Demand Response Emerging Markets and Technology Program

Semi-Annual Report: Q1 – Q2 2025

Prepared by:
Southern California Edison (U-338-E)

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Abbreviations and Acronyms

AC	Air Conditioning
ACEEE	American Council for an Energy-Efficient Economy
ADR	Automated Demand Response (aka Auto-DR)
AHRI	Air Conditioning, Heating, and Refrigeration Institute
AHU	Air-Handling Unit
AI	Artificial Intelligence
AMI	Advanced Metering Infrastructure
API	Application Program Interface
ASHRAE	American Society of Heating and Air Conditioning Engineers
ASP	Automation Service Provider
AutoDR	Automated Demand Response
BAN	Building Area Network
BBI	Better Buildings Initiative
BCD	Business Customer Division
BE	Building Electrification
BEMS	Building Energy Management System
BESS	Battery Energy Storage System
BOD	Biochemical Oxygen Demand
BTO	Building Technology Office
C&S	Codes and Standards
CAISO	California Independent System Operator
CARE	California Alternate Rates for Energy
CASE	Codes and Standards Enhancement
CCS	Conditioned Crawl Spaces
CEC	California Energy Commission
CPUC	California Public Utilities Commission
CSI	California Solar Initiative
CZ	Climate Zone
D.	Decision (CPUC)
DAC	Disadvantaged Community
DER	Distributed Energy Resource
DF	Demand Flexibility
DOE	Department of Energy
DP	Dynamic Pricing
DR	Demand Response
DRAS	Demand Response Automation Server
DRLIMFH	Deep Retrofits in Low-Income Multi-Family Housing
DRMEC	Demand Response Measurement and Evaluation Committee
DRMS	Demand Response Management System
DRRC	Demand Response Research Center
DSM	Demand-Side Management
EE	Energy Efficiency
EEC	Energy Education Center
EERP	Energy Efficient Retrofit Packages
EM&T	Emerging Markets & Technology
EMCB	Energy Management Circuit Breaker
EMS	Energy Management System

EPA	Environmental Protection Agency
EPIC	Electric Program Investment Charge
EPRI	Electric Power Research Institute
ESA	Energy Savings Assistance
ET	Emerging Technologies
ETCC	Emerging Technologies Coordinating Council
EVSE	Electric Vehicle Supply Equipment
EVTC	Electric Vehicle Test Center
EWH	Electric Water Heater
FDD	Fault Detection and Diagnostics
FERC	Federal Energy Regulatory Commission
GHG	Greenhouse Gas
GIWH	Grid Integrated Water Heater
GWP	Global Warming Potential
HAN	Home Area Network
HEMS	Home Energy Management System
HFC	Hydrofluorocarbons
HIL	Hardware-In-The-Loop
HPWH	Heat Pump Water Heater
HVAC	Heating, Ventilation, and Air Conditioning
IALD	International Association of Lighting Designers
IAQ	Indoor Air Quality
IDSM	Integrated Demand-Side Management
IESNA	Illuminating Engineering Society of North America
IoT	Internet of Things
IOU	Investor-Owned Utility
kW	Kilowatt
kWh	Kilowatt-hour
LADWP	Los Angeles Department of Water and Power
LBNL	Lawrence Berkeley National Laboratory
LEED	Leadership in Energy and Environmental Design
LF	Load Flexibility
LIMF	Low-Income Multi-Family
LM	Load Management
M&V	Measurement and Verification
MF	Multi-Family
MPC	Model Predictive Control
MSO	Meter Services Organization
MW	Megawatt
NDA	Non-Disclosure Agreement
NEEA	Northwest Energy Efficiency Alliance
NEM	Net Energy Metering
NMEC	Normalized Metered Energy Consumption
NPDL	New Product Development & Launch
NREL	National Renewables Energy Laboratory
NYSERDA	New York State Energy Research and Development Authority
OCST	Occupant-Controlled Smart Thermostat
OEM	Original Equipment Manufacturer
OP	Ordering Paragraph
OADR	Open Automated Demand Response

