VALLEY CLEAN ENERGY ALLIANCE

Staff Report – Item 11

TO: Board of Directors

FROM: Mitch Sears, Chief Executive Officer
Rebecca Kuczynski, Chief Customer Officer

SUBJECT: VCE Participation in Smart Home Energy and Load Flexibility Pilot (Action)

DATE: October 14, 2025

RECOMMENDATION
Approve a resolution authorizing Valley Clean Energy's participation in the Smart Home Energy and Load Flexibility (SHELF) Pilot with UC Davis and Panasonic.

BACKGROUND AND ANALYSIS
In July 2024, UC Davis' California Lighting and Technology Center (CLTC), in partnership with VCE and Panasonic, submitted a grant application to the California Energy Commission (CEC) for GFO-23-309: Virtual Power Plant Approaches for Demand Flexibility. The grant application (which was not ultimately funded by the CEC) built upon two previous pilots: (1) VCE's AgFIT dynamic pricing pilot and (2) a CLTC pilot that leveraged funding and partnerships with Panasonic and the Sacramento Municipal Utilities District (SMUD) that tested smart home technology, demand flexibility and residential control strategies under normal day-to-day home schedules and activities.

Building on this work, the project scope for GFO-23-309 proposed deployment and evaluation of a residential load management pool comprised of approximately 50 households for the purposes of providing aggregated load shift/shed resources in response to utility and grid operator requests and dynamic pricing signals. The load available for shift and/or shed would have been provided by smart heat pump water heaters, smart heat pump space conditioning, electric vehicle (EV) chargers and behind-the-meter (BTM) battery energy storage systems. The scope of work included enrolling participating households in VCE's currently active, CPUC-approved, Hourly Flex Pricing (HFP) Pilot[1]. VCE's role in GFO-23-309 would have been to leverage HFP enrollments for GFO-23-309, for customer recruitment, education, and any additional tasks associated with HFP Pilot administration.

Though the GFO-23-309 grant application was not funded by the CEC, there was still an appetite on the part of the three partners to continue with the work. To that end, VCE, Panasonic, and the CLTC recently executed a non-binding Memorandum of Understanding (MOU) (Attachment 3), detailing a

[1] The CPUC approved funds for program participation for VCE ("CCA Incentives") based on customer enrollments in HFP in its January 25, 2024, Decision 24-01-032.

similar project scope to GFO-23-309 but scaled back to 25 homes, with an opportunity for more funding upon successful enrollment of 25 homes. This work is to be funded by Panasonic while each of the partners would retain their general roles as defined in the grant application. VCE's role would continue to be customer recruitment, education, and any additional tasks associated with HFP Pilot administration.

Staff believes that participating with CLTC and Panasonic in this Pilot could be advantageous for VCE customers, as it would provide additional incentives to residential customers that could be recruited into the HFP Pilot. VCE's financial commitment over the 2-3 year pilot is limited to in-kind staff time estimated at less than 0.25 FTE that will be partially compensated through pilot funding.

This Pilot is consistent with several objectives proposed in the Strategic Plan 2025 Major Update, including:

- (Proposed) Objective 2.3: Identify and pursue cost-effective, local distributed energy resources, including both front-of-meter renewable + storage resources for VCE's renewable energy supply portfolio, as well as behind-the-meter renewable + storage aggregations (VPPs) to help reduce RA requirements.
- (Proposed) Objective 3.5: Develop and implement customer programs and initiatives that prioritize decarbonization, community resiliency, rate affordability, and customer savings, including focused efforts on low-income and medically vulnerable customers.

Partnering on the Pilot will also help VCE assess the value of expanding efforts to enroll residential customers in Hourly Flex Pricing.

FISCAL IMPACT

Fiscal impact is limited to in-kind staff time estimated at less than 0.25 FTE that will be partially compensated through pilot funding. Additionally, CPUC-approved funds for the HFP Pilot could be leveraged to offset staff time.

Attachments:

1. Resolution 2025-XXX
2. Evaluation of Smart Home Load Flexibility under Varying Utility Programs and Household Operations Proposal for CEC Grant GFO-23-309
3. Memorandum of Understanding (MOU) between VCE, CLTC, and Panasonic

VALLEY CLEAN ENERGY ALLIANCE

RESOLUTION NO. 2025-___

RESOLUTION OF THE BOARD OF DIRECTORS OF VALLEY CLEAN ENERGY ALLIANCE AUTHORIZING THE CHIEF EXECUTIVE OFFICER TO EXECUTE AN AGREEMENT TO PARTICIPATE IN THE SMART HOME ENERGY AND LOAD FLEXIBILITY (SHELF) PILOT.

WHEREAS, Valley Clean Energy Alliance ("VCE") was formed as a community choice aggregation agency ("CCA") on November 16, 2016, under the Joint Exercise of Power Act, California Government Code sections 6500 et seq., among the County of Yolo, and the Cities of Davis and Woodland, to reduce greenhouse gas emissions, provide electricity, carry out programs to reduce energy consumption, develop local jobs in renewable energy, and promote energy security and rate stability in all of the member jurisdictions. The City of Winters, located in Yolo County, was added as a member of VCE and a party to the JPA in December of 2019; and

WHEREAS, On January 25, 2024, the California Public Utilities Commission issued decision 24-01-032 authorizing the expansion of the "Agricultural Flexible Irrigation Technology (AgFIT)" dynamic rate pilot program into the Hourly Flex Pricing (HFP) Pilots, including the expansion of eligibility to residential customers with funding for VCE Pilot implementation; and

WHEREAS, the California Lighting and Technology Center at the University of California, Davis (CLTC), submitted a grant application on July 1, 2024, to the California Energy Commission's (CEC) GFO-23-309, in partnership with Valley Clean Energy and Panasonic, to establish a testbed of homes in Yolo County to test smart home appliances and load shift in response to dynamic pricing signals in residential homes through enrollment in the HFP Pilots; and

WHEREAS, the GFO-23-309 grant application was not funded by the CEC; and

WHEREAS, CLTC and Panasonic executed a Memorandum of Understanding solidifying a modified scope of work similar to the scope submitted in GFO-23-309.

NOW, THEREFORE, the Board of Directors of Valley Clean Energy authorizes the CEO or their designee to take all actions necessary to execute agreements to participate in the "Smart Home Energy and Load Flexibility (SHELF)" Pilot with CLTC and Panasonic as partners, with a scope of work similar to the scope submitted in GFO-23-309.

PASSED, APPROVED AND ADOPTED, at a regular meeting of Valley Clean Energy , held on the _____ day of _____ 2025, by the following vote:

AYES:
NOES:
ABSENT:
ABSTAIN:

_____
Bapu Vaitla, VCE Chair

_____
Alisa M. Lembke, VCE Board Secretary

UCDAVIS
California Lighting Technology Center
Department of Design

Evaluation of Smart Home Load Flexibility under Varying Utility Programs and Household Operations

A laboratory and field study.

Abstract

In response to the success of the Panasonic partnership, the joint research completed to date and significant interest of new organizations, UC Davis proposes an expansion of its smart home research to address two important topics: 1) continuation and expansion of research at the Sacramento area SHFT to further develop customer nudging and HEMS control features and 2) deployment of a new smart home RTP field testbed in Yolo County to study load flexibility technologies, their deployment, and customer participation under RTP programs.

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Introduction

The California Lighting Technology Center at UC Davis (CLTC at UCD), leveraging funding and partnerships with NEDO, Panasonic, and SMUD, has established a Smart Home Laboratory (SHL) at its facilities in Davis, CA. The Smart Home Laboratory is a dynamic testbed used for evaluating emerging residential energy and load flexibility technologies and strategies. It includes a set of residential living spaces, which can be modified to accommodate smart home appliances and devices and is equipped with environmental sensors to monitor and automatically control selected devices based on programmed constraints. The SHL also includes device-specific instrumentation and data visualization tools to report performance in real-time.

In parallel, CLTC developed, deployed, and now manages in partnership with SMUD, a Smart Home Field Testbed (SHFT) of eight single-family homes in the Sacramento area that is used to understand smart home technology, demand flexibility and residential control strategies in-situ under normal day-to-day home schedules and activities. The SHFT is outfitted with environmental sensors, device controls and a range of smart home technologies, allowing for data collection on technology performance including energy and demand flexibility use and savings. The SHFT also provides research opportunities on human factors, occupant behaviors and user attitudes associated with smart home technology, related utility programs and other strategies such as nudging and messaging.

During a previous field study at the SHFT, partners such as SMUD, PG&E, Valley Clean Energy (VCE) and the California Energy Commission (CEC) provided feedback about the home energy management system (HEMS) functionality they wish to prioritize as part of future HEMS research. These partners, as well as CLTC, are interested in technologies and strategies for automatically shifting and/or shedding residential load to improve grid reliability, reduce peak demand, enable residential energy resiliency and lower costs for customers.

