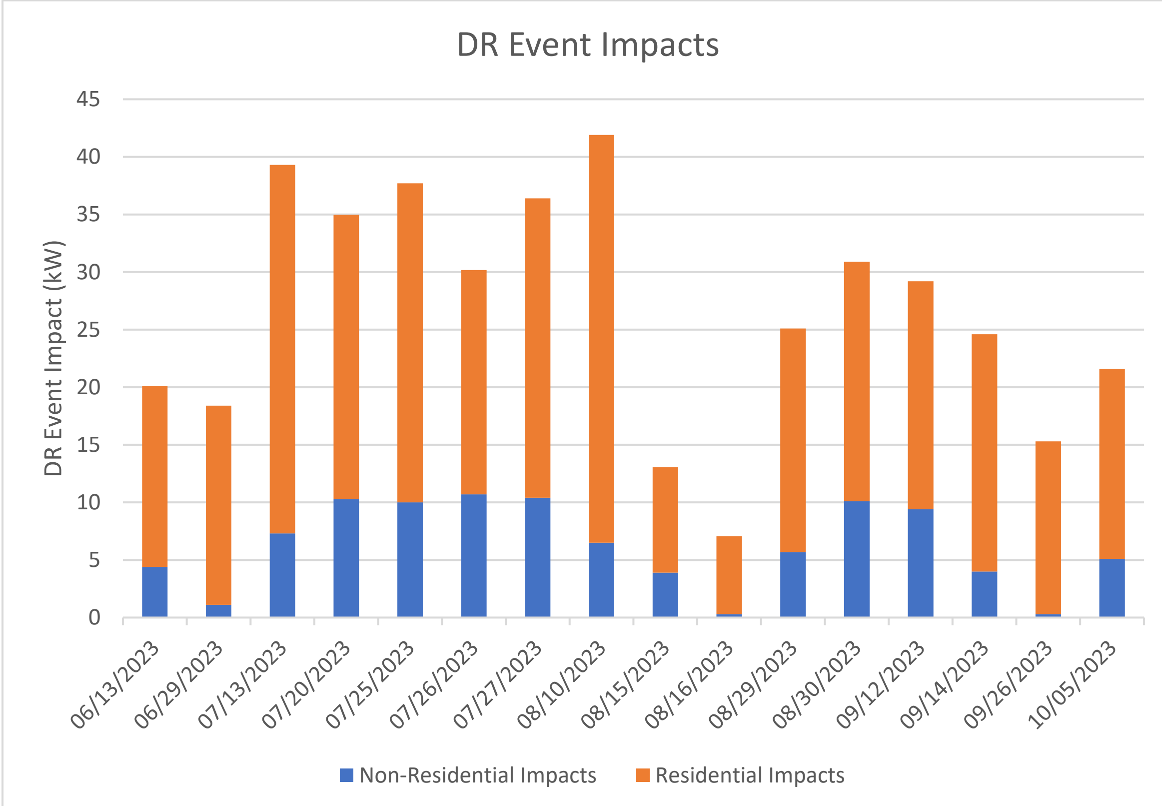


FIGURE 18. DR EVENT IMPACTS

Overall, there was a large variance in results. As illustrated in Figure 18, the two four-hour events on 8/15/2023 and 8/16/2023 had significantly lower average DR event impacts due to the demand reduction being averaged over an increased duration. Connectivity errors for equipment described in the sections below also contributed to variances in DR event performance.

Table 9 shows the average baseline loads of the VPP. The data shows that there is little to no correlation between the baseline load and the amount of impact the VPP has as visualized in Figure 19. Across all two-hour events, the VPP had an average impact of 29 kW with an average combined baseline load of 13.9 kW. The four-hour events had an average impact of 17.5 kW with an average baseline load of 15.9 kW for the entire VPP.

Table 9. Combined Non-residential and Residential Baselines and Impacts

Event Start	Average Non-residential Baseline Load (kW)	Average Residential Baseline Load (kW)	Combined Average Baseline Load (kW)	Combined Average Non-residential + Residential Impacts (kW)
6/13/2023 19:00	0.3	7.6	7.9	20.1
6/29/2023 16:00	-0.6	-5.1	-5.6	18.4
7/13/2023 17:00	0.3	15.8	16.0	39.3
7/20/2023 19:00	0.7	21.9	22.6	35.0
7/25/2023 19:00	0.6	24.3	25.0	37.7
7/26/2023 19:00	0.9	16.5	17.4	30.2
7/27/2023 19:00	0.6	24.3	25.0	36.4
8/10/2023 17:00	0.3	8.3	8.7	41.9
8/15/2023 17:00	0.6	7.8	8.4	13.1
8/16/2023 17:00	0.6	7.8	8.4	7.1
8/29/2023 18:00	0.3	15.5	15.8	25.1
8/30/2023 18:00	0.3	15.5	15.8	30.9
9/12/2023 18:00	0.2	15.4	15.6	29.2
9/14/2023 17:00	0.1	9.5	9.6	24.6
9/26/2023 18:00	0.7	10.2	10.9	15.3
10/5/2023 18:00	0.6	9.0	9.6	21.6

*Negative baseline values are due to a net export of power to the grid during that time.

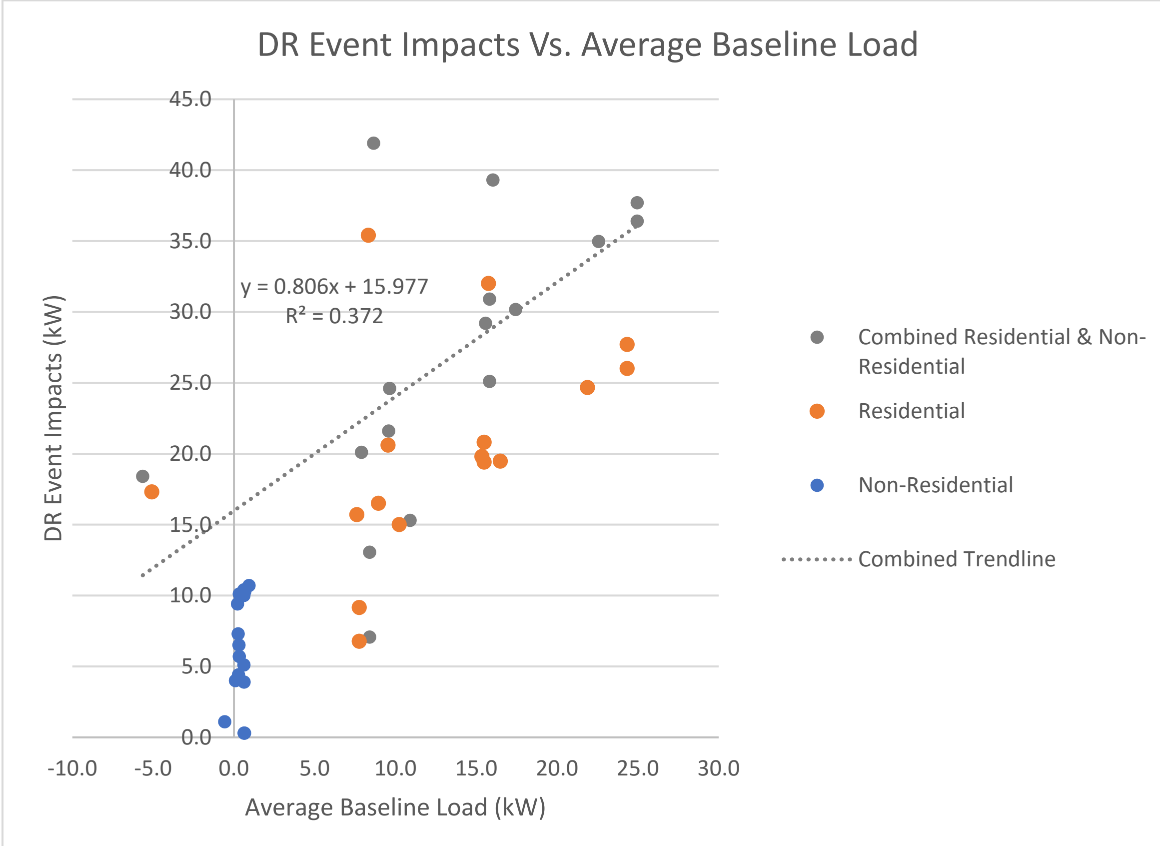


FIGURE 19. DR EVENT IMPACTS VS. AVERAGE BASELINE LOADS

When comparing the impacts to daily maximum outdoor temperatures, there was a limited correlation between the data shown in Figure 20. Since DR events were only analyzed during DR season (6/13/2023 – 10/05/2023) when weather is usually warmer, there is a limited amount of temperature data available to conclude with certainty.

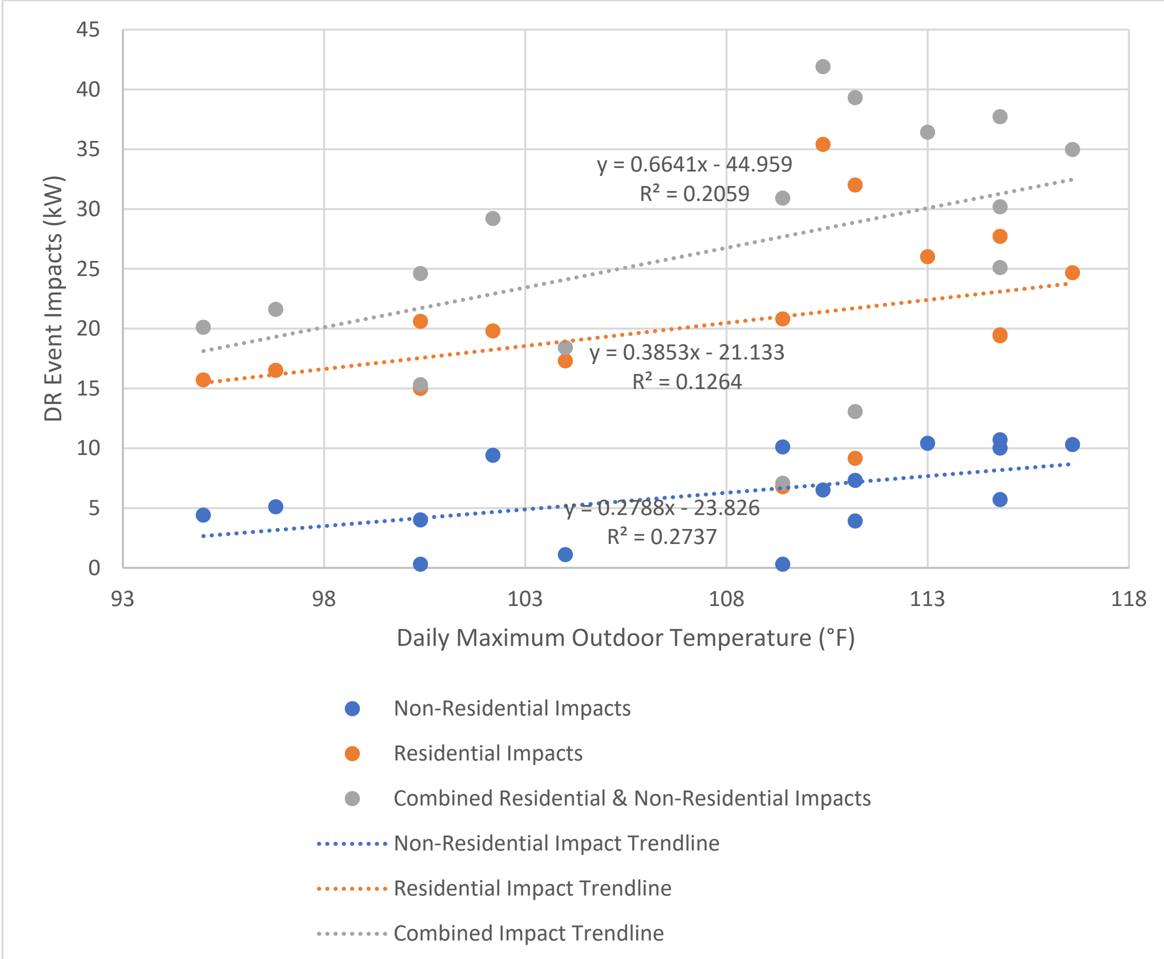


FIGURE 20. DR EVENT IMPACTS VS. DAILY MAXIMUM OUTDOOR TEMPERATURE

SOLAR AND BATTERY SYSTEMS IMPACTS

In this study, solar power was used to charge the battery during the day using the Self Supply Mode. During normal operation, the battery would discharge during the night to sustain any site loads. However, when a DR event was called, the battery switched to Priority Backup Mode to charge during the day and hold its charge until the DR event started. During the DR event, the battery switched to Sell Mode and discharged until it reached the minimum state-of-charge. The batteries had a minimum SOC of 20%, a maximum discharge power of 7.6 kW while grid tied, and a maximum energy capacity of 18 kWh. This means that the average theoretical load reduction for each individual fully charged battery is 6.3 kW for a 2-hour event, and 3.15 kW for a 4-hour event.