PCT	Programmable Communicating Thermostat
PDR	Proxy Demand Response
PEV	Plug-In Electric Vehicle
PG&E	Pacific Gas and Electric
PLMA	Peak Load Management Alliance
PLS	Permanent Load Shift
PMS	Property Management System
PRP	Preferred Resource Pilot
PSPS	Public Safety Power Shutoffs
PTR	Peak Time Rebate
PV	Photovoltaic
QI/QM	Quality Installation/Quality Maintenance
RDD&D	Research Development, Demonstration and Deployment
RESU	Residential Energy Storage Unit
RFI	Request for Information
RPS	Renewable Portfolio Standard
RSO	Revenue Services Organization
RTU	Rooftop Unit (air conditioning)
SCE	Southern California Edison
SDG&E	San Diego Gas and Electric
SEER	Seasonal Energy Efficiency Ratio
SEPA	Smart Electric Power Alliance
SGIP	Self-Generation Incentive Program
SME	Subject Matter Expert
SMUD	Sacramento Municipal Utility District
SoCalGas	Southern California Gas Company
SONGS	San Onofre Nuclear Generating Station
SPA	Special Project Agreement
T-24	Title 24 (California building energy efficiency code)
TES	Thermal Energy Storage
TRL	Technology Readiness Level
TOU	Time of Use
TTC	Technology Test Center
UCOP	University of California – Office of the President
UL	Underwriters Laboratories
USGBC	U.S. Green Building Council
VCAC	Variable-Capacity Air Conditioning
VCHP	Variable-Capacity Heat Pump
VCRTU	Variable-Capacity Roof Top Unit
VEN	Virtual End Node
VNEM	Virtual Net Energy Metering
VRF	Variable Refrigerant Flow
VTN	Virtual Top Node
WW	Wastewater
WWTP	Wastewater Treatment Plant
XML	Extensible Markup Language
ZNE	Zero Net Energy

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1. Summary

Southern California Edison (SCE) submits this Q1 – Q2 2025 semi-annual report in compliance with Ordering Paragraph (OP) 59 of the California Public Utilities Commission (CPUC) Demand Response Decision (D.) 12-04-045, dated April 30, 2012. In that Decision, the CPUC stated:

> "In D.08-06-027, the Commission determined that given the continuing evolution in DR techniques, enabling technologies, and evaluation methods, California benefits from investing in research and development that will encourage the adoption of cost-effective DR. We find it reasonable to continue funding Emerging Technology projects for all three utilities. Our review of utility Emerging Technology proposals indicates that the programs address appropriate technologies needing evaluation and appear reasonable in terms of budget requests."

That Decision also directed SCE to submit a semi-annual report regarding its demand response (DR) Emerging Markets and Technology (EM&T) projects by March 31 and September 30 of each program year. Those reports have been submitted in compliance with D.12-04-045 and are available at the DRET website.[1]

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The SCE DR EM&T program, consistent with guidance from the CPUC, invests in accelerating the deployment of innovative new DR technologies, software, and system applications to enable cost-effective customer participation and performance in SCE's programs, tariffs, and grid operations. The EM&T program funds technology research, market studies, reviews emerging consumer technologies and conducts scaled demonstrations, equipment field trials, and laboratory tests. These activities help enable the innovative high-tech and consumer market participants to adopt DR methods and standards, and also advocate for continuous improvement in DR technological innovation.

The benefit to ratepayers from these investments in DR research, in all sectors and income levels, disadvantaged communities and new growth areas, helps enable customers to meet their future energy needs in a cost effective manner that ultimately results in enhanced grid reliability for all. These benefits can accrue in the near term, and also through new models of programs and technologies, developing the foundational capabilities required for the future needs of the electric system, and enhancing local grid flexibility and customer affordability.