- SMUD wants to automatically shift at least 1 kW of residential load, excluding air conditioning (AC) and implement BESS in a variety of home types to understand the cost and reliability of load shifting while pursuing their net zero goals for 2030.
- PG&E has approval from the CPUC to implement a residential real time pricing (RTP) pilot and is interested in understanding the reliability of residential load scheduling based on RTP signals (see Appendix A for more information).
- VCE also plans to implement residential RTP and wishes to evaluate the load shift benefits of using a HEMS to automate appliance operation and inform customers about current and upcoming energy prices (see Appendix B for more information).
- PG&E and VCE want to identify the best technologies for inclusion in RTP programs and understand how they can be used successfully when operating in response to a dynamic pricing signal.
- All partners wish to quantify the availability, reliability, potential costs and cumulative benefits of using residential, site-level, BESS as a utility program resource to reduce their resource adequacy (RA) costs, which currently range between $180/kw-yr and $360/kw-yr.
- CEC wants to determine the availability and magnitude of shiftable, residential load during evening, peak, summer hours (7 PM to 9 PM, typically) associated with electric water heaters, heat pump AC, dishwashers and electric clothes dryers.
- CEC is also interested in testing the communications reliability of smart, electric, water

heaters so that they may be considered as part of future regulatory updates to California's Load Management Standards.

General Research Description

In response to the success of the Panasonic partnership, the joint research completed to date and significant interest of new organizations, UC Davis proposes an expansion of its smart home research to address two important topics: 1) continuation and expansion of research at the Sacramento area SHFT to further develop customer nudging and HEMS control features and 2) deployment of a new smart home RTP field testbed in Yolo County to study load flexibility technologies, their deployment, utility program structures and customer participation under RTP programs with and without nudging.

Topic 1: Smart Home RTP Testbed – Yolo County, CA

CLTC, in collaboration with PG&E, VCE and Panasonic (collectively called "Team") proposes to deploy and evaluate a residential load management pool composed of approximately 50 households for the purposes of providing aggregated load shift/shed resources in response to utility/grid operator requests and real-time pricing signals. The total, aggregated load available for shift and/or shed is planned at 400 kW provided by smart heat pump water heaters, smart heat pump space conditioning, electric vehicle (EV) chargers and behind-the-meter, (BTM) battery energy storage systems (BESS). The Team plans to enroll participating households in PG&E's RTP pilot rate called Hourly Flex Pricing, which will be dispatched by GridX, a utility rate design and PG&E program partner.

Currently, automated reductions of residential loads like water heating and space conditioning are not eligible loads to be counted for use in resource adequacy programs. This means that utilities cannot count the value of the load reduced by automatically shifting the operation of these appliances as an option for meeting their energy generation targets. Therefore, the inclusion of these devices as part of this research will serve to quantify their overall contribution in terms of kW-hours for future use.

For this research, "availability" means determining when appliances are typically "ON" so that utilities can plan for controlling them as part of a load management program or as an alternative to traditional energy generation (solar, etc.). This data is not currently available to the utilities or the public for planning purposes. "Feasibility" means quantifying the magnitude of energy use that can reasonably be shifted as part of that same program. So, for example, just because a HP product may be "ON" for a certain number of hours per day, if those hours do not align with the time of day needed by the utility, the feasibility of using them as part of a utility program is reduced. This type of study is critical in pilot programs. Individual technologies like HP appliances must be tracked and measured in many households before the utility can determine a value to use in their energy planning activities.

If these technologies are determined to contribute a significant amount of energy at a certain time of day or season, then they can be used to meet project targets. Currently, our study will help the utilities to quantify the value of these technologies. That is the intent of the HFP pilot, as well. The utilities are trying to understand how different residential devices can contribute to overall load flexibility and resource adequacy programs.

In California, barriers to use of residential, demand-side load aggregation combined with dynamic pricing exist as technical and programmatic knowledge gaps in several important areas. First, California community choice aggregators like VCE have yet to attempt enrollment and automated dispatch of RTP to their residential customers in partnership with the IOUs. This approach is untested,

and its demonstrated value as a demand-side resource is yet to be fully determined and documented [1,5]. The Smart Home RTP Testbed will provide a clear method to test and learn how to expand RTP rates to more customer segments and end uses to support grid reliability and ensure adequate electric power during times greatest need[2]. In addition, this project will inform PG&E, VCE and other interested load-serving entities (LSEs) on methods, challenges, and solutions for implementing automated RTP to achieve cost-effective shift DR prior to the January 2027 deadline contained in the Load Management Standards for hourly RTP to be available to all customer classes[3].

Secondly, most IOUs and CCAs have limited to no experience with co-design and implementation of dynamic rates and programs for the residential sector using a shared pricing server like GridX that can serve customers from both groups simultaneously.

Last, the actual value of demand-side, BTM programs and technologies lacks real-world data to support claims[4]. All types of stakeholders, from individual customers to aggregators to LSE's, have yet to invest in the research, development, or demonstration for DR combined with residential end-use automation and RTP necessary to collect and validate energy use, demand, and related savings of this approach. While California represents the largest portion of DR operating today, these DR programs focus on supply-side DR services and event-based load reductions.

This research will provide insights on RTP rate design, customer recruitment, two-way communications between utilities and customers through Panasonic as an ASP, the load reduction value of specific residential end-uses in real-world applications, and coordination between community members, technology providers, CCAs and IOUs[5].

The overall EP2 pilot program/project is funded at tens of millions of dollars by the California Public Utilities Commission. No single entity, other than the utility itself, can run a study that focuses on the entire pilot. Therefore, this research project proposed by CLTC is designed to help answer a subset of questions with information needed by the utilities to inform future residential RTP load management programs. CLTC's mission is aligned with the goals of the pilot program, and we believe that the research proposed is also aligned with Panasonic's interests to understand RTP programs, load management and methods for deploying load management strategies and technologies in Japan. Learning from both the pilot and the subset of research contributed by this project are critical for helping Panasonic understand its role in future US programs as well as its role in forthcoming Japanese RTP / energy programs.

Given the breadth of potential research areas and opportunities associated with such a project, CLTC and its partners propose to address the following specific research questions:

1. What is the composition of the smart technology stack (combination of smart home devices and DERs) that provides the most cost savings for customers when those

[1] Existing valuation of RTP and residential VPPs in California are based on modeling not measured performance.

[2] PG&E Advice Letter 7223-E submitted to CPUC March 25, 2024.

[3] California Load Management Standards.

[4] LBNL, "California Demand Response Potential Study, Phase 3".

[5] Each of these RTP and DR goals and objectives will help California to meet its statutory energy and demand flexibility goals including its goal to achieve 7,000 MW of demand flexibility by 2030 per Senate Bill 846 (Statutes of 2023).

customers are enrolled in RTP? Are there existing incentives or potential for new incentives that benefit the customer and the utility when considering specific, smart home technologies?

2. What are the typical load profiles for residential HP water heater, HP space conditioning, and other appliances in a SF and/or multi-family home?
3. Can residential load aggregation of select technologies be reliable[6] enough to reduce a utility's resource adequacy (RA) burden? Can we confidently justify, based on project results, a capacity factor for residential load shift/shed?
4. What is the potential of residential load shift/shed at the service territory and state level assuming estimates are based on measured field data?

Partner Roles and Responsibilities

- GridX, on behalf of PG&E and VCE, will program and dispatch a customized HFP signal reflecting LSE-specific prices as well as transmit event-based signals that indicate grid operator needs in real-time.
- VCE will assist with participant recruitment and rate enrollment, as needed, and conduct project performance evaluations supporting the utility business perspective.
- CLTC will complete recruitment and enrollment activities required by UC; survey, design and manage technology installations at each participating home; and test, in its laboratory, basic functionality and ensure connectivity among smart appliances, EV charges, BESS, intermediate software or HEMS necessary for integration between BTM loads and the price server. CLTC will also equip each home with necessary monitoring equipment, collect performance data develop load profiles and quantify load shift/shed for each event and over time in relation to the RTP.
- Panasonic will serve as the automation service provider (ASP) by providing the necessary integration solution for ensuring each home load responds as designed to the RTP and event signals. Integration may be provided in the form of a hardware and/or software solution such as a HEMS, directly between the GridX server and each appliance using custom programming and APIs, or a combination of measures.

VCE must serve as the initial point of contact for the individual customers in their service territory. They will give CLTC access to a set of customers who are most likely to qualify for inclusion in this study and they will facilitate meetings between CLTC and selected customers. In addition, VCE will create and distribute program materials on this study like flyers and surveys to help CLTC to engage

[6] Load shift reliability is defined by the percent of the enrolled loads participating in the load shift event and how many hours that load shift remains in place. In a recent meeting, SMUD mentioned that 60-80 percent of enrolled customers participate in thermostat program load shift events. After one hour, up to five percent of people manually override control settings to nullify the load shift. After two hours, up to an additional five percent of participants nullify the load shift, followed by an additional five to 15 percent of participants opting out after hour three. By hour four, SMUD reports that 20-60 percent of people ended their participation in a load shift event; however, SMUD requires at least four hours of uninterrupted load shift to count the load for its market programs.

with the customers interested in participating.