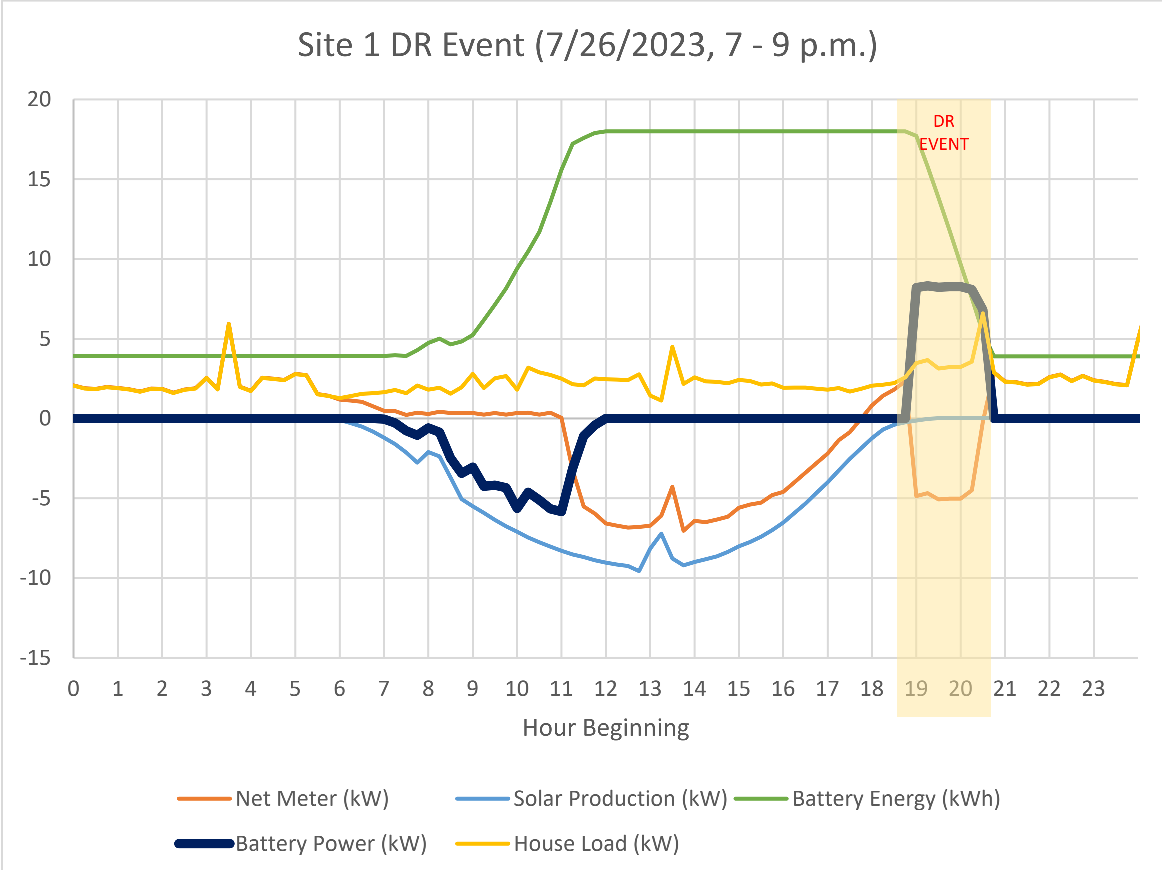
Out of six sites with batteries, only two sites had a 100% signaling success rate during the 16 DR event days. Others had connectivity issues that prevented DR signals from being received during some events. Site 3 had a 31% (five out of 16) success rate in receiving DR event signals due to connectivity issues, stressing the importance of telecommunications infrastructure in DR programs. When looking at the VPP as a whole, the battery equipment signaling success rate is highly correlated with the calculated impacts since the battery acts as the main resource in the VPP. The DR event with the highest impact (8/10/2023) was seen on the day where all batteries were signaled successfully with 100% SOC. Table 10 shows DR event signaling success rate. When SOC% is shown in the table below, DR event signals were successfully received by battery equipment.

Table 10. DR Event Signaling Success Rate and SOC% Before Event for Battery Equipment

Site ID	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6 Community Facility
Equipment Signaled	Battery	Battery	Battery	Battery	Battery	Batteries (2)
6/13/2023 7:00 PM	Invalid Configuration*	100%	Connectivity Error	100%	100%	1/2 Batteries Offline
6/29/2023 4:00 PM	100%	Connectivity Error	Connectivity Error	100%	100%	1/2 Batteries Offline
7/13/2023 5:00 PM	100%	100%	Connectivity Error	100%	100%	100%
7/20/2023 7:00 PM	100%	40%	Connectivity Error	100%	60%	100%
7/25/2023 7:00 PM	100%	60%	Connectivity Error	100%	80%	100%
7/26/2023 7:00 PM	100%	50%	Connectivity Error	100%	72%	100%
7/27/2023 7:00 PM	100%	40%	Connectivity Error	100%	72%	100%
8/10/2023 5:00 PM	100%	100%	100%	100%	100%	100%
8/15/2023 5:00 PM	94%	88%	94%	100%	88%	97%
8/16/2023 5:00 PM	94%	66%	100%	100%	66%	1/2 Batteries Offline
8/29/2023 6:00 PM	Connectivity Error	Connectivity Error	100%	100%	100%	1/2 Batteries Offline
8/30/2023 6:00 PM	Connectivity Error	Connectivity Error	100%	100%	100%	100%
9/12/2023 6:00 PM	Connectivity Error	Connectivity Error	Connectivity Error	100%	100%	100%
9/14/2023 5:00 PM	100%	Connectivity Error	Connectivity Error	100%	100%	1/2 Batteries Offline
9/26/2023 6:00 PM	88%	Connectivity Error	Connectivity Error	100%	100%	Connectivity Error
10/5/2023 6:00 PM	88%	Connectivity Error	Connectivity Error	100%	100%	1/2 Batteries Offline

*Not included in VPP signaling event scheduled for 6/13/2023. To comply with interconnection rules, this battery was under its own VPP event scheduled from 5 p.m. to 7 p.m. until the configuration was changed to Self Supply Mode.

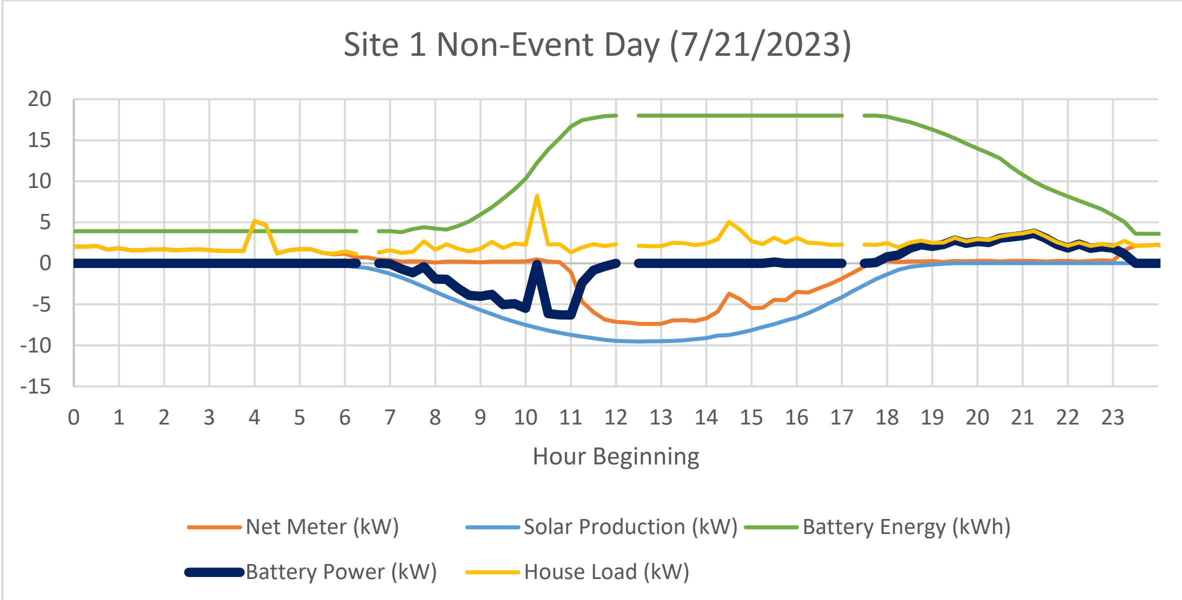
An example of the solar power charging and battery usage during a typical DR event day for one of the sites (Site 1) is shown in Figure 20. The battery started to charge from solar as the sun rose at around 7 p.m. until it reached the full SOC at around 11 p.m. Since the 2-hour DR event was called for 7 p.m. to 9 p.m., the battery operated in Priority Backup Mode and it retained its charge until the DR event at 7 p.m. At 7 p.m., the battery discharged at its maximum rate until its minimum SOC of 20% was reached. The battery discharged at a peak power output of 8.3 kW during the DR event, resulting in a net export of electricity to the grid at 5 kW between 7 p.m. and 8 p.m.



Negative (-) Battery Power is CHARGING
Negative (-) Solar Production is PRODUCTION
Negative (-) Net Meter is EXPORT TO GRID

FIGURE 21. SITE 1 BATTERY BEHAVIOR DURING DR EVENT (7/26/2023, 7 – 9 P.M.)

When compared to an event day, the battery behavior on a non-event day is slightly different as shown in Figure 21. Since the battery is operating in Self-Supply Mode, excess solar power is used to charge the battery throughout the day until it reaches 100% SOC. When the sun sets, the amount of solar production decreases and the battery slowly discharges to meet the site load needs. In this case, the battery discharged at 3.7 kW at 9:15 p.m. By 11:30 p.m., the battery reached its minimum SOC of 20% and stopped discharging until the next day.



Negative (-) Battery Power is CHARGING
Negative (-) Solar Production is PRODUCTION
Negative (-) Net Meter is EXPORT TO GRID

FIGURE 22. SITE 1 BATTERY BEHAVIOR DURING NON-EVENT DAY (7/21/2023)

Site 1 performed as expected because the solar and battery system was sized appropriately to charge and handle house loads simultaneously during the day. However, Site 2 had an improperly sized system where the solar production was not capable of sustaining house loads while charging the battery during some DR events. An example is shown in Figure 22, where the battery discharged only 3.4 kWh during the event, having a minimal 1.7 kW average impact across the entire DR event period. During the event day (7/20/23), the battery started with a minimum SOC and was unable to charge sufficiently during the day, leading to minimal impacts during the DR event.