EM&T program activities are also designed to identify and mitigate barriers that impede or restrict SCE customers and the overall consumer industry from understanding and

[1] https://www.dret-ca.com/emtcompliancereports/

adopting effective DR behaviors and technology measures. The program's technology adoption influence strategy includes delivering upstream industry market facilitation to bring DR awareness to the consumer industry so that there is a flow of "off the shelf" systems that ratepayers can adopt at no incremental cost to them. This includes, through technology-driven DR standards advocacy, codes and standards adopted by the California Energy Commission that now brings DR innovation to market and the overall cost savings benefits for participants and non-participants alike.

The EM&T program's core investment strategies align with the guidance from D.17-12-003, and the strategies facilitate DR-enabling technology market adoption through education, in-situ field testing, assessing customer perspectives, understanding of market barriers, technology transfer, and increased customer participation in DR programs and tariffs. The learnings and results from each activity, study, and assessment type are made publicly available and are effectively disseminated via virtual presentations and in person summits and forums to energy stakeholders who can act upon these results (including investors, technology developers, customers, local governments, and policymakers).

The five EM&T core investment strategies are as follows:

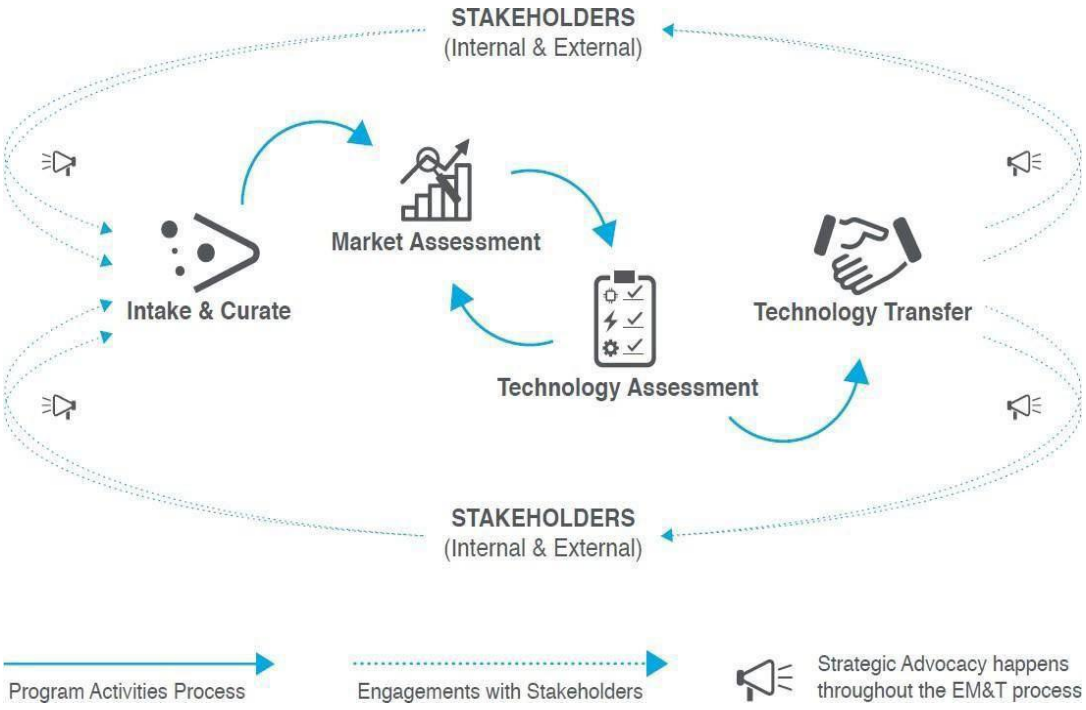
- Intake and Curation: Identifies studies, projects, or collaborations for inclusion in EM&T's portfolio and selects which ones to fund based on a well-informed understanding of the broader industry context.

- Market Assessments: Create a better understanding of the emerging innovation and developments of new consumer markets for DR-enabling technologies and an awareness of consumer trends for smart devices.

- Technology Assessments: Assess and review the performance of DR-enabling technologies through lab and field tests, and demonstrations designed to verify or enable DR technical capabilities.