Based on the initial pool of participants provided by VCE, CLTC will identify those of interest, call them and visit their home as needed to verify technologies identified in the surveys. Once CLTC identifies the best DERs to implement in the homes and provides the customer with a research use agreement, the customer can agree to participate and CLTC will enroll the participant by executing research use agreements (RUA) between UC and the participant. These RUAs are required to conduct a study on property not owned by the University. VCE will enroll the participant in any rate programs needed to execute the study.

Technical Specifications

This Smart Home RTP Testbed implementation is composed of three discrete technical elements: 1) the communication systems necessary for two-way exchange between LSEs, enabling technologies and residential participants; 2) the forecasted RTP prices and RTP signal; and 3) the enabling technologies and BTM DERs installed in each household.

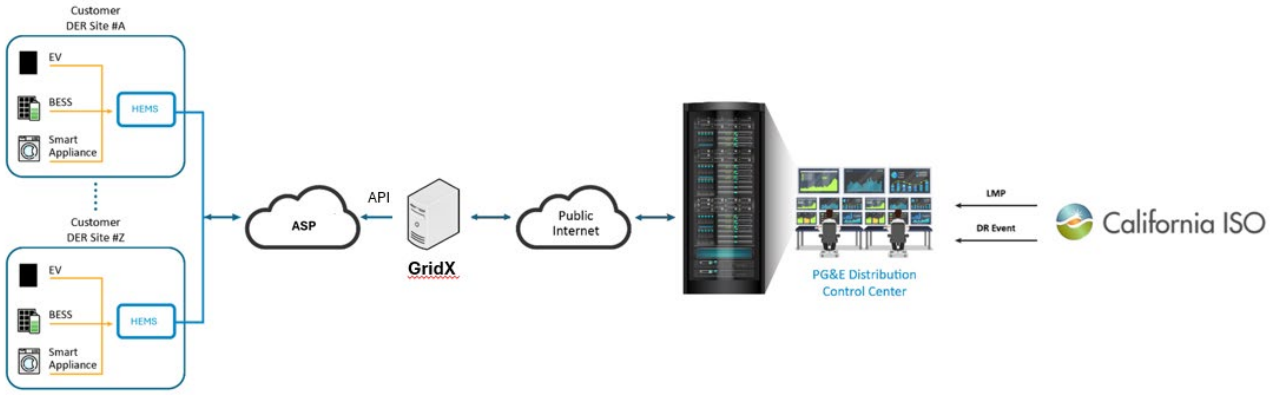

Figure 1. Residential distributed energy resource (DER) bi-directional communication network from the HEMS to the ASP aggregator network, GridX, public internet, PG&E's distribution control center, and CAISO.

In addition to evaluating the business case for residential load shifting from the VCE's utility perspective and Panasonic as an ASP, this research will evaluate the availability and feasibility of using heat pump water heater, heat pump HVAC, EV chargers and BESS technologies in both single and/or multi-family buildings located in VCE service territory and controlled in response to PG&E/VCE's upcoming Hourly Flex Pricing signal, which is slated for customer launch in 2025. See Appendix A for more information on the Hourly Flex Pricing pilot (previously called Expanded Pilot 2 or EP2) including a depiction of the planned system architecture.

Specific smart appliances and residential distributed energy resources (DERs) of interest include:

- Solar photovoltaic generation (site-level)
- Battery energy storage systems (site-level)
- Heat pump water heaters
- Heat pump HVAC
- EV chargers and control systems (uni- or bi-directional)

Home Energy Management Systems

The ideal home energy management system (HEMS) is "an intelligent network control system that can integrate all power generation, power consumption, and energy storage equipment in the home for control and management, …, change the power consumption habits of the user, reduce the user's electricity bill, and realize two-way communication with the grid, two-way energy flow, etc." The HEMS in this project will connect the DERs and smart appliances (heat pump water heaters, heat pump HVAC, EV chargers and BESS), and implement state changes wirelessly, provide two-way communication with a secondary ASP device/cloud software and/or act directly implement the load shift for each of the DERs and smart appliances and inform the appliance users of the load shift plan before and during the event via audio or visual messaging.

Using a HEMS device provided by the ASP, smart technologies will be programmed for automated response and/or operation based on hourly prices, which will be provided by the HFP pilot. In addition, certain households in low-income, disadvantaged and/or high-fire risk communities may qualify for non-Panasonic BESS, which can be used to replace grid-provided electricity during the costliest hours of the day, LSE peak periods or unscheduled, emergency events, as well as deliver additional capacity back to the grid when available.

The Smart Home RTP Testbed will target a subset of EP2 participants enrolled with VCE. The EP2 enrollment goal is 50 MW of flexible load provided by participation from 500 – 1000 residential customers. The Smart Home RTP Testbed is aligned with this goal, and the Team expects to enroll 5-10% of EP2 participants in its to achieve 400 kW of load-modifying flexibility during PG&E and VCE's annual peak hour(s). Community members currently on rate plans EV2-A and E-ELEC will be eligible for the Smart Home RTP Testbed (and EP2 pilot) per D. 24-01-032.

Dynamic Rate and Price Signal

Dynamic electricity rates are the gold standard for realizing load flexibility opportunities[7]. For this project, dynamic electricity pricing will be provided by PG&E as part of the "Expanded Pilot 2" (EP2) authorized in January 2024 by the CPUC under Decision 24-01-032. The dynamic rate, called Hourly Flex Pricing (HFP), will provide eligible PG&E and VCE residential customers with time-varying hourly prices that reflect forecasted demand, associated cost, and imbedded carbon intensity of grid-supplied electricity. Higher hourly prices will reflect the need for households to conserve electricity in support of local and system electric reliability. Hourly Flex Pricing will encourage households to schedule their loads during the most cost-effective hours of the day. The EP2 pilot is authorized to provide summer reliability benefits through December 2027. Today RTP is available on the PG&E website here Current Hourly Flex Pricing starting in November 1st, of 2024.

To support this CPUC decision, the Team will utilize Gridx, a tariff design expert, to produce a non-binding, rolling, seven-day forecast of electricity prices under a new rate, called Hourly Flex Pricing (HFP). HFP will provide a dynamic rate similar to the hourly pricing signal provided by VCE in its original RTP pilot designed for agricultural customers (AgFit). AgFit used dynamic generation and distribution rate components, customer subscriptions, and transactive buy/sell options based on the CPUC Energy Division (ED) Staff's CalFUSE framework. PG&E's EP2 dynamic rate, HFP, contains

[7] CEC, Commission Report, "Senate Bill 846 Load-Shift Goal Report", page 27, May 2023.

the same dynamic rate components and customer subscription as the VCE Ag Pilot but does not have the transactive elements. Participating households will connect to the GridX signal to receive price forecasts either directly, via local management, or from aggregated management signals from third-party automated service provider (ASP), Panasonic, via WIFI/LTE to the secure receivers at the participant's home.

A draft of the GridX API specification may be found here: Calculate API GridX Docs.

Automation Service Provider

Automation service providers (ASPs) receive utility program funds to automate customer devices and respond to dynamic pricing signals, with specific rates depending on the program and the amount of load managed. Incentives are often based on kW-yr magnitude of customer loads managed. ASP incentive rates reflect the program complexity, enrollment difficulty and anticipated customer availability associated with program participation. Higher incentives are used to encourage program participation. When higher incentives are available, ASPs are more motivated to seek out and enroll participants, thereby increasing program adoption. Lower rates reflect a program with less complex program requirements, a larger eligible customer base, and therefore higher levels of expected customer participation. Other ASP payment methods include annual flat rate payments based on the magnitude of annual customer load managed and rates that vary based on the customer sector or customer response frequency. Exact rates vary among utilities and programs. Additional information on ASP incentive and payment structures may be found on the CPUC website for each approved program utilizing one or more ASPs. CLTC can research and document current and expected rates for ASP incentives to help Panasonic create a business case for ASP services in California.

Enabling Technologies

Smart appliances, BESS and EVs are all widely available DERs will the potential to deliver automated load management for residential customers. From the utility perspective, all are considered BTM, demand-side resources capable of contributing to, but not formally accounted for, as part resource adequacy programs. Therefore, consistent reductions in BTM energy use over time may contribute to resource adequacy credits for the utility, which could ultimately be used to invest in shift DR, RTP and associated incentives passed on to ratepayers. In addition, demand potential studies estimate that when these technologies are augmented by universally applied dynamic pricing, they could contribute up to 3.5 GWh of load shift[8].

Laboratory evaluation is necessary to determine and verify basic functionality, connectivity and controllability of any appliance, device or system proposed for use in a customer's home. Technologies must be tested for compatibility with ASP aggregation software/systems. A minimum set of requirements will be developed for each technology type. Eligible technologies will then be made available for home installation and the results of each evaluation can be shared with participating ASPs to improve installation and commissioning efficiency.