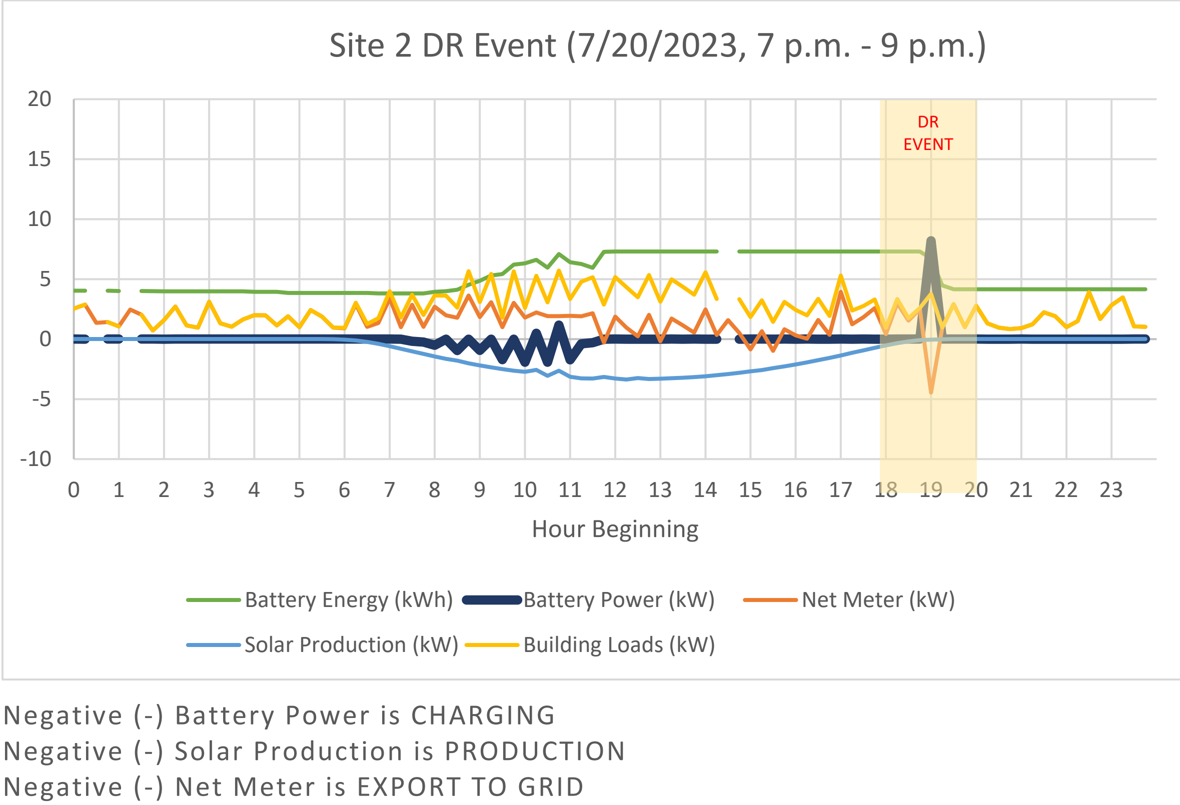


Figure 23. Site 2 Battery Behavior During DR Event (7/20/2023, 7 – 9 p.m.)

For the community facility (Site 6), the two batteries behaved similarly to the residential sites, charging during the day and discharging during the DR events. However, there were intermittent connectivity issues with the inverters, sometimes preventing batteries from discharging or receiving signals properly. An example of a successfully executed DR event can be seen in Figure 24 compared to a non-event day shown in Figure 25. On the non-event day, the community facility batteries discharged slowly, especially if the facility was not in use. However, during a DR event, the community facility batteries discharged completely until the minimum SOC was reached. During both cases, the batteries charged to 100% SOC during the day through solar.

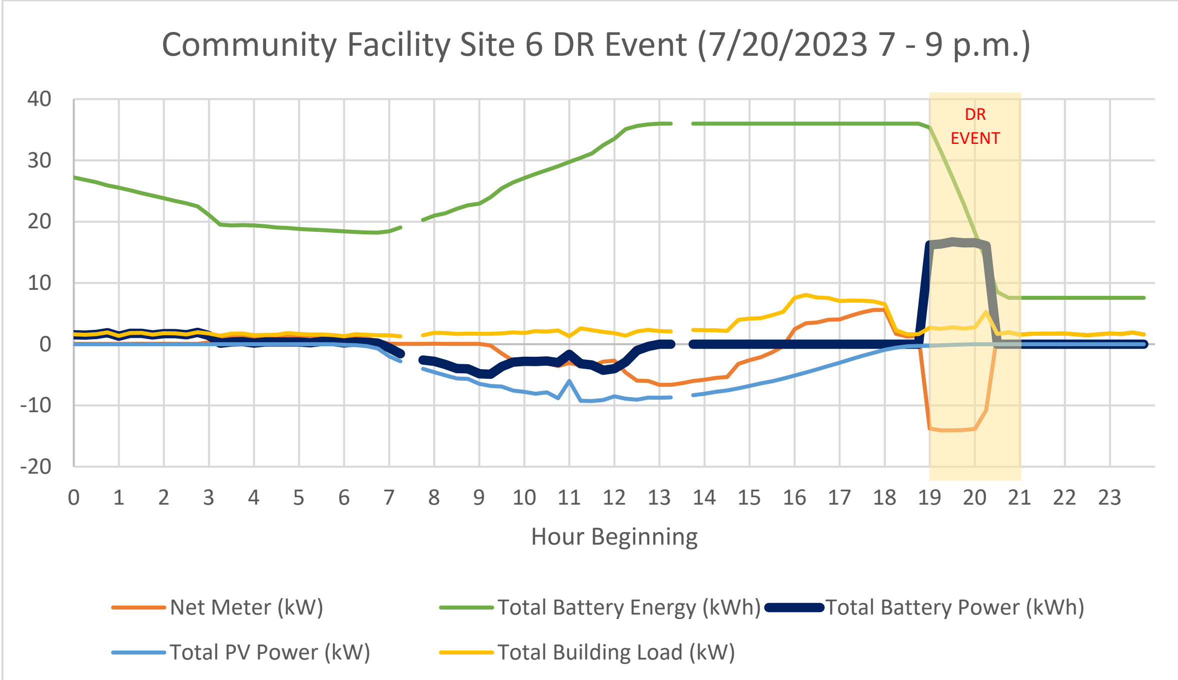


FIGURE 24. COMMUNITY FACILITY (SITE 6) BATTERY BEHAVIOR DURING DR EVENT (7/20/2023, 7 – 9 P.M.)

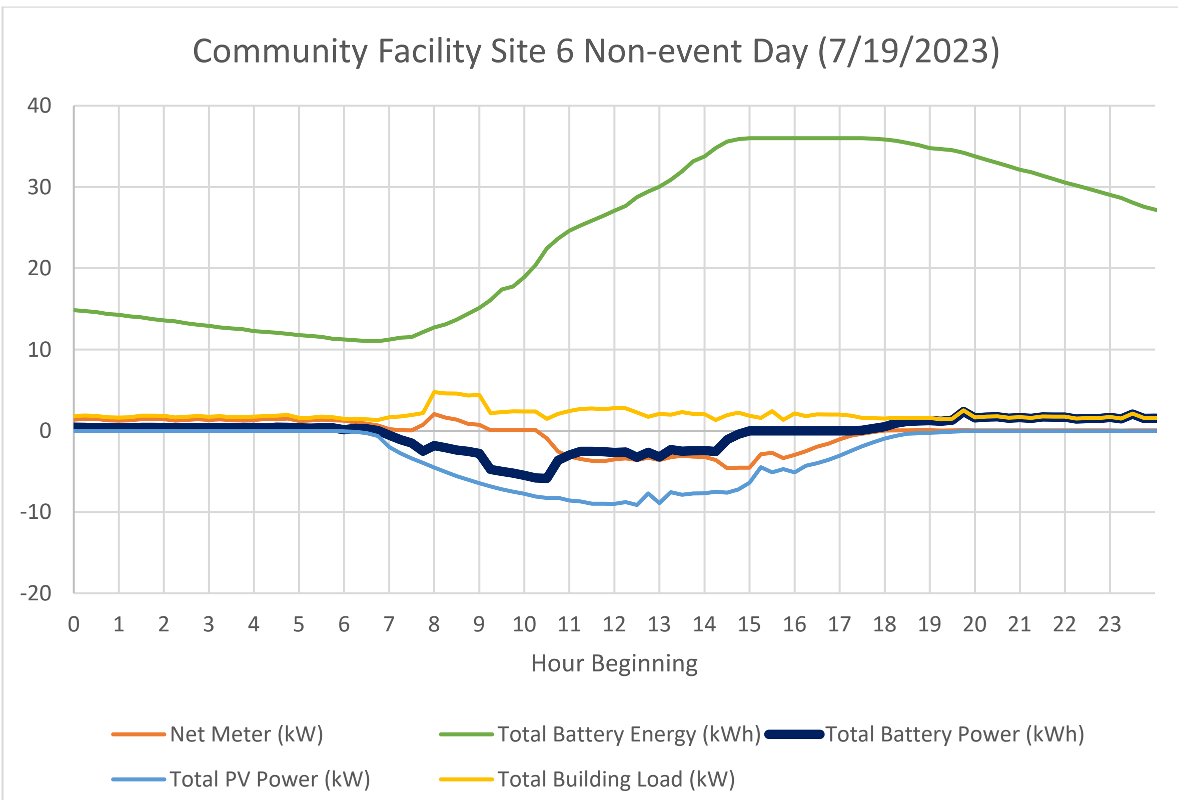


FIGURE 25. COMMUNITY FACILITY (SITE 6) BATTERY BEHAVIOR DURING NON-EVENT DAY (7/19/2023)

Outside of the DR season, the batteries were tested for a newly developed feature to sustain power delivery across the entire event. This throttles the batteries' discharging behavior throughout the event to ensure that their capacity lasts the entire duration of the event. An example of this test is shown for Site 4 in Figure 26. Due to data availability, only battery and solar data is shown. This event shows the battery having a sustained discharge rate of around 4 kW during the entire event, leaving additional capacity to sustain house loads after the event. The battery provided approximately half of the 8 kW peak power seen by the batteries during other events. This feature may be beneficial if only a partial VPP resource is needed during a DR event, or if the grid resource benefits need to be sustained consistently throughout the duration of the event.

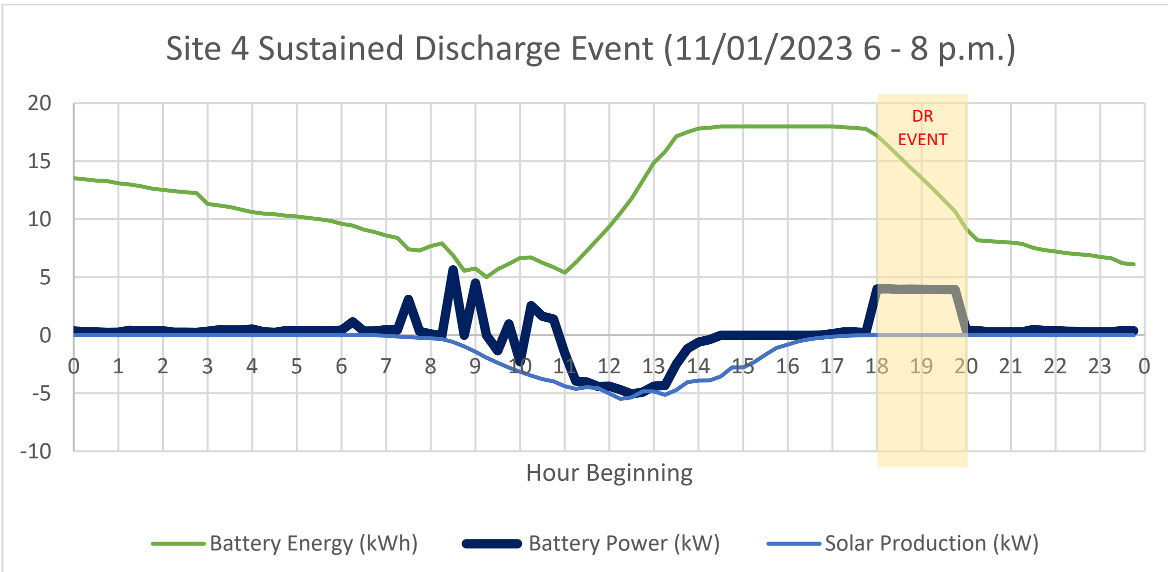


FIGURE 26. SITE 4 SUSTAINED DISCHARGE EVENT (11/01/2023, 6 – 8 P.M.)