A general list of performance criteria includes, but is not limited to, the following:

1. Appliance includes native WiFi or central control hub connection capabilities to view data

[8] LBNL, "The California Demand Response Potential Study, Phase 4: Report on Shed and Shift Resources Through 2050," May 2024.

from a remote source. The appliance should have a functional API that can be queried to collect data and transmit change of state commands to the appliance.

2. Space conditioning and water heating appliances must provide temperature setpoint control accessed via its API.
3. ASP must provide hardware and software services that enables connection to the GridX price server via its API to gather and interpret pricing signals at least one day ahead and hourly to generate load shift schedules and logical sequence of events that can be sent to a HEMS or directly to an appliance in the customer's home.
4. CLTC will verify connection of the ASP hardware/software to the price server and/or VCE as prices, schedules and similar information is sent to the HEMS by recording the information received by the HEMS. CLTC will also evaluate the repeatability and reliability of the ASP to receive and send information.
5. CLTC requires that a HEMS be able to connect to the DERs and smart appliances (heat pump water heaters, heat pump HVAC, EV chargers and BESS), and implement control commands wirelessly, provide two-way communication between the signal provider (ASP hardware/software or GridX server directly) and the home appliance/system, and inform the appliance users of the load shift plan before and during the event via audio or visual messaging.

In addition, PG&E and VCE have yet to determine the specific residential appliances that will be eligible or incentivized under the RTP pilot. They do expect to include customers with existing BESS and EVs; and the laboratory research on smart home appliances proposed herein is designed to support these utilities during pilot planning over the next 6-12 months. Similarly, PG&E and VCE have yet to determine the communication and commissioning logic needed to make these loads responsive to the Hourly Flex Pricing signal. Therefore, this research, its questions and their outcomes all focus on advancing performance and market adoption of residential load flexibility solutions that provide value to local utilities, customers and manufacturers.

Research Activities

UC Davis will survey local utilities customers (VCE and PG&E) to gather appliance information and determine a typical single-family home and multi-family home appliance configuration. CLTC will then select approximately 50 homes to form the new RTP Field Testbed in Yolo County (VCE+PG&E service territory). The economic strata of selected customers, building types such as single family, duplex and multi-family homes, and occupancy arrangements such as rental versus owner-occupied dwellings will be determined in advance of site selection.

Following participant selection and enrollment, CLTC will deploy power measurement equipment to collect individual load profiles and operating schedules of major appliances at each test site. Collection of baseline information will then be followed by procurement, installation and evaluation of emerging smart home appliances/devices appropriate for use with dynamic utility tariffs. Activities will also include continued engagement with utility leadership and partner R&D teams to understand potential benefits of smart appliances combined with HEMS for relevant programs and customers.

CLTC will verify connection of HEMS to the appliances, monitor energy consumption of loads to ensure load shift, monitor HEMS notifications to appliance users, and survey appliance users before,

during and after the project. CLTC will also evaluate the repeatability and reliability of the HEMS to change the state of the DERs and smart appliances and messaging to ensure load shift effectiveness and communication with load users.

Additional research questions to be addressed include:

- How much load can be shifted with a BESS in the average California home in VCE and PG&E territory?
- What is the process for connecting a BESS and HEMS to an RTP server?
- Does inclusion of local BESS make residential load shift participation more reliable in both magnitude and frequency as compared to homes without local BESS?
- What are the costs, permits and other implications of implementing a BESS in a single-family home and/or multi-family building?
- How prevalent are heat-pump water heaters, heat-pump HVAC and EVs in the average California home in VCE and PG&E territory?
- What are the necessary connectivity and integration requirements for heat pump water heaters, heat-pump HVAC and EV chargers to operate in conjunction with a HEMS, BESS and an RTP signal such as Hourly Flex Pricing?
- Are automation service providers necessary for connecting, maintaining or managing any part of a residential system enrolled in RTP programs? What is their role, if any, and what value do they provide to the utility and/or customers?

Task 1: Enroll and Survey Participants

UC Davis will identify and enroll approximately 50 households to form the RTP Field Testbed in Yolo County. UC Davis will determine, in advance, the household characteristics of interest and use this information as the basis for participant selection. Following enrollment, UC Davis will survey testbed participants to gather appliance information and determine the typical single- family home and/or multi family home appliance configurations for this demographic.

- Deliverable: RTP Field Testbed Participant memo

Task 2: Laboratory Evaluation of Select Technologies

UC Davis will complete laboratory evaluations of battery energy storage technologies, heat- pump water heaters, heat pump HVAC, EV chargers and other selected smart home technology to determine those that are feasible and ready for field testing. Technologies will include emerging products and engineering prototypes provided by partner organizations. Work will include BESS and smart appliance installation and testing to verify functionality in response to dynamic residential rates and pricing signals such as the Hourly Flex Pricing, which will be deployed through the GridX and integrated at each home by the ASP. UC Davis will document a preliminary installation procedure for certain tested devices to help streamline the field demonstration to be conducted in Task 4.

- Deliverable: Lab Evaluation Memo, Preliminary Installation Procedure(s)

Task 3: Field Installation and Operations Planning

UC Davis will develop load shift operating plans for residential single and/or multifamily buildings equipped with smart appliances, HEMS and energy storage operating under Hourly Flex Pricing. UC Davis will collaborate with utility partners, customers and other stakeholders to ensure operating plans and schedules reflect viable load shed and savings opportunities for both the customer and the utility. Outcomes will include a step-by-step programming/commissioning guide for technology providers, installers and customers that will help these groups to establish appliance operating plans that best suit their needs while ensuring they receive the financial benefits available with RTP.

- Deliverable: Load Shift Operations Memo, Smart Home Programming Guide for RTP Customers

Task 4: Field Study

UC Davis will deploy a field study of at least 50 homes enrolled in PG&E/VCE Hourly Flex Pricing. UC Davis will install power meters to quantify potential for residential electricity load shift at each home. Once the baseline is determined, UC Davis will procure some equipment (power measurement hardware, internet routers, and EV chargers), and oversee the installation of this equipment and donated smart appliances/devices (heat pump water heaters and heat pump HVAC), along with a HEMS plus donated DERs like BESS (up to 25 homes) to demonstrate load shift operation and quantify the savings potential in residential single-family homes and multifamily buildings. The field study will support development of the programming guide (Task 3) and provide experience and data necessary for determining the costs and benefits of using various smart home technologies for homes enrolled in RTP.

- Deliverables: Available Shiftable Load Memo, Load Shift Feature/Device Results Memo (for each feature incrementally).

Task 5: Final Reports

UC Davis will document research activities and outcomes in a final project report and provide recommended next steps for continued research. Work will include presentations and meetings with project stakeholders to share research findings and, potentially, engage new partners.

Research outcomes and lessons learned will be valuable for informing and improving future RTP deployments in California and elsewhere.

- Deliverable: Final Report and Presentations

Proposed Topic Budget and Schedule

- Duration: 3.0 years
- Proposed start date: January - March 2025
- Total Budget Request: $2,682,000 + $12,000 per additional home above 50 homes
    - Includes $600,000 for smart home technologies, installation, maintenance and monitoring over three years: $12,000 per home: up to $5,200 equipment ($1,800 for measurement equipment hardware/install and up to $3400 for smart appliances but

others smart appliances can be evaluated if donated), $600 customer incentives, $1,450 home site internet and other routine maintenance costs for sensors and data collection devices, $4,750 CLTC staff labor and/or installation contractor costs over the duration of project to install and maintain each home/field site.
    - Includes $140,000 for Valley Clean Energy labor to support project enrollment and research.
    - ASP services/functionality/equipment provided by Panasonic or up to $250,000 additional funding to contract with 3rd party ASP. Cost of 3rd party ASP to be determined based on final customer and appliance inventory.
- Panasonic: Requested Equipment/In-Kind Support
    - EverVolt BESS equipment (hardware and software with functional API) – at least 25 for first 50 homes, then more if Panasonic elects
    - SmartBox equipment – at least 25 units, more if Panasonic elects
    - Solar photovoltaic generation – Qty TBD by Panasonic

- Daiken: Additional Requested Equipment/In-kind Support
    - Heat pump water heaters (Daikin) – 15 for first 50 homes (15 annually, 2 years), then more if desired by Daiken and Panasonic
    - Heat pump HVAC (Daikin) – 15 for first 50 homes (15 annually, 2 years), then more if desired by Daiken and Panasonic: Equipment + Installation estimated at $150,000.
    - Daiken project support: $300,000.
        - 1st payment due at project launch: $100,000
        - 2nd payment at 12-month milestone: $100,000
        - Final payment 24-month milestone: $100,000

TOPIC 1: RTP Field Testbed	2025				2026				2027			
Research Activity	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Task 1: Enroll & Survey Participants												
Task 2: Lab Evaluation of Select Technologies												
Task 3: Field Installation & Operations Planning												
Task 4: Field Study												
Task 5: Final Reports, Project Management												
Annual Research Budget - Base only	$ 847,822				$ 1,377,652				$ 457,047			
Annual Research Budget - Base + Expanded HP + Partner Match	$ 1,142,822				$ 1,652,652				$ 627,047			

Research Activity	2025	2026	2027	Funding Request	Partner Match/In-kind
Task 1: Enroll & Survey Participants	$ 102,863	$ -	$ -	$ 102,863	
Task 2: Lab Evaluation of Select Technologies	$ 404,234	$ 323,387	$ 80,847	$ 808,468	
Task 3: Field Installation & Operations Planning	$ 259,984	$ 86,661	$ -	$ 346,645	
Task 4: Field Study	$ -	$ 887,105	$ 295,702	$ 1,182,807	
Task 5: Final Reports, Project Management	$ 80,740	$ 80,499	$ 80,499	$ 241,738	
Annual Base Research Budget	$ 847,822	$ 1,377,652	$ 457,047	$ 2,682,522	
Additional Funding: Daiken HP/CLTC scope	$ 100,000	$ 100,000	$ 100,000	$ 300,000	
Additional Funding: Daiken, Materials and install*	$ 75,000	$ 75,000	$ -	$ 150,000	
Additional Funding: VCE In-Kind Support	$ 70,000	$ 50,000	$ 20,000	$ -	$ 140,000
Additional Funding: PG&E In-Kind Support	$ 50,000	$ 50,000	$ 50,000	$ -	$ 150,000
Total Annual Funding Request: Base + HP Expansion	$ 1,142,822	$ 1,652,652	$ 627,047	$ 3,132,522	$ 290,000

Match Funding

- Total Match Funding: $290,000
    - Valley Clean Energy is providing $140,000 in match funding in the form of in-kind services to support participant recruitment and utility billing and support.
    - PG&E is providing approximately $150,000 in match funding in the form of in-kind services to support deployment of the HFP signal, utility bill data analysis and related support.
- CLTC expects to leverage additional utility funding provided by the following programs:
    - Hourly Flex Pricing – ASP incentives of at least $42 kW-yr of managed enrollment
    - Energy Savings Assistance – incentives for purchase and installation of smart home appliances for CARE and FERA rate customers.

Topic 2: Smart Home Field Testbed – Sacramento, CA

The SMUD project provided the first evidence that specific residential appliances may be useful and "reliable" as a load-shift resource for energy planning purposes. The sample size and duration of the data collected in that study, while very promising, does not provide the level of rigor required for the IOUs to rely on the data for system-wide planning purposes. Therefore, we are proposing a larger study group to validate some of the original SMUD findings and continue to quantify and refine the value of these resources for use in future utility programs and tariff design. This research is important for the utilities and the product manufacturers because should specific residential appliances be found "reliable" and "available", then the utilities can use them as a lower-cost alternative to traditional energy generation and manufacturers know that the demand and subsequent sales of these appliances will grow and be sustained in the IOU markets.

SMUD has expressed interest in understanding the benefit of using a HEMS to nudge homeowners to avoid electricity use under their new critical peak pricing (CPP) rate structure rather than using phone and/or email notifications. SMUD also expressed interest in exploring the load limiting HEMS feature developed by CLTC as part of its prior research at the SHFT. See Appendix C for more details. CLTC hypothesizes that the load limiting feature is the next step required for effective load management after load shifting itself, because once loads are shifted out of a specific time period, these loads are likely to be reenergized at full power later in the day causing a large spike in electricity demand (Figure 1). Large spikes can be costly to customers in terms of demand charges, regardless of the energy price for the time period.

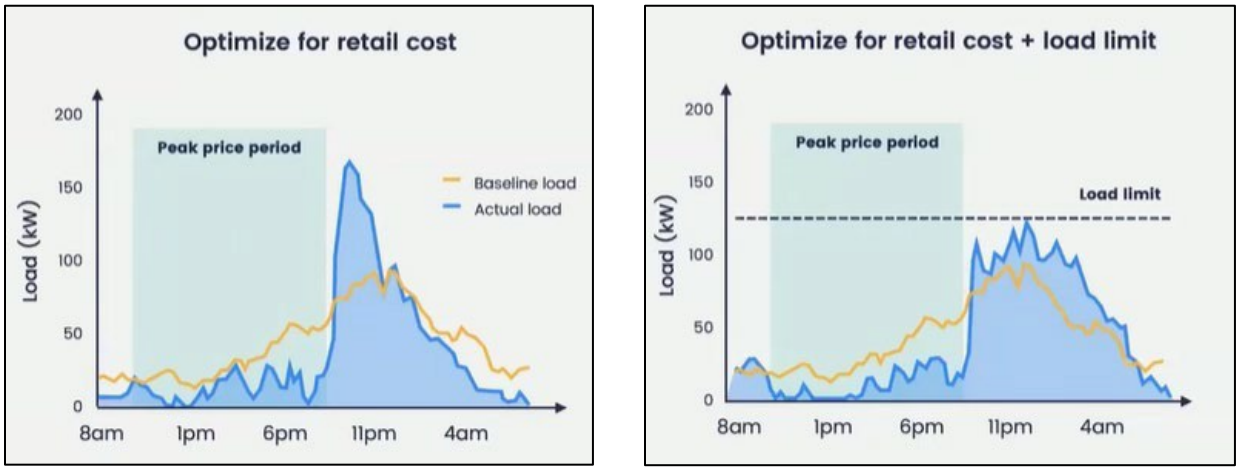

Figure 1. Example of loads shifted away from the peak price period and set to begin at 8 PM without load limiting (left), which causes an unnecessary spike in demand, and an example of the same loads shifted to start at 8 PM, but limited to not exceed 130 kW, which reduces the spike by staggering the start times of individual loads over several hours (right)[9].

SMUD also provided feedback that they only offer load shifting in an opt-in arrangement, rather than an opt-out arrangement, which is also the arrangement previously implemented for the thermostat, dishwasher, clothes washer and clothes dryers tested previously at the SHFT. Opt-in nudges are nudges where the user is notified about an upcoming opportunity to shift load, and the user can choose

[9] https://www.energyhub.com/resource/webinar-recording-future-of-vpps-cross-der/

to participate by postponing appliance use or continue to use their appliance as usual. Opt-out nudges are nudges where the user is told that the load will be shifted automatically (dishwasher is automatically set to delay mode, for example) and the user must manually start their appliance/load to operate and override the shift/delay. It is hypothesized that the acceptance and reliability of load shifting will increase with the opt-out control style rather than the opt-in because the decision has already been made in advance and the user will not take additional actions to override the system. Seven of eight homes in the SHFT are interested in participating in a study with this control type. SMUD also expressed interest in understanding the difference in effectiveness between the two approaches.

In response to SMUD and other partner feedback, UC Davis proposes to continue studying the eight SMUD homes, and possibly expand the testbed to include up to 20 homes, in order to evaluate refined controls features and determine when and why nudges are accepted by homeowners enrolled in alternative utility plans such as SMUD's CPP electricity rate. See Appendix C more information about CPP. Desired research outcomes focus on advancing performance and market adoption of residential load shifting related to CPP demand events and different nudge/automated load shift approaches to existing and new smart appliances/devices.

New smart appliances/devices of interest include:

- Lighting (dimming)
- Lighting + TVs (dimming).
- EV Charging (delay)
- TVs (dimming)
- Ceiling fans (fan speed and on/off control)
- Kitchen ventilation fans (fan speed & on/off)
- Bathroom/Laundry ventilation fans (fan speed and on/off)
- Windows (open/close)
- Plugged in device (ideal time for use, and on/off)
- Cooking range (delay)

Research Activities

UC Davis will continue to engage with the existing SHFT and SMUD customers to gather additional data and insights on their residential load profiles. This research will include identification, procurement, installation and evaluation of new emerging smart home appliances/devices as appropriate for the SMUD testbed including enrollment of up to 12 additional households. Activities will also include continued engagement/support of utility leadership and R&D teams to understand potential benefits of smart appliances combined with HEMS for relevant programs and customers.

Research questions for this topic include:

- How much more load shift is achieved when homes have a Critical Peak Pricing (CPP) electricity rate structure in place than with the standard TOU or flat electricity rate structures?
- Does load shift engagement increase or decrease when nudges are presented visually and audibly on a screen near the appliance as compared to SMUD's standard communication methods using email and text?
- What is the incremental load shift acceptance benefit for residential loads when comparing SMUDs standard opt-in and CPP communications to opt-out messages displayed on a speaker/display on or near the smart appliance being load shifted?
- What is the incremental load shift acceptance benefit for residential loads when comparing opt-out nudges to opt-in nudges displayed on a speaker/display on or near the smart appliance being load shifted?
- What is the acceptance rate and total load shift effectiveness of a systemic, residential, load limiting control feature compared to periodic financial incentives/nudges?
- What is the acceptance rate and total load shift effectiveness between various messaging formats such as nudges reporting relative cost savings (% savings) compared to absolute cost savings ($ savings)?

Task 1: Field Test and Technology Planning

UC Davis will evaluate new smart appliances/devices in its smart home laboratory, then develop and/or evaluate refined load shifting and nudging features to determine the best suite of products and control strategies for field deployment. The goal is to identify the products and communication strategies with the most potential for use (magnitude and frequency of shifted load) as part of residential load shifting for customers operating under time-varying utility pricing programs such as SMUD's CPP.