THERMOSTAT IMPACTS

Sites 3, 7, and 8 had a combined total of four thermostats participating in the DR events. Thermostats were able to provide air AC runtime, room temperature, and setpoint temperature data. One hour before the event start time, the thermostat setpoint was reduced by 4°F to precool the home. Next, the setpoint was increased by 4°F at the beginning of the event and returned to its original state at the end of the event. This led to a decrease in the amount of AC operating time during an event, leading to overall house load reduction. If participants were uncomfortable with the increased setpoint, they had the option to opt out of the event during the event, allowing the user to reset the setpoint.

Table 11 shows the timing of signaling and corresponding opt-outs of thermostats during the DR events. Out of the 16 events analyzed during the DR season, one participant (Site 3) opted out of 12 events with at least one of their thermostats. Site 7 opted out of one of the 16 events. Site 8 had significant connectivity errors but did not opt out once. This shows that customer behavior may be a factor in VPP impacts and implementation. While the other two sites 7 and 8 had fewer opt-outs during all 16 DR events, there were events where the thermostat could not receive signals due to internet connectivity issues.

TABLE 11. DR EVENT SIGNALING SUCCESS RATE AND OPT-OUTS FOR THERMOSTAT EQUIPMENT

EVENT START	SITE 3 THERMOSTATS (2)	SITE 7 THERMOSTAT	SITE 8 THERMOSTAT
6/13/2023 7:00 PM	1/2 overridden	Success	Connectivity Error
6/29/2023 4:00 PM	2/2 overridden	Success	Connectivity Error
7/13/2023 5:00 PM	1/2 overridden	Success	Connectivity Error
7/20/2023 7:00 PM	1/2 overridden	Success	Connectivity Error
7/25/2023 7:00 PM	1/2 overridden	Success	Connectivity Error
7/26/2023 7:00 PM	Success	Success	Connectivity Error
7/27/2023 7:00 PM	2/2 overridden	Success	Success
8/10/2023 5:00 PM	2/2 overridden	Success	Success
8/15/2023 5:00 PM	2/2 overridden	Connectivity Error	Success
8/16/2023 5:00 PM	2/2 overridden	Connectivity Error	Success
8/29/2023 6:00 PM	2/2 overridden	Overridden	Success
8/30/2023 6:00 PM	1/2 overridden	Success	Success
9/12/2023 6:00 PM	1/2 overridden	Success	Connectivity Error
9/14/2023 5:00 PM	Success	Success	Connectivity Error
9/26/2023 6:00 PM	Success	Success	Connectivity Error
10/5/2023 6:00 PM	Success	Success	Connectivity Error

Thermostats were able to shift consumer load from the DR period and was captured in the net meter data analyzed. An example of this thermostat behavior at Site 8 on a DR event day is shown in Figure 27. The site had a setpoint of 73°F during the day, but the setpoint was manually increased to 75°F at 10 p.m. The DR event was called for 7 p.m., so the thermostat started to pre-cool the space at 6 p.m., dropping the setpoint to 71°F. During the DR event, the setpoint increased to 79°F, 4°F above the original setpoint before the event (75°F). After the DR event, the setpoint was reset to 73°F because the user's manual setpoint changes expired after a set amount of time. When looking at the AC status, the AC cycled on and off to maintain the desired temperature setpoint when the pre-cool started. However, during the pre-cool period, the AC continuously operated until the pre-cool setpoint was met. During the DR event, the AC turned off completely until the end of the event because space temperature was kept within the setpoint. The temperature impacts on the customer can be seen as well. During the pre-cool period, the room temperature dropped to 71°F, and increased to approximately 78°F during the DR event.

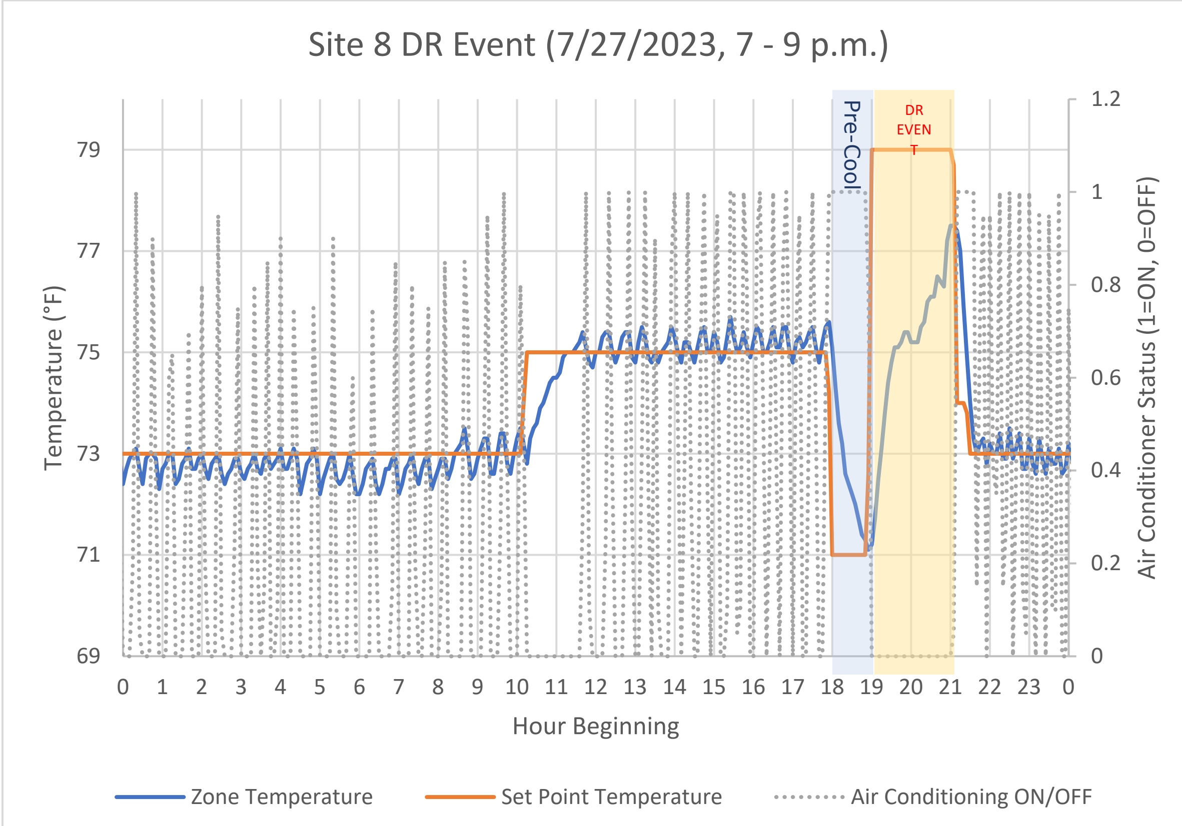


FIGURE 27. SITE 8 THERMOSTAT BEHAVIOR DURING DR EVENT (7/27/2023, 7-9 P.M.)

Figure 28 shows the thermostat behavior of the same site (Site 8) on a non-event day. The customer adjusted the setpoint to meet their comfort needs, and the AC continued to cycle on and off throughout the day to maintain the setpoints.

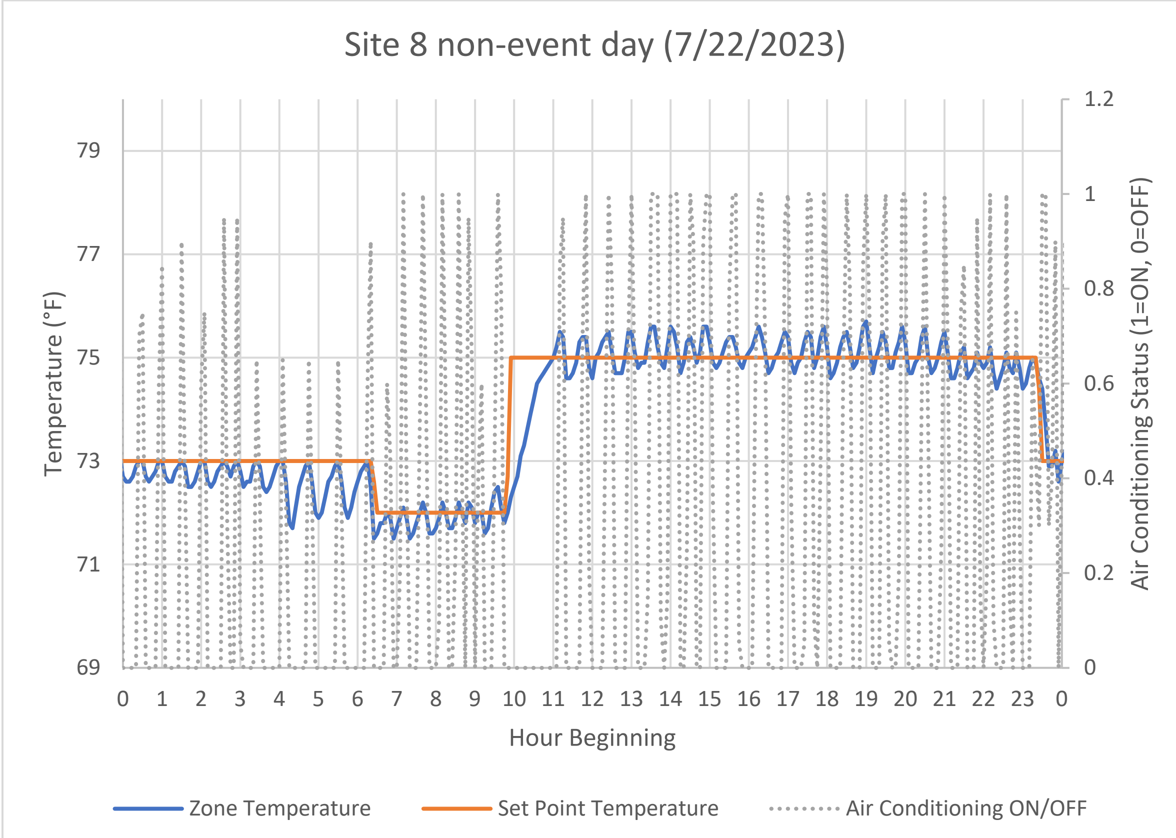


FIGURE 28. SITE 8 THERMOSTAT BEHAVIOR DURING NON-EVENT DAY (7/22/2023)

WELL PUMP CONTROLLERS

To understand the baseline behavior and monitor the well pump power, CTs were attached to the motor to monitor the current to the pumps. With the nameplate voltage rating of 230V, the power and energy usage were calculated. The well pumps were used to pump ground water to a storage tank that was later pressurized by a separate pump for potable and agricultural use. The well pump power was continuously monitored to understand the baseline usage patterns. Each site had different usage patterns.

Figure 27 shows the average aggregated residential well pump power per day from 6/6/2023 – 9/6/2023 excluding DR events. All residential sites appeared to have sporadic usage of the well pumps with most of them only running for about an hour, a few times per week. The residential well pumps had an idle power of around 5W per pump, meaning a total idle power of around 20W for the four residential well pumps in aggregate. The average daily power excluding DR events was 123W for all residential pumps. This is equivalent to an average daily power usage of 31W per pump.