- Deliverable: Laboratory Evaluation Memo

Task 2: Stakeholder Review

UC Davis will invite stakeholders to review the new features, functionality and deployment methodology at CLTC's SHL in order to gather additional insights and feedback before finalizing the second cohort of smart home technologies and control strategies for field deployment at the SHFT.

- Deliverable: Stakeholder Feature Review Memo(s)

Task 3: Field Deployment and Analysis

UC Davis will install and evaluate new smart home technologies and control strategies at its SHFT to quantify their residential load shifting potential. New technologies may include lighting, TVs, ceiling fans, kitchen ventilation fans, bathroom/laundry ventilation fans and cooking ranges. UC Davis will analyze the acceptance of load shifting nudges, collect data and report on findings. Results will be shared with SMUD and other interested parties to gather further development support and ongoing testbed participant engagement.

- Deliverable: Available Shiftable Load Memo, Load Shift Feature/Device Results Memo (for each feature incrementally)

Task 4: Final Report

UC Davis will document research activities and outcomes in a final project report and provide recommended next steps for continued research. Work will include presentations and meetings with project stakeholders to share research findings and, potentially, engage new partners.

- Deliverable: Final Report and Presentations

Proposed Topic Budget and Schedule

- Total Budget: $1,200,000
- Duration: 3.0 years
- Start Date: January - March 2025

	2025				2026				2027			
Research Activity	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Task 1: Field Test & Technology Planning												
Task 2: Stakeholder Review												
Task 3: Field Deployment & Analysis												
Task 4: Final Reports												
Annual Research Budget	$400,000				$600,000				$200,000			

Appendix A: Expanded Pilot 2

Dynamic electricity rates are the gold standard for realizing load flexibility opportunities[10]. Dynamic electricity pricing will be provided by PG&E as part of the "Expanded Pilot 2" (EP2) authorized in January 2024 by the CPUC under Decision 24-01-032. The dynamic rate, called Hourly Flex Pricing (HFP), will provide eligible PG&E and VCE residential customers with time-varying hourly prices formatted to meet the OpenADR 3.0 communication standard. Pricing will reflect forecasted demand, associated cost, and imbedded carbon intensity of grid- supplied electricity.

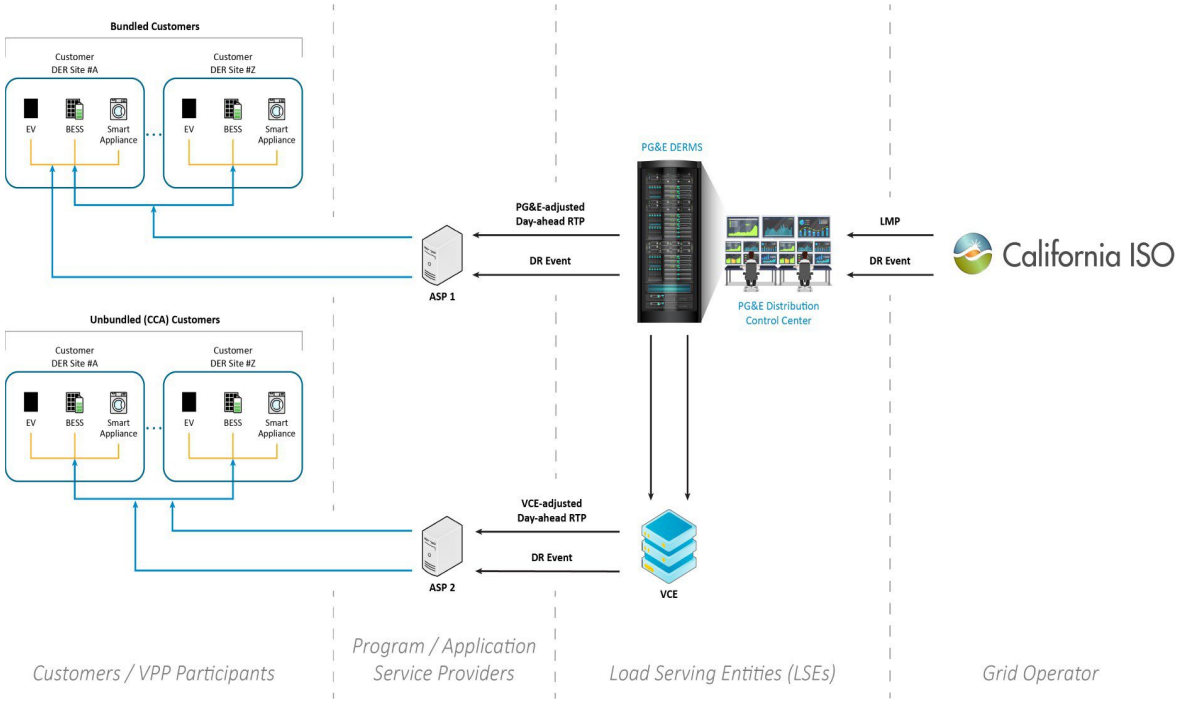

Figure A1. Expanded Pilot 2 system architecture.

Higher hourly prices will encourage households to conserve electricity in support of local and system electric reliability by scheduling their loads during the most cost-effective hours of the day. The rate will be formatted and delivered according to the OpenADR 3.0 communication standard. The EP2 pilot is authorized to provide summer reliability benefits through December 2027. A copy of the CPUC's final decision regarding EP2 implementation is provided as Attachment A.

This project will target a subset of EP2 participants located in Yolo County including both bundled (PG&E) and unbundled customers (VCE). The EP2 enrollment goal is 50 MW of flexible load provided by participation from 500 – 1000 residential customers. For this research, the team expects to enroll 50 EP2 participants to achieve to demonstrate load-modifying flexibility over the course of one year.

[10] CEC, Commission Report, "Senate Bill 846 Load-Shift Goal Report", page 27, May 2023.

Appendix B: VCE Ag-FIT

As California continues its leadership role in building and transportation decarbonization by aggressively pursuing energy efficiency and electrification programs to meet its climate goals[11], the addition of electrically powered appliances to replace gas equivalents will have a serious impact on the State's overall electricity needs. Consequently, the residential market sector is under immense pressure to electrify, and manufacturers have responded with modern electric appliances such as heat-pump water heaters and induction cooktops to replace natural gas units. As part of this transition, there is an opportunity to incorporate secondary features that will further improve electric appliance performance and user experience. For example, smart appliances, which provide access to local and/or cloud-hosted appliance-control applications (apps) and operating data, are becoming more common. While smart appliance apps are primarily focused on providing users with additional amenities, they can also deliver energy efficiency and load management benefits by considering and responding to utility and/or grid- level signals such as dynamic energy pricing, carbon intensity, peak demand forecasts, or Energy Emergency Alerts.

Valley Clean Energy (VCE) is a Community Choice Aggregator (CCA) serving Yolo County, California. They are a recognized leader in the development of dynamic energy pricing tariffs and accompanying customer tools and resources focused on reducing energy use during critical days and times. With the support of the California Public Utility Commission (CPUC), VCE has implemented a successful, four-million-dollar, multi-year dynamic pricing pilot project called Ag-FIT for agricultural customers[12]. VCE is working in partnership with Polaris Energy Services and TeMix to generate the hourly dynamic pricing tariff used in this pilot. The pilot's primary objective is to quantify the load shift potential of agricultural irrigation pumps controlled via a web-based scheduling app[13]. The app allows agricultural customers to easily understand electricity prices seven days in advance for each hour of the day to schedule their pumping based on their specific operational needs. Due to the success of implementing a dynamic pricing tariff with the Ag-FIT pilot, CPUC is considering VCE's request to pursue implementing a dynamic pricing tariff pilot demonstration project for their residential customers.

VCE has found that the market value of Resource Adequacy (RA) load shift associated price for the PG&E service territory is $180/kW-yr[14] during their agricultural pump program. Power data collected from the eight single-family homes indicates that 2 kW of load on average is available throughout the year to be controlled by a HEMS in single family homes. Assuming that 10 percent of all single-family homes in California implement a HEMS system and all controllable loads are shifted, then the average available load shift is approximately 1.6 GW for a RA cost savings of $281 million annually, based on 7.8 million single family homes[15]. An analysis of the summer power consumption in the 8

[11] Goals such as those detailed in the 2022 Scoping Plan to Achieve Carbon Neutrality (updated and released in November 2022 as required by California AB 32).

[12] https://valleycleanenergy.org/wp-content/uploads/Item-12-Amendment-to-2022-Budget-AgFIT-9-8-22.pdf

[13] https://valleycleanenergy.org/programs/a-flexible-irrigation-pilot-program-for-agriculture/

[14] Current Market Price Benchmark established by the CPUC for RA costs in PG&E service territory

[15] https://www.infoplease.com/us/census/california/housing-statistics

homes also indicates that 3 kW of load on average is available to be controlled by a HEMS in single family homes.

The benefit of implementing a dynamic pricing tariff and shifting load starts when electricity is purchased. The California Public Utility Commission requires utilities to ensure they will have enough capacity to serve their customers regardless of conditions. This is known as resource adequacy. In order to estimate their power requirements, CCA's and IOU's use a conservative forecast combined with a margin of safety[16]. Customer load shifts out of peak hours allow the CCA or IOU to purchase less reserve power thus saving money for their customers and the company.

Dynamic pricing allows load serving entities such as Community Choice Aggregators and investor-owned utilities to provide hourly market-based price signals to customers. The customers have the choice to respond to those prices and shift electricity usage into more favorable times of the day. Prices are based on the wholesale generation and distribution prices established by the local ISO – CAISO in this case. The prices are a proxy for grid system conditions and are generally lower when more intermittent renewable resources are producing and higher during ramp and overnight hours when these resources are less available. By responding to these price signals the customer makes a rational economic decision which benefits the grid and reduces reliance on fossil fueled powerplants. Access to this pricing information allows the customer to make more informed decisions about operational profiles based on their need and cost-effectiveness.

Approximately 3 Megawatts (MW) of load are currently enrolled in VCE's AG-Fit pilot with participants shifting about 40 percent of their electricity usage out of summer peak periods (Figure C1)[17]. The current average system RA price for the PG&E service territory of $180/kw- yr., the avoided RA market value of 1 MW of load shift is approximately $180,000/yr[18]. The avoided net RA market value of load shift associated with the VCE AgFIT pilot is approximately $362,000/yr, assuming a 67% capacity factor is applied to the total 3MW of enrolled load (3MW x 0.67 x $180,000/MW-yr).

[16] https://www.caiso.com/Documents/Resource-Adequacy-Fact-Sheet.pdf

[17] https://www.wintersexpress.com/news/local/valley-clean-energy-receives-award-for-agfit-pilot-program/article_c821c1b8-e988-566a-8ee8-09dced18d685.html.

[18] Current Market Price Benchmark established by the CPUC for RA costs in PG&E service territory.

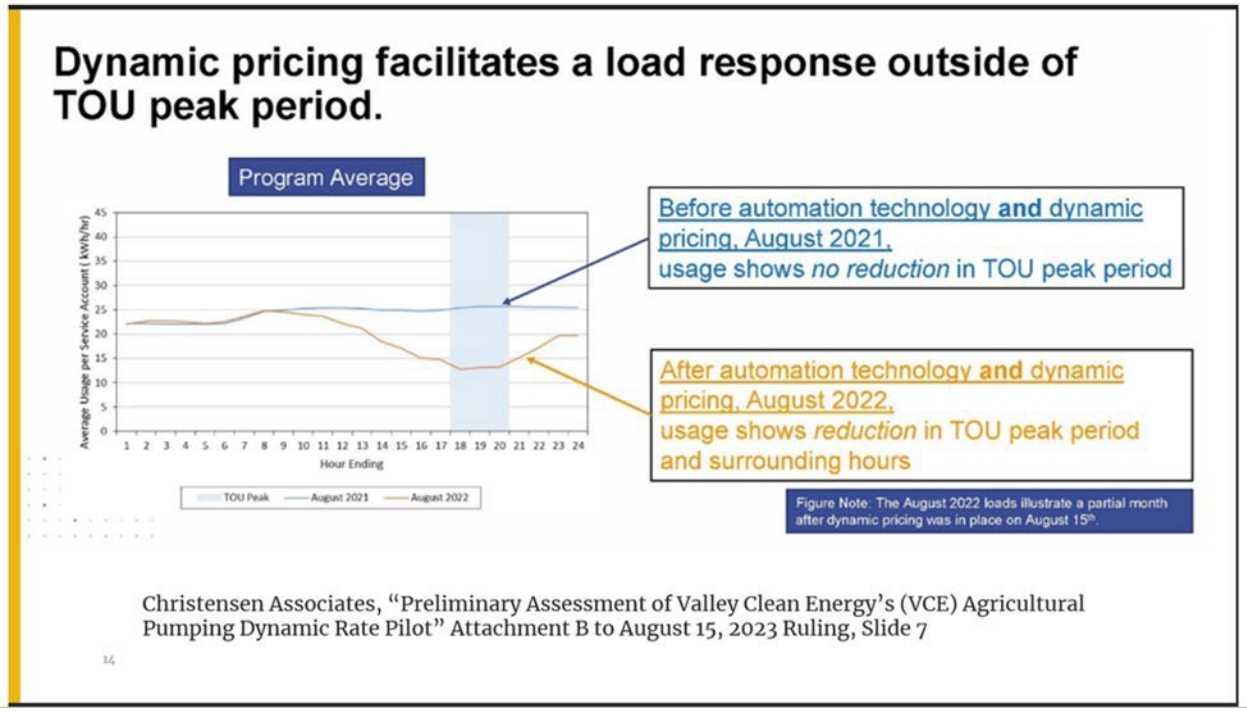

Figure B1. – VCE AgFIT Pilot – Mid-Term Report

Appendix C: Load Limiting

Load limiting is a control approach where the total power consumed by the home is limited to a defined amount, for example 4000 Watts on-peak (5 PM to 8 PM). The homeowner could be nudged so that when they are close to or try to exceed the 4000 W limit, they are shown their current power draw (W) and the demand associated with their current request so that they can decide how best to proceed. For example, if a household is running its air conditioner and television, and then they try to start their clothes dryer, they must choose to eliminate concurrent use of one of the three appliances in order to meet the 4000 W cap. This type of nudging provides households with the information needed for prioritizing their appliance use and ensuring they do not exceed demand limits. SMUD has expressed interest in this type of feature, which could eliminate the need for expensive upgrades to the distribution network as well as customer's electrical panel. Using SMUD's motivation as a design constraint, the home could be limited to power draw of just less than that allowed by the home's current electrical panel. If the electrical panel is rated at 120 Amps, for example, then a HEMS would limit the home's total power consumption to 90 percent of that or 12,960 W.

SMUD has devised the Critical Peak Pricing (CPP) rate structure to increase the cost of electricity by 50 cents during specific CPP events. Events may be up to four hours long, and cumulatively occur up to 50 hours total during the year. SMUD has expressed how important it is to collect data from existing homes during the summer of 2025, with and without nudges, in order to educate the homeowner prior to CPP implementation in 2026. Seven of the eight existing SHFT homes have expressed interest in participating in the CPP rate structure.

In response to SMUD's interest and the forthcoming deployment of RTP and CPP across California, CLTC recommends testing new device categories in its SHFT to determine cost effectiveness and acceptability. This information will be valuable to other organizations and governments preparing for RTP adoption in the future:

- **Lights (nudge to dim)** – Lighting accounts for up to 20 percent of the electrical load in homes based on the data from the phase 1 SHFT study. Lighting gets power from the same circuits at receptacles and fans so at a minimum, additional devices (like smart light switches) should be installed to determine their frequency of use and potential for shiftable. All eight homes are interested in nudging related to dimming the lights and three of the eight homes are interested in automated lighting controls. Smart switches allow for monitoring and controlling the lights on/off and dimming setpoints through an API.
- **Lights + TVs (nudge to dim)** – Combining TV diming and lighting dimming could be a large reliable power reduction in homes. Seven of the eight homes are interested in nudging related to dimming their TVs.
- **EV Charging (nudge to delay)** – EV charging is a very high-power activity. Preventing any of this load from occurring during peak would be beneficial. Six of the eight homes are interested in nudging related to EV charging and two are interested in automated charging controls. Smart EV chargers or control switches allows for monitoring and controlling EV charging on/off operation through an API.
- **TVs (Nudge to dim)** – Entertainment accounts for up to 40 percent of the electrical load in homes based on the data from the SHFT field study. Smart TVs can be dimmed to save up to 70 Watts and every home has two TVs on average. One of the TVs is often being used.
- **Ceiling fans (fan speed & fan on/off control)** – Ceiling fans are part of the same electrical

circuit as lighting which makes their operation times difficult to monitor. Additional devices (like smart light switches) should be installed to determine their frequency of use and potential for shiftable load. In addition to potential shiftable load, homeowners could be nudges about when to use their ceiling fan in combination with opening windows to improve air quality in the home. All eight homes are interested in nudging related to fan use for improving air quality and two of the eight homes are interested in automated control.