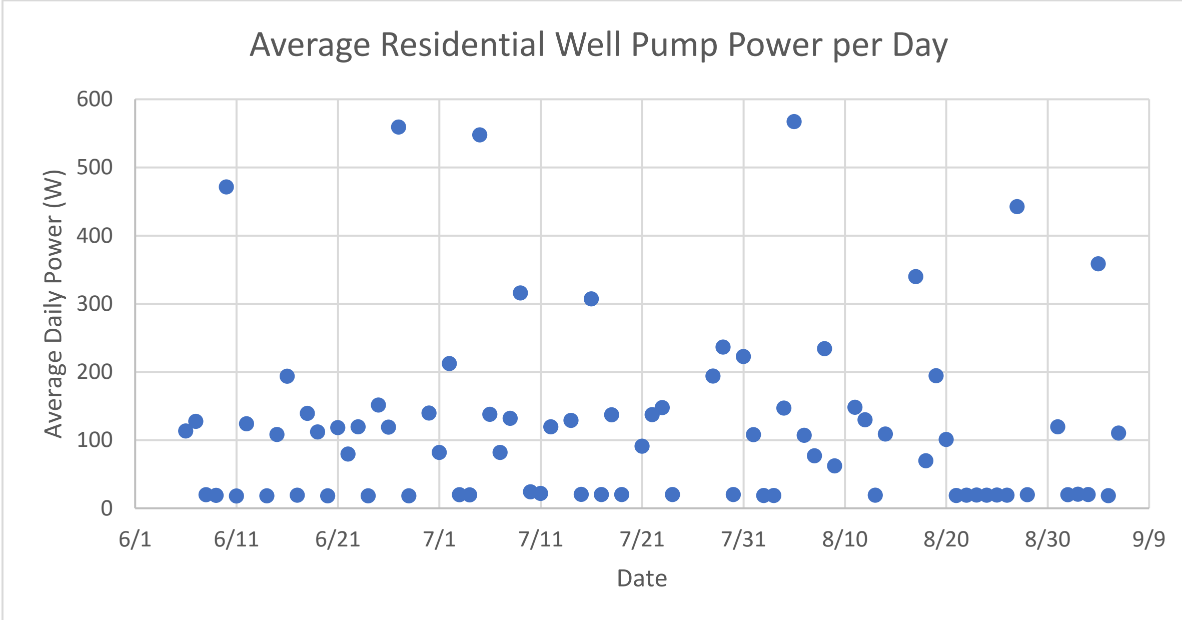


Figure 29. Average Residential Well Pump Power Per Day

During the DR events, the well pump controllers were signaled to remain off, unless the override button was pressed. In this manner, the well pumps had the possibility of shifting their usage for DR events, operating at a later time after the event finished. Table 12 shows the DR event signaling success rate for the well pump controllers. There were no opt-outs for this equipment for any of the events but since the well pump controllers were installed far from the primary building of residence, some sites had unreliable Wi-Fi connectivity. The community facility (Site 6) and Site 2 did not have any successfully signaled events during the DR season.

Table 12. DR Event Signaling Success Rate for Well Pump Equipment

Event Start	Site 2 Well Pump Controller	Site 6 Community Facility Well Pump Controller	Site 7 Well Pump Controller	Site 8 Well Pump Controller	Site 9 Well Pump Controller
6/13/2023 7:00 p.m.	Connectivity Error	Connectivity Error	Success	Connectivity Error	Success
6/29/2023 4:00 p.m.	Connectivity Error	Connectivity Error	Success	Success	Success
7/13/2023 5:00 p.m.	Connectivity Error	Connectivity Error	Success	Success	Success
7/20/2023 7:00 p.m.	Connectivity Error	Connectivity Error	Success	Success	Connectivity Error
7/25/2023 7:00 p.m.	Connectivity Error	Connectivity Error	Success	Success	Success
7/26/2023 7:00 p.m.	Connectivity Error	Connectivity Error	Success	Success	Success

7/27/2023 7:00 p.m.	Connectivity Error	Connectivity Error	Success	Success	Success
8/10/2023 5:00 p.m.	Connectivity Error	Connectivity Error	Success	Success	Success
8/15/2023 5:00 p.m.	Connectivity Error	Connectivity Error	Success	Success	Success
8/16/2023 5:00 p.m.	Connectivity Error	Connectivity Error	Success	Connectivity Error	Success
8/29/2023 6:00 p.m.	Connectivity Error	Connectivity Error	Success	Success	Success
8/30/2023 6:00 p.m.	Connectivity Error	Connectivity Error	Success	Success	Success
9/12/2023 6:00 p.m.	Connectivity Error	Connectivity Error	Success	Connectivity Error	Success
9/14/2023 5:00 p.m.	Connectivity Error	Connectivity Error	Success	Connectivity Error	Success
9/26/2023 6:00 p.m.	Connectivity Error	Connectivity Error	Success	Connectivity Error	Success
10/5/2023 6:00 p.m.	Connectivity Error	Connectivity Error	Success	Connectivity Error	Success

The daily load shapes of residential well pumps averaged from 6/6/2023 – 9/6/2023 are shown in Figure 30. While there was a maximum load of approximately 4 kW observed for one day, pumps were idling on most days or running intermittently during daytime hours.

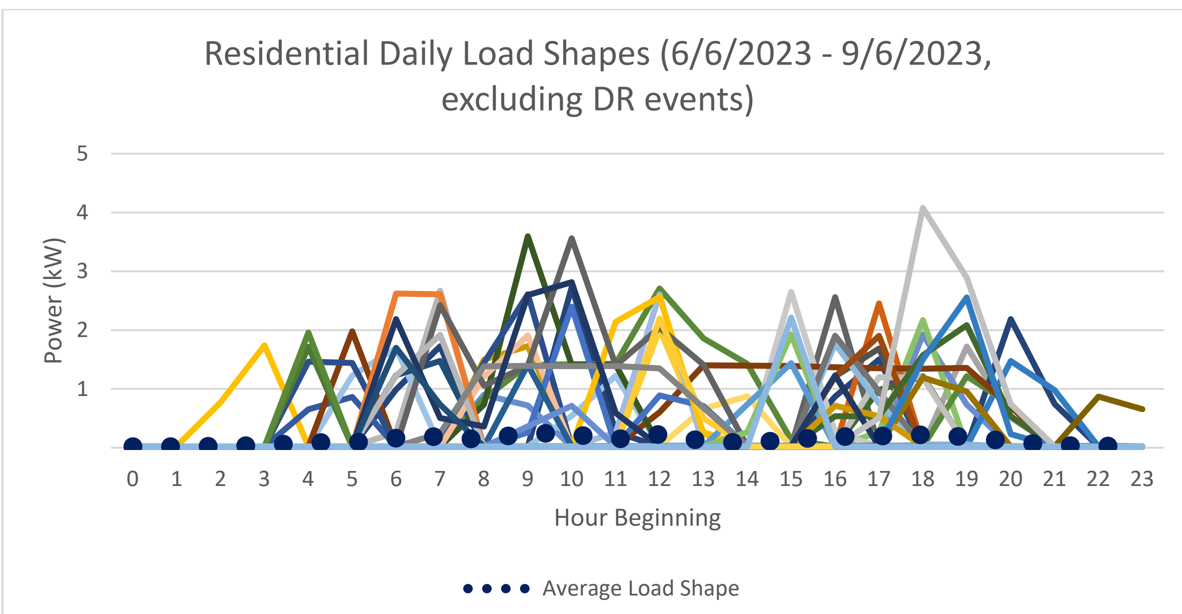


FIGURE 30. DAILY LOAD SHAPES FOR THE AGGREGATED RESIDENTIAL WELL PUMPS (EXCLUDING DR EVENTS)

There were a few instances when multiple pumps ran simultaneously during the testing period. Figure 31 shows the total number of well pumps active between 6/9/23 and 9/9/23. A maximum of two different pumps were seen running at a given time throughout the 3-month period, showing the intermittent behavior of well pump operations.

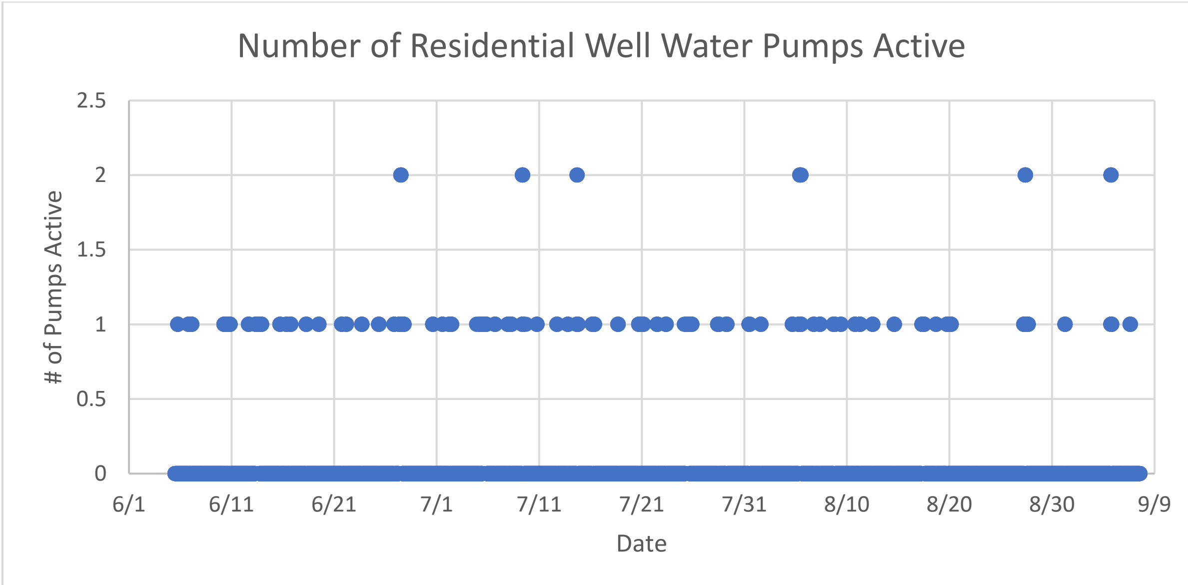


FIGURE 31. NUMBER OF RESIDENTIAL WELL PUMPS ACTIVE

An aggregated residential pump load over the same period is shown in Figure 32. The average aggregated well pump load was minimal, with a peak load of 256 W seen at around 9 a.m. Per device, this is an average peak load of around 64 W.

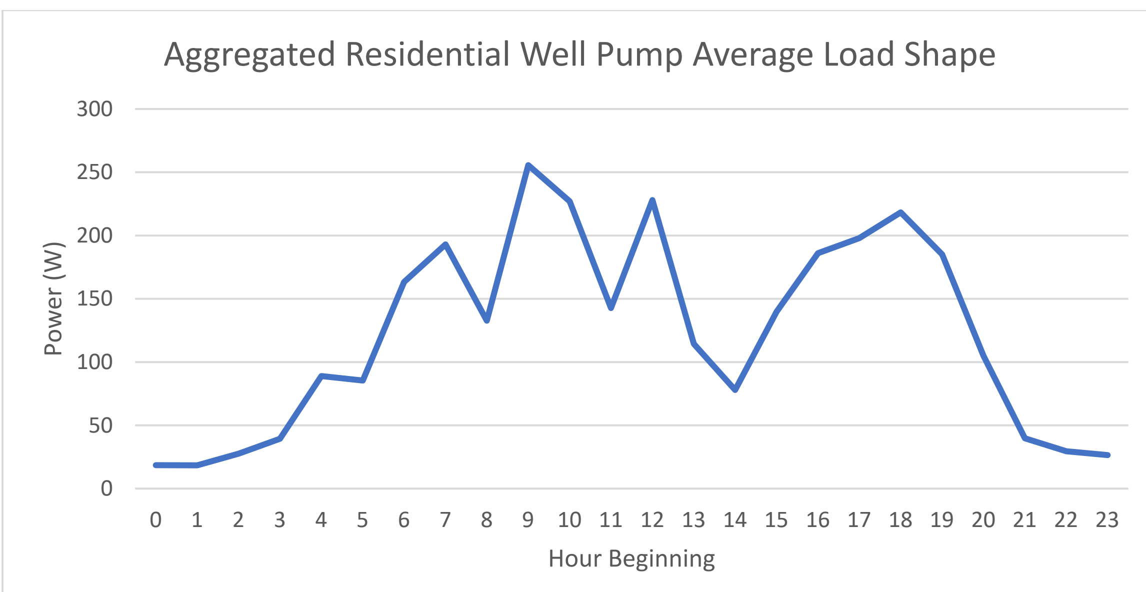


FIGURE 32. AGGREGATED RESIDENTIAL WELL PUMP AVERAGE LOAD SHAPE

SURVEY RESULTS

At the end of study, a survey was conducted to gather additional information from the study participants. The survey was distributed to all participants through email, and comprehensive feedback from each customer was gathered during telephone conversations. The survey questions and results can be found in Appendix E- Virtual Power Plant - Customer Survey.