- **Kitchen ventilation fans (fan speed & fan on/off)** – Kitchen ventilation fans are generally found to be range hood fans used to exhaust smoke, steam and heat generated during cooking on the stove. Smart range hood fans can be controlled with on/off control and different speeds through an API. See the description for ceiling fans for recommended controls.
- **Bathroom/Laundry ventilation fans (fan speed & fan on/off)** – Bathroom ventilation fans are similar to kitchen ventilation fans in that they steam and heat, but in this case the steam and heat is generated by hot water in showers. Smart light switches can be used for on/off control and different fan speeds through an API. See the description for ceiling fans for recommended controls.
- **Windows (open/close)** – Opening windows can be beneficial for pre-cooling a home and for improving air quality by bringing in fresh air or keeping the windows closed when outdoor air quality is poor. There are smart window actuators that can retrofit sliding windows in homes to automate window opening and closing. All eight homes are interested in nudging related to opening/closing windows to improve air quality in their homes and three of the eight homes are interested in automated
- **Plugged in device (ideal use time of day & on/off)** – Plugged in devices are part of the same electrical circuit as lighting and fans. Smart plug load controller enables on/off control of these plug loads at a low cost. Understanding the acceptance of nudges or automated control of these plugs could be a valuable way to shift load in homes. All eight homes are interested in nudging related to plug loads and one of the eight homes are interested in automated control.
- **Cooking range (nudge delay)** – Cooking with an electric range is a very high-power activity. Preventing any of this load from occurring during peak would be beneficial. Seven of the eight homes are interested in nudging related to cooking and two are interested in automated cooking load shift controls. Smart ranges or control switches allow for monitoring and controlling cooking on/off operation through an API.

Memorandum of Understanding

This Memorandum of Understanding ("MOU") effective when all parties have signed ("Effective Date") is made by and among:

- Valley Clean Energy ("VCE"), a California Community Choice Aggregator, serving Yolo, County, CA, with its principal executive offices at 604 2nd St., Davis, CA 95616; and

- Panasonic R&D Company of America, Division of Panasonic Corporation of North America, having its principal place of business at 205 Ravendale Drive, Mountain View, CA 94043 ("Panasonic"); and

- The Regents of the University of California, on behalf of its Davis campus ("UC Davis"), 1850 Research Park Drive, Davis, CA 95618

This MOU memorializes the understanding between the parties relating to joint activities for the Evaluation of Smart Home Load Flexibility under Varying Utility Programs and Household Operations: A Laboratory and Field Study. Each party acknowledges and agrees that nothing in this MOU shall impose upon any party any legal obligation to consummate a transaction or enter into any discussions or negotiations with respect thereto. The terms and conditions regarding all transactions contemplated herein, including but not limited to, license, service, payment etc., will be set forth in definitive contract agreements, which are to be negotiated and agreed upon between the parties as deemed necessary.

1. Intention of the Parties. All parties wish to work together to productionize emerging technologies in the space of home energy optimization and greenhouse gas emission minimization. Panasonic, and its affiliates, wish to enlist the knowledge and experience of VCE and UC Davis to test the performance of a smart home energy management and optimization system in a field demonstration project. Capabilities of said system include predicting and optimizing energy use in residential homes and live communication with utility companies to minimize various objectives, including maximum power used in peak time and minimizing greenhouse gas emissions related to the energy based on MIDAS database information. To better productionize such a system, Panasonic seeks knowledge of energy use patterns and potential business, legislative or technological benefits that such a system would have for a utility company. UC Davis, as a premier research institution in the space of energy efficiency and policy impact, has the knowledge and expertise needed to successfully carry out the next step in the smart home energy product development, namely conducting performance studies in multiple households and analyzing the results. Moreover, VCE and UC Davis are already engaged in a strategic partnership related to minimizing greenhouse emissions in California and welcome the opportunity to work with a significant technology development business like Panasonic. Panasonic, VCE and UC Davis intend to negotiate in good faith terms and conditions for a contract benefiting all parties. More specifically, Panasonic and UC Davis intend to enter into negotiation of a definite agreement to memorialize their intended collaboration.

2. Responsibilities. Panasonic, itself or through its affiliates, are responsible for providing load flexibility hardware such as battery energy storage systems and applicable software, as well as funding to carry out the field demonstration project. VCE is responsible for promoting this emerging technology among selected customers, providing input on selection of appropriate households to run a performance study in, and reviewing the results of the study to assess the business impact of said technology has for them. In addition, VCE agrees to allocate time and personnel to discuss project-related business and technological considerations pertaining to VCE's operations. UC Davis, under a proposed future agreement with Panasonic, will be responsible for managing all operations related to the project, including (but not limited

to) contact with selected households, installation of necessary hardware, commissioning of the energy management software, conducting the study, analyzing results, and providing reports for the other parties' use. Together, the parties will produce a brief joint project report summarizing their findings. UC Davis and VCE agree that Panasonic may share this joint project report with its affiliates. Parties agree that this report will be owned by all parties and subject to ownership of any potential new intellectual property that may be generated by the parties under their respective definite agreements.

3. No Further Obligation. Nothing in this MOU will be construed to (a) oblige any party to enter into any further agreement or transaction; or (b) preclude any party from independently developing or acquiring from a third-party products, services or technology competing with the other party's products, services or technology.

4. Term. This MOU becomes effective as of the Effective Date and shall remain in force and effect until the earlier of: (a) one year from the Effective Date, (b) execution of a definitive agreement, or (c) termination by either Party in accordance with this Section 4, however, that a party may extend the term of this MOU subject to the other parties' consent. A party may terminate this MOU at any time, for any reason or for no reason, upon written notice to the other parties.

5. Confidential Information. The parties agree that the exchange of confidential and proprietary information contemplated herein shall be governed by the Mutual Confidentiality and Non-Disclosure Agreement signed alongside this MOU.

6. Use of Trademarks; Publicity. No party may use any of the other party's trademarks, trade names, logos, slogans, or other marketing material in any way without the owning party's prior written consent, which may be withheld in its sole and absolute discretion. No party may publish any press releases, announcements, or marketing materials relating to the terms of this MOU or the proposed relationship, including the potential for execution of a definitive agreement, without the prior written consent of the other parties.

7. Costs. No party shall receive any monetary compensation from any other party under this MOU. Exchange of funds and related obligations between Panasonic and UC Davis to implement this joint project will be discussed in a separate agreement between Panasonic and UC Davis.

8. Non-Binding Agreement. This MOU does not create a binding contract and will not be enforceable, except for Sections 5 through 9. The proposed relationship may happen only after the definitive agreement is entered into by the respective parties.

9. Miscellaneous.

a) *Independent Contractors.* All parties are independent contractors under this MOU. Nothing herein contained will be deemed to create an employment, agency, joint venture or partnership relationship between the parties hereto or any of their agents or employees, or any other legal arrangement that would impose liability upon one party for the act or failure to act of the other parties. No party will have any express or implied power to enter into any contracts or commitments or to incur any liabilities in the name of, or on behalf of, the other parties, or to bind the other parties in any respect whatsoever.

b) *Governing Law.* This MOU shall be governed by and construed in accordance with the internal laws of the State of California, U.S.A., without giving effect to any choice or conflict of law provision or rule (whether of the State of California or any other jurisdiction) that would cause the application of laws of any jurisdiction other than those of the state of California.

c) *No Third-Party Beneficiaries.* Nothing herein is intended or shall be construed to confer upon any person or entity other than the parties and their successors or assigns, any rights or remedies under or by reason of this MOU.

d) *No Assignment.* Neither this MOU, nor any rights or obligations hereunder may be assigned, delegated or conveyed by a party without the prior written consent of the other parties.

e) *Equitable Remedies.* The parties acknowledges and agrees that (i) a breach or threatened breach by a party (as the breaching party) of any of its obligations under Section 5 (Confidentiality) or Section 6 (Use of Trademarks; Publicity) would give rise to irreparable harm to the other parties (as the non-breaching parties) for which monetary damages would not be an adequate remedy and (ii) in the event of a breach or a threatened breach by breaching party of any such obligations, the non-breaching parties shall, in addition to any and all other rights and remedies that may be available to non-breaching parties at law, at equity or otherwise in respect of such breach, be entitled to seek equitable relief, including a temporary restraining order, an injunction, specific performance and any other relief that may be available from a court of competent jurisdiction.

f) *Entire Agreement.* This MOU constitutes the sole and entire agreement of the parties with respect to the subject matter of this MOU, and supersedes all prior and contemporaneous understandings, agreements, representations, and warranties, both written and oral, with respect to the subject matter. No amendment to this MOU is effective unless it is in writing, identified as an amendment to this MOU and signed by an authorized representative of each party.

g) *Counterparts.* This MOU may be executed in counterparts, each of which shall be deemed an original, but all of which together shall be deemed to be one and the same agreement. A signed copy of this MOU delivered by facsimile, e-mail or other means of electronic transmission shall be deemed to have the same legal effect as delivery of an original signed copy of this MOU.

[Signatures on Next Page]

In witness whereof, the parties have, by their duly authorized representatives, executed this MOU.

Valley Clean Energy

By: _____ Date: March 17, 2025
Mitch Sears, Chief Executive Officer

Panasonic R&D Company of America, Division of Panasonic Corporation of North America

By: _____ Date: 3/17/2025
Akihiko Inoue, President

The Regents of the University of California, on behalf of its Davis campus

Denise Ehlen Digitally signed by Denise Ehlen Date: 2025.04.02 18:52:51 -07'00'

By: _____ Date: _____
Denise Ehlen, Executive Associate
Vice Chancellor for Research