A few notable observations from the survey include:

- Regarding how participants learned about the VPP project, a majority of the customers (75%) responded to community outreach/community events.
- Several customers who received pump controllers expressed dissatisfaction with the equipment's operation due to the inconvenience of having to reset the device after every DR event was over.
- Customers who received batteries expressed their satisfaction, highlighting that they appreciate the device for supplying power during outages and contributing to a reduction in their energy bills.

DISCUSSION

VPP DEMAND IMPACT

The test results showed that the VPP was able to have a maximum combined demand impact of 41.9 kW on 8/10/2023 and a minimum combined demand impact of 7.1 kW on 8/16/2023. The average demand impact across the 14 two-hour DR events analyzed during the DR season (6/13/2023 – 10/05/2023) was 29.0 kW, while the average impact across the two four-hour events was 10.1 kW. The battery equipment was the main contributor to the VPP impacts, with a specified 14.4 kWh in usable storage and a maximum theoretical discharge power of 7.6 kW when grid tied. However, some sites were not able to maintain a 100% SOC before every DR event. This was caused by an undersized solar system, solar availability due to weather conditions, or increased building loads during the day. Also, there were several events where batteries could not work to their full capacity because of connectivity or configuration issues like the battery going into shutdown mode instead of Sell Mode.

The thermostat behavior was also monitored during the DR events. Pre-cooling to shift AC demand was successful when there was connectivity. Connectivity of using the smart thermostat devices over Wi-Fi was also unreliable depending on the site. Additionally, some customers opted out of events, prioritizing their comfort over the DR event. Since power metering of AC units was not done, the exact impacts of thermostat controls were not calculated for the DR events. However, their impacts were reflected in the net metering data for each event analyzed.

The demand impacts of controlling the well pumps were found to be minimal. Due to their sporadic operating behavior, their average daily load was only 123W for all pumps. The pumps were also found to have an idle load of 20W, meaning their operating load was minimal compared to the battery impacts for this VPP. The well pumps were found to have a peak load of around 4 kW. However, the infrequent use of the well pumps made their impacts insignificant in this VPP. One recommendation may be to schedule well pump operations to turn on only during non-peak hours to avoid the need for automated DR.

BARRIERS ENCOUNTERED

Since the project's inception, the VPP team encountered various challenges throughout customer acquisition, installation, and testing. The most significant obstacle was maintaining consistent equipment connectivity. Poor cellular coverage and reliance on only one cellular tower connection contributed to intermittent connectivity issues throughout the project. Additional trips by the electrical contractor and AESC were necessary to address and rectify these challenges. An overview of the challenges faced during different phases of the project is provided below.

VPP CUSTOMER RECRUITMENT CHALLENGES

- Limited number of customers participated in community events, with only approximately 20 out of 212 customers engaging.
- Most customers did not respond to mass email communications.

- Minimal responses were received through the VPP signup page.
- Hesitation among customers, with concerns about trusting utilities and fear of energy usage monitoring or control.
- Delays in signing customer agreement forms, with approximately 50 percent taking more than a month to respond.
- A very limited number of residents had central HVAC systems. There is no control device available for window AC units without remote control.
- Some customers already maintained high cooling setpoints around 80-82°F, making increased setpoints during DR events very discomforting for customers.
- Requirement for multiple customer agreement forms (one for the battery and another for other equipment) at a single site.

BTM Resource Installation Challenges

- Limited cellular coverage and a few customers were without home Wi-Fi.
- Ara controller's dependence on full-coverage cellular network for proper functionality.
- For customers leasing solar PV systems and receiving batteries from SDG&E, touching any solar PV components would have voided the warranty on the solar system. Hence the electrical contractor could not move the solar breaker into the critical loads/ emergency load panel. In this setup, in the event of a power outage, the solar was disconnected from the grid and shut off, not charging the battery even when the sun is available.

Equipment and Connectivity Challenges

- Frequent hardware failures were observed with the BESS, necessitating frequent interventions.
- Issues with losing equipment connectivity after installation.
- Incidents of pests, likely rats chewing on battery wires, causing damage
- Customers not promptly notifying SDG&E and AESC about changes in their internet service providers, resulting in devices remaining offline until Wi-Fi credentials were updated.

Testing Challenges

- The initial use cases needed to be modified to better fit with the VPP platform’s capabilities.
- When equipment lost and regained connectivity, abnormal high spikes were observed in the telemetry from the BESS. This anomaly appeared to be a data quality issue rather than an actual hardware operation problem.

Several challenges were identified during the project and were addressed by the team as identified in Table 13.

TABLE 13: CHALLENGES AND SOLUTION

CHALLENGES	SOLUTION
During the initial community outreach events, it was observed that a limited number of homes were equipped with a central HVAC system. The majority of residences relied on evaporative coolers, window AC units, and a few had split systems.	An Air Conditioner Smart Device was identified for the study to encompass window AC units and split systems. Unfortunately, due to insufficient customer participation, this device was not utilized in the project.
A number of customers voiced concerns about the utility (SDG&E) having control over their equipment, such as HVAC systems and well pump operation.	Customers were provided with the capability to override both thermostats and the well pump controller. AESC and SDG&E emphasized the override feature to ensure all customers were aware of this capability.
For DC coupled systems, such as the Community Facility battery, when a DR event is initiated in Concerto, the Generac inverter can communicate with third-party solar inverters. This allows the batteries to enter a clean backup mode, where they charge from solar to maximize the SOC and be prepared for the event. In contrast, for AC coupled systems like residential setups, the Generac inverter can't communicate with third-party solar inverters. Consequently, the battery remains idle, retaining its charge until the DR event commences.	To comply with the requirement of providing a minimum 24-hour notice to customers for scheduled events, AESC implemented a two-step process. A preliminary event was created 24 hours in advance (the day before the actual event) to send notifications to customers. Subsequently, this preliminary event was canceled in Concerto. On the day of the event, a new DR event was generated a few hours before the scheduled start time. This approach ensured that all batteries were operating in Self Supply Mode until the day of the event, which was crucial for capturing baseline conditions.
At Site 1, the battery was set up in TOU (Time of Use) 4 to 9 p.m. mode due to CAT5 cable issues. In this mode, the battery does not charge from 4 to 9 p.m. but charges from the grid after 9 p.m. It's important to note that this configuration deviates from the interconnection agreement.	As an interim solution, the battery was signaled daily from 5 to 7 p.m. This action set the battery to Priority Backup Mode 24 hours before the event and prevented charging from the grid. Signaling events were established from 5/19/2023 until 6/14/2023 when the cable was replaced, and the battery was subsequently set to Self Supply Mode.
At Site 2, during the installation of the thermostat, the contractor encountered difficulty accessing the interior of the fan coil unit. Additionally, there was no C-wire present at the thermostat. Complicating matters, refrigerant lines and condensate lines obstructed the access panel opening. The customer expressed concerns about the potential voiding of the unit warranty if these pipes were removed or rerouted.	The fan coil unit at the site had been installed by an HVAC installer. Upon encountering difficulties with thermostat installation, AESC reached out to the installer to secure an approved mechanical contractor for the task. However, the fan coil unit had been installed upside down, and a section of the access panel had been glued to the floor, making it impossible to remove without causing damage. Consequently, it was jointly decided to abandon the idea of installing a thermostat at this site.
At Site 3, the solar system was leased from Sunrun. Relocating the solar breaker to the panel with the battery would result in voiding Sunrun's warranty. Unfortunately, no alternative configuration on the battery would enable the charging of the battery from solar power.	Charging batteries from the grid is prohibited according to Rule 21, but storage systems with a capacity of less than 10 kW are exempt. At this site, the battery was configured in Priority Backup Mode to serve both the customer and the VPP. The TOU schedule on the battery was set up to prevent grid charging during peak hours.
At Site 5, the customer faced an issue where the battery entered islanding mode as expected during a power interruption. However, it did not	The customer was advised to reset the automatic transfer switch to restore normal operation (i.e., Self Supply Mode).

automatically return to Self Supply Mode once the power was restored.	
There were disruptions in battery connectivity due primarily to customers changing their internet service providers during the project period.	To enhance resiliency, a cell card was installed for all the batteries, utilizing customer Wi-Fi as an additional layer of connectivity.
At the Community Facility, one of the batteries did not discharge during the 9/26/2023 event despite receiving signals through the Concerto Platform.	The Generac team identified that the Zero Export setting on the battery was turned on, preventing both the battery and solar from feeding the grid. The battery configuration was remotely adjusted, and it discharged to the grid successfully in the subsequent DR event.

CONCLUSIONS

The solar and battery equipment was identified as the primary contributor to the demand impacts observed in the VPP. The battery storage showed a significant amount of potential during DR season to act as a dispatchable resource particularly when remotely controlled, enabling valuable contributions to grid services. Table 14 summarizes the questions that were examined in this project and the findings.

TABLE 14. SUMMARY OF QUESTIONS AND FINDINGS

QUESTIONS	FINDINGS
1. Can a VPP provide immediate automated response to Flex Alert or DR events?	During this project, a total of 25 events were initiated, spanning from December 2022 to November 2023. Some of these events were pre-planned (simulated), while 10 were actual events called out a day in advance. All the real events were signaled (described in Table 5), and the devices were dispatched based on internet connectivity during the events.
2. Can the VPP respond to PSPS events and optimize battery?	At present, the Concerto platform needs additional advanced VPP control algorithms to fully optimize battery performance during PSPS events.
3. Can the VPP provide aggregated response to grid needs?	The capabilities of multiple DERs were unified and coordinated to provide an aggregated response to the grid.
4. Would the operations of a VPP reduce overall load on the grid?	The study concluded that this VPP project has potential to shift the peak loads. Conducting a larger-scale study with more participants from diverse regions of San Diego could test the scalability and yield additional demand impacts.

LESSONS LEARNED

Throughout the course of the VPP project implementation in Shelter Valley, a myriad of valuable lessons has been collected. From customer recruitment challenges to equipment connectivity issues and communication network considerations, each phase of the project has provided insights that contribute to a more nuanced understanding of the intricacies of deploying residential energy solutions. This overview encapsulates the key lessons learned, shedding light on the successes, challenges, and adaptations made throughout the course of the project.

Key lessons learned from the VPP project:

- **Diversify Outreach Channels:** Email, physical mail, websites, and community events were used for customer acquisition, but considering additional strategies like in-person canvassing or a cold-call campaign may enhance results.
- **Address Distrust:** Recognize and address natural distrust some individuals may have towards utility or government agencies.
- **Streamline Agreements:** Combine customer agreement forms to prevent confusion caused by multiple forms.
- **Assess Connectivity:** Before deploying wireless equipment, thoroughly assess cellular network coverage to preempt connectivity issues.
- **Emphasize Connectivity Responsibility:** Customer agreement forms should highlight the significance of maintaining device connectivity.

Customers should understand the importance of providing a reliable Wi-Fi connection, especially when receiving expensive equipment like a BESS at no cost.

- **Plan for Solar Monitoring:** Solar power data for residential use is often not easily accessible through customers' solar company portals. For future projects, plan to install solar monitoring devices in advance.
- **Set Solar Size Thresholds:** Establish a minimum solar size threshold to ensure sufficient excess generation for charging the battery to its full capacity.
- **Consider Solar Warranties:** Be aware that adding a battery to an existing solar system might void the customer's solar warranty from the solar installer.

RECOMMENDATIONS

While this technology holds significant potential, there are several aspects that warrant further investigation and study. The following considerations should be thoroughly evaluated before contemplating the implementation of this project on a larger scale.

- **Participants:** The study was limited by a smaller number of participants than initially anticipated, largely due to challenges with non-engaging and non-responsive customers. It should be noted that the total population (approximately 212 accounts) was small when compared to a typical marketing campaign. While the results suggest scalability, it is recommended to conduct a larger-scale study with more participants in various areas of San Diego County. This broader study would provide a more comprehensive understanding of customers' opt-in/opt-out behaviors and validate whether the observed energy savings are representative and typical across a more diverse population.
- **Communications:** Conducting a comprehensive assessment of the cellular network coverage or Wi-Fi signals in the targeted areas is a critical step in ensuring the successful implementation of technology. It is crucial to ensure that the customer is well-informed about the significance of having reliable and robust connectivity as well as emphasizing the importance of customer engagement for feedback is equally vital for the optimal operation of the technology and the overall success of the project. Additionally, reliable communication technology beyond Wi-Fi and LTE should be explored and studied.
- **Interoperability:** Over the course of the project, the interoperability of various devices was considered and assessed. Many of the devices from external sources required additional API development to be controlled. Standardization of communications is key to providing a VPP at scale.
- **Equipment Reliability:** Battery energy storage systems are generally reliable in a single use backup capacity, however signaling these devices for numerous event days uncovered unexpected technical issues. For example, on several occasions, a battery would not revert back to standard operations after an event was called, which required a technician for repair.

APPENDICES

APPENDIX A- RECRUITMENT MATERIALS

COMMUNITY EVENT FLYER SAMPLE

SDGE | aesc

Now Recruiting Shelter Valley Participants

Join us **March 23, 2022, from 7 AM to 9 AM and 12 PM to 2 PM** at the Shelter Valley Community Hall to learn more about the Virtual Power Plant project planned for your neighborhood. Qualified program participants will receive $100 in gift cards.

Presented by: San Diego Gas and Electric (SDG&E®) and Alternative Energy Systems Consulting, Inc. (AESC).

The SDG&E® Emerging Technologies Program is working with AESC, an energy consultant, on a Virtual Power Plant (VPP) project. This project will help improve power grid resiliency for your community. It's also part of a larger effort to keep critical assets energized during a Public Safety Power Shutdown (PSPS) or other emergency event.

To learn more about the project visit www.sdge.com/vpp

VPP Project Fact Sheet

Virtual Power Plant Project

Receive two $50 gift cards* for participating

*see details below

We are looking for participants now through April 2022.
Sign up at sdgevpp.aesc-inc.com/

To learn more, visit **sdge.com/vpp**

What is this project?

The SDG&E® Emerging Technologies Program is working with Alternative Energy Systems Consulting, Inc. (AESC), an energy consultant, on a Virtual Power Plant (VPP) project. This project will help improve power grid resiliency for your community and is part of a larger effort to keep critical assets energized during a Public Safety Power Shutoff (PSPS) or other emergency event.

What do I get for participating?

Eligible participants will receive a $50 TANGO gift card after the equipment installation and a $50 TANGO gift card at the end of the project. Participants might also be eligible to receive the following equipment:

- A smart thermostat or control unit for packaged terminal units/ window AC units
- A smart plug and/or smart controllers (e.g., well or agricultural pumps)
- Battery energy storage system (for select existing solar PV customers; priority to medical baseline or Access and Functional Need (AFN) customers)

Who is eligible to participate?

Participants must be an SDG&E customers located in Shelter Valley and meet at least one of the following requirements can participate:

- Own a functioning central air conditioner or heat pump system or a packaged terminal AC unit
- Have an electric water heater or well pump
- Be willing to let us monitor your energy usage and adjust your temperature settings until end of 2022. *Note: that while home thermometer settings will be based on current weather conditions, participants can always override the thermostat setting to adjust for their comfort.*
- **All data collected for this project will be analyzed confidentially and anonymized or aggregated for reporting purposes.**
- **Program participants will have no out-of-pocket expenses.**

aesc

LETTER MAIL SAMPLE- PAGE 1

Participate in a research project and receive a $100 in gift cards

Dear Shelter Valley Customer,

Now through May 2022, Alternative Energy Systems Consulting, Inc. (AESC), in collaboration with SDG&E®, is seeking a limited number of participants for a Virtual Power Plant (VPP) project in Shelter Valley. Participation is on a first come, first served basis.

What is the Project?

SDG&E is working with AESC, an energy consultant, on a Virtual Power Plant (VPP) project. This project will help improve power grid resiliency for your community. It's also part of a larger effort to keep critical assets energized during a Public Safety Power Shutoff (PSPS) or other emergency event.

As part of this project, eligible residences and business will receive free equipment, such as a smart thermostat, a load controller or a home energy storage system, that will help keep your power ON during an emergency event. The equipment will also help you manage your energy costs during normal operation.

Additional details on the project are available on the next page. If you're interested in participating, sign up at sdgevpp.aesc-inc.com or call 442-333-0246

Sincerely,

SDG&E & AESC Virtual Power Plant Project Team

Letter Mail Sample- Page 2

Additional Information

What do I get for participating?

Eligible participants will receive a $50 TANGO gift card after the equipment installation and a $50 TANGO gift card at the end of the project.

Participants may also receive any of the following equipment:

- A smart thermostat or a control unit for packaged terminal units / window AC units
- A smart plug and/or smart controllers (e.g., electric water heater, well or agricultural pumps)
- Battery energy storage system (for select existing solar PV customers; priority to medical baseline / Access and Functional Need (AFN) customers)

Who is eligible to participate?

Participants must be an SDG&E customer located in Shelter Valley and meet at least one of the following requirements:

- Own a functioning central air conditioner or heat pump system or a portable terminal window AC unit
- Have an electric water heater or well pump
- Be willing to let us monitor your energy usage and adjust your temperature settings until end of 2022. Note that while home thermometer settings will be based on current weather conditions, participants can always override the thermostat setting). The data collected for this project will be analyzed confidentially and anonymized or aggregated for reporting purposes.

Program participants will have no out-of-pocket expenses.

I'm interested. What are next steps?

- To participate, sign up at sdgevpp.aesc-inc.com or call 442-333-0246
- AESC will schedule a phone call or email you to learn more about your home or building.
- AESC will also visit your home or building to set up energy monitoring devices to help us study real-world energy usage.

Por favor llame al 442-333-0246 para obtener información en español

Help boost energy reliability and build emergency preparedness in your community. Sign Up today to participate!

Email Sample

Participate in an energy research project in Shelter Valley and receive $100 in TANGO gift cards.

SIGN UP NOW

What is the Project?

Now through May 2022, Alternative Energy Systems Consulting, Inc. (AESC), an energy consultant, in collaboration with SDG&E®, is seeking a limited number of participants for a Virtual Power Plant (VPP) project in Shelter Valley.

Participation is on a first come, first served basis. This project will help improve power grid resiliency for your community. It's also part of a larger effort to keep critical community sites energized during a Public Safety Power Shutoff (PSPS) or other emergency event.

As part of this project, eligible residences and business will receive free equipment that will help keep your power ON during an emergency event. The equipment will also help you manage your energy costs during normal operation.

What do I get for participating?

Eligible participants will receive a $50 TANGO gift card after the equipment installation and a $50 TANGO gift card at the end of the project.

Participants may also receive any of the following equipment:

- A smart thermostat or a control unit for packaged terminal units / window AC units
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Participants must be an SDG&E customer located in Shelter Valley and meet at least one of the following requirements:

- Own a functioning central air conditioner or heat pump system or a portable terminal AC unit
- Have an electric water heater or well pump
- Be willing to let us monitor your energy usage and adjust your temperature settings until end of 2022. Note that while home thermometer settings will be based on current weather conditions, participants can always override the thermostat setting). The data collected for this project will be analyzed confidentially and anonymized or aggregated for reporting purposes.

Note: Final customer eligibility will be determined based on an onsite inspection of the customer's premise or home receiving service.

Program participants will have no out-of-pocket expenses.

I'm interested. How do I sign up?

- Use the links in this email to SIGN UP.
- We will schedule a phone call or email you to learn more about your home or building.
- We'll visit your home or building to set up energy monitoring devices to help us study real-world energy usage.

Si necesita información en español, regístrese en la página en español e indique su preferencia de idioma. Un representante de AESC le devolverá la llamada. ¡Gracias!

SIGN UP NOW

This email has been sent as a promotional communication. To unsubscribe from future AESC emails like this, please CLICK HERE.

Appendix B- Frequently Asked Questions (on SDGE Webpage)

What are Distributed Energy Resources (DERs)?

The term distributed energy resource is used to describe renewable energy sources which generate electricity near the point of use (like your home or business) instead of centralized generation sources from power plants. Examples of distributed energy resources that can be installed include:

- Roof top solar photovoltaic units
- Wind farms
- Battery storage
- Batteries in electric vehicles used to export power back to the grid
- Combined heat and power units
- Gas turbines
- Fuel cells, etc.

DER can also be used to describe intelligent devices used to reduce (shed) electrical usage at certain times or to manage (shift) electric usage to different times of the day. Utilities can use DER technologies to delay, reduce, or even eliminate the need to obtain additional power generation, transmission, and distribution equipment and infrastructure. At the same time, DER systems can also provide voltage support to maintain grid stability and enhance local electric service reliability.

What is Smart Thermostat?
A smart thermostat is a Wi-Fi enabled device that is connected to your heating and cooling system and allows you to create automatic and programmable temperature settings based on daily schedules, weather conditions, and heating and cooling needs, via both a desktop and a mobile app. A smart thermostat has the capability to receive a signal from the utility to make minor adjustments to thermostat setpoints, which reduces energy use during peak demand. You still maintain control of your thermostat during peak demand events and can opt-out of adjustments at any time. An example of Smart thermostat can be found on the Ecobee website.

What is a load Controller?

A load controller is a device that puts a cap on how much electrical usage a home can use at one time. They tie directly into the electrical panel and limit how much power a home can draw. Like smart thermostats, load controllers can be used by a utility to turn off certain equipment like pool pumps, well pumps or water heaters to reduce your peak demand usage.

What is a Battery Energy Storage System (BESS)?

Battery storage, or battery energy storage systems (BESS), are devices that enable energy from renewable sources like solar to be stored and then released when customers need power the most. With on-site storage, the customer can charge the batteries generated by their rooftop solar system and then discharge the energy from the batteries to avoid paying peak prices during the most expensive times of the day. An example of battery energy storage systems (BESS) can be found on this website.

Who will have access to my energy usage data?

If you choose to participate, only SDG&E and authorized program contractors will have access to your energy usage data. It will NOT be shared with anyone else.

How long is the study?

The study will take approximately 18 months and we will request your energy billing data to be shared with us during this period.

How long will it take to install the energy equipment?

Depending on what equipment you receive, it will take between 3 to 4 hours to install and test the equipment. We may need to schedule a follow-up visit with you, if we run into unforeseen issues.

Will I lose control over my thermostat?

Absolutely NOT. SDG&E will send a signal to your thermostat to raise or lower the thermostat setpoint, but you can override the setpoint if you choose not to participate in an electric load shedding (demand response) event. Utilities call demand response events when they need customers to conserve energy to alleviate strain on the grid.

Can I keep the equipment after the study is complete?

Yes, you can keep the equipment after study or have your home restored to original configuration.

Can I drop out in-between the study period?

Yes, you can. However, we recommend you participate until the end of the study to receive your second $50 gift card.

Appendix C- DR Event Notifications

Email Sample

Dear [redacted]

A Shelter Valley Demand Response event has ended on Wednesday, July 26 2023 at 9:00 PM Pacific Time on behalf of San Diego Gas and Electric.

Event details:

Starting: Wednesday, July 26 2023 at 7:00 PM Pacific Time
Ending: Wednesday, July 26 2023 at 9:00 PM Pacific Time
Site(s):

- Internal Ecobee Group Site
- Kusum_Home

You are listed as a primary contact.

To maximize your results, please support or implement your site load reduction plan by the start time.

If you have any questions about this event, please contact your Shelter Valley Demand Response Account Manager directly.

Sincerely,

Your Shelter Valley Demand Response Team

Text Sample

Today 10:54 AM

Hello [redacted], this is an Shelter Valley Demand Response event notification. Event start time is Thursday, September 14 2023 at 5:00 PM Pacific Time at your site(s).

Hello [redacted], this is an Shelter Valley Demand Response event notification. An event has been cancelled at your site(s).

APPENDIX D- AESC PRELIMINARY INSPECTION CHECKLIST

Customer Data

Name	☐ Owner ☐ Renter		
Address			
No. of Resident		**Conditioned Area**	sq. ft.
Phone		**Email**	
Resides full or partial year?		**If partial what months?**	
Wi-Fi connection	☐ Yes ☐ No	**Wi-Fi Source**	☐ Hotspot ☐ Cellular modem ☐ Other ________________________

Heating Ventilation and Air-Conditioning (HVAC) System

System	☐ AC/Furnace ☐ Heat Pump ☐ Packaged Terminal AC Unit / window AC ☐ Evaporative Cooler ☐ Fireplace ☐ Other: ________________________
Number of Units	☐ One ☐ Two ☐ Three ☐ Other: ________________________
Heating Type	☐ Propane ☐ Electric ☐ Other: ________________________
System Location	☐ Garage ☐ Attic ☐ Roof ☐ Closet ☐ Crawlspace ☐ Livingroom ☐ Bedroom(s) ☐ Other: ____________________
Thermostat	☐ Analogue ☐ Digital ☐ Ecobee ☐ Nest ☐ Other: _____________________________
Thermostat Location	☐ Hallway ☐ Bedroom ☐ Living Room ☐ Other: ________________________________
Setpoints	Cooling: _________°F Heating: _________°F

Central HVAC- Indoor Unit

Location	☐ Garage ☐ Crawl ☐ Attic ☐ Int. Closet ☐ Ext. Closet ☐ Other: ____________________		
Manufacturer		**Year of Install**	
Model No.		**Input Btu/h**	
Serial No.		**Output Btu/h, kW**	

Central HVAC - Outdoor Unit

Location	☐ Side Yard ☐ Front Yard ☐ Backyard ☐ Roof ☐ Porch/Deck		
Manufacturer		**Year of Install**	
Model No.		**Capacity**	
Serial No.		**SEER**	

Packaged Terminal AC / window AC 1

Location	☐ Living Room ☐ Bedroom ☐ Other: ____________________		
Manufacturer		**Year of Install**	

Model No.		**Cooling Capacity (tons or btuh)**	
Serial No.		**Heating Capacity (btuh)**	

Packaged Terminal AC / window AC 2

Location	◻ Living Room ◻ Bedroom ◻ Other: ___________________		
Manufacturer		**Year of Install**	
Model No.		**Cooling Capacity (tons or btuh)**	
Serial No.		**Heating Capacity (btuh)**	

Packaged Terminal AC / window AC 3

Location	◻ Living Room ◻ Bedroom ◻ Other: ___________________		
Manufacturer		**Year of Install**	
Model No.		**Cooling Capacity (tons or btuh)**	
Serial No.		**Heating Capacity (btuh)**	

Evaporative Cooler 1

Location	◻ Living Room ◻ Bedroom ◻ Other: ___________________		
Manufacturer		**Year of Install**	
Model No.		**Airflow (CFM)**	
Serial No.		**Other details**	

Evaporative Cooler 2

Location	◻ Living Room ◻ Bedroom ◻ Other: ___________________		
Manufacturer		**Year of Install**	
Model No.		**Airflow (CFM)**	
Serial No.		**Other details**	

Other Equipment Inventory

Solar PV	◻ Yes ◻ No If Yes, what Size? ______________ kW **Electric Panel size**: _________________________ Amps Hybrid Inverter? ◻ Yes ◻ No **Inverter Make and model:** ______________________________ Request drawings if available?
Battery Storage System	◻ Yes ◻ No If Yes, what Size? ______________ kW/kWh **Manufacturer:** ____ **Model No.** ____ **Serial No.** ____

	□ Partial Home Backup □ Whole Home Backup Critical Loads: ____
Generator	□ Propane □ Diesel □ Other: ______________________ **Manufacturer:** ____ **Model No.** ____ **Serial No.** ____ **Size:** ________________________ Connection to Grid: ____
Electric Vehicle Charger	□ Yes □ No If Yes, how many? ______________
	How often do you charge your car at home? □ Once a week □ Everyday □ Other: _________________________________
	When do you typically charge your car? □ Daytime □ Nighttime Specify time: ____________________________
Pool Pumps	□ Yes □ No If Yes, what Size? ______________ HP **Manufacturer:** ____ **Model No.** ____ **Serial No.** ____
Well Pumps	**Lift Pump (well to Storage)** □ Yes □ No If yes, what Size? ______________ HP **Manufacturer:** ____ **Model No**. ____ **Serial No.** ____ **Booster Pump (tank to home)** □ Yes □ No If yes, what Size? ______________ HP **Manufacturer:** ____ **Model No.** ____ **Serial No.** ____ **Storage Tank Size:** ______________________________________
Propane Tank	Size: ____ Uses: ____
Water Heater	**Heating Type:** □ Propane □ Electric □ Other: ______________________ **Manufacturer:** ____ **Model No.** ____ **Serial No.** ____ Heating Capacity (btuh/h): ______________________________ Storage Tank Size: ______________________________________
Medical Equipment List	
Refrigerator 1	**Manufacturer:** ____ **Model No.** ____ **Serial No.** ____ Capacity: ____

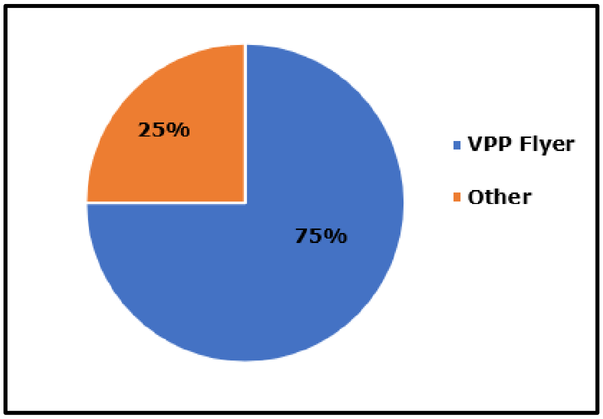
Refrigerator 2	**Manufacturer:** ________________ **Model No.** ________________ **Serial No.** ________________ Capacity: ________________
Freezer 1	**Manufacturer:** ________________ **Model No.** ________________ **Serial No**. ________________ Capacity: ________________
Freezer 2	**Manufacturer:** ________________ **Model No.** ________________ **Serial No.** ________________ Capacity: ________________
Lighting	▫ Incandescent ▫ LED ▫ Other: ________________
Other Notes	

APPENDIX E- VIRTUAL POWER PLANT - CUSTOMER SURVEY QUESTIONS AND SURVEY RESULTS

1. How did you hear about the Virtual Power Plant Project?

- VPP Flyer (Community event)
- Neighbor
- SDGE Email
- Snail Mail
- Other

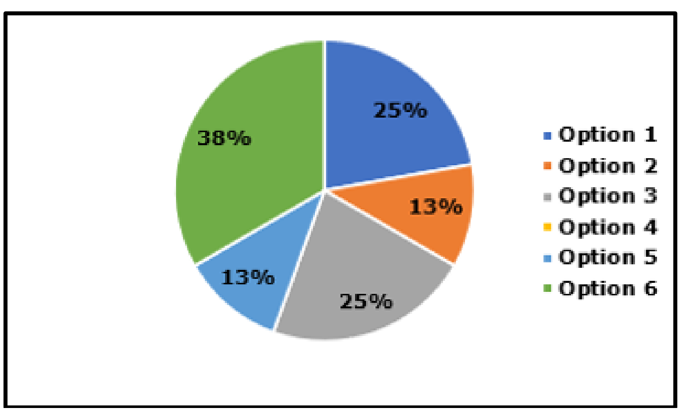
Survey Results



2. What motivated you to participate in this project? (check all that apply)

I wanted to:
- receive free smart controllers and equipment
- reduce my energy and utility bill
- participate in a project
- receive gift cards
- contribute to sustainability/environmental efforts (Being Green)
- contribute to resilience/energy security (Public Safety Power Shutoffs)

Survey Results



3. How satisfied are you with the following?

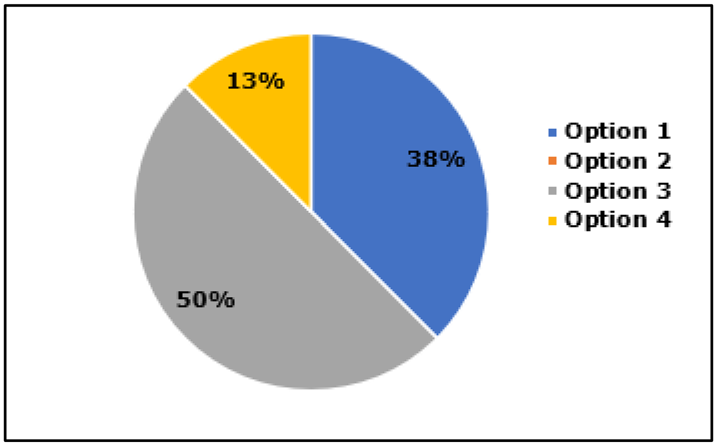
Survey Results

	Very dissatisfied	Somewhat dissatisfied	Somewhat satisfied	Very satisfied	Not sure	NA
Application / signup process	-	-	13%	75%	-	13%
Installation process	-	-	12%	88%	-	-
Contractor/ Installation Technician	-	-	-	100%	-	-
Your new battery	-	-	-	100%	-	-
Your new thermostat	-	-	-	100%	-	-
Your well pump controller	-	50%	25%	25%	-	-
Your control over the equipment during demand response (DR) signaling events (e.g., opt out)	-	13%	-	86%	-	-
Communication with SDG&E	-	-	25%	75%	-	-
Customer Service	-	-	-	100%	-	-

4. Did you notice any differences in your energy/utility bill after installation?

- Reduced bill charges
- Increased bill charges
- No impact
- Didn't notice

Survey Results



5. What did you like about your new equipment?

Survey Results

- Customer with Battery - Supplying power to their home for few hours during outage and Contributing to a reduction in their utility bills.

- Customer with Thermostat- very user friendly, different settings, more functionality and shows current time on display.

6. What did you dislike about your new equipment?

Survey Results

- One customer expressed dissatisfaction with the placement of the battery at the front of her house. However, she understands that there might not have been any alternative options for installation.
- Outside air temperature is not accurate on the thermostat display.

7. Do you want to keep the thermostat at your site?

Survey Results: 100% responded yes

8. Any additional concerns / comments?

Survey Results

- The majority of customers expressed their satisfaction with the battery installation.
- A customer has expressed interest in learning about the findings and results of this project.

Customer Testimonial

"We can use this equipment to maintain a place for people if the power goes off and keep the facility cool and hope we can provide food if needed for our community residents" from SDG&E News.