- Technology Transfer: Advances DR-enabling technologies to the next step in the adoption process, including raising awareness, developing capabilities, and informing stakeholders during the initial stages of emerging technology development for potential DR program and product offerings.

- Strategic Advocacy: Actively supports key market actors to integrate DR-enabling emerging technologies into their decisions, including promoting DR-enabling technologies for program adoption and supporting the development of open industry standards (Note: Strategic Advocacy is embedded in all the EM&T projects and occurs throughout the stakeholder process).



EM&T Program's Current Portfolio Investment Approach

The following table lists the EM&T projects described in this report that were initiated and in progress during the Q1 – Q2 2025 period. The table also identifies each project with the singular or bundled core EM&T Investment Category that each project addresses to facilitate the continued development of DR emerging technologies:

Project ID	Project Name	EM&T Investment Category
Projects Initiated		
DR25.07	Smart Panel Field Study	Market Assessments Technology Assessments
In-Progress Projects		
DR19.11	LOC-GFO-19-301-4 Optimizing Heat Pump Load Flexibility	Technology Assessments Technology Transfer
DR22.02	HP-Flex: Next Generation Heat Pump Load Flexibility DR	Market Assessments Technology Assessments
DR23.01	DR-TTC Dynamic HVAC Test Chamber	Technology Assessments Technology Transfer
DR23.03	Achieving Integrated and Equitable Decarbonized Loads with the CalFlexHub	Market Assessments Technology Assessments
DR24.01	Behind the Meter Optimization of Load Technologies (BOLT) Study	Market Assessments Technology Assessment
Projects Completed		
DR21.03	Dynamic Rate Pilot	Technology Assessments Technology Transfer

EM&T Program Projects Investment Categories

SCE works collaboratively with the electric California Investor-Owned Utilities (IOUs), and with other DR research organizations, national laboratories, trade allies, and state agencies, to leverage other sources of funding, and to avoid duplication of their research that operate in parallel with the EM&T program. The EM&T program has successfully leveraged projects and research funded from the California Energy Commission's (CEC) Electric Program Investment Charge (EPIC) program, the Department of Energy's (DOE) Building Technology Office (BTO), and other research organizations and their activities conducted in the United States and overseas.

SCE's Customer Solutions (CS) organization oversees EM&T program's activities, which focus on advancing DR-enabling technologies for SCE's programs, tariffs, and grid operations. The EM&T program is now continuing with the CPUC's four-year approved authorization from (D.) 23-12-005, dated December 14, 2023. In accordance with the CPUC direction for the reporting of the DR EM&T program, this report covers SCE DR EM&T program activities during the period between January 1, 2025, and June 30, 2025, for Q1 and Q2 of program year 2025.

1. Projects Initiated Q1 – Q2 2025

DR25.07 Smart Panel Field Study

Overview

A "smart" electrical panel is an advanced version of the standard household electrical panel for providing electrical service protection for circuit distribution to a home, with the main difference is that the "smart" panel has the capability to measure and control electricity usage. There are three types of smart panels: 1) main panel replacement; 2) supplemental load panel to house, monitor, and control critical loads only; and 3) traditional load panel with smart circuit breakers.

Smart electrical panels offer a potential alternative to costly service upgrades at an all-electric house by actively managing end use loads and on-site distributed energy resources (DERs) such as electric vehicle charging, batteries, and heat pump water heaters. When circuit loads approach the maximum service capacity, the panel can automatically prioritize or shed specific circuits to prevent exceeding service limits. This can defer or avoid costly service upgrades while enabling the installation and efficient use of new electric appliances.

Growing Landscape of Smart Panel Products

Beyond load control, these panels provide granular telemetry that can help residents better understand and optimize their electricity use. By networking multiple smart panels across SCE's service territory, they could form part of a broader demand-side management portfolio, supporting dynamic demand management and grid-edge operations. The technology may also open new pathways for customer engagement, allowing easier integration of DERs, and enabling participation in demand response programs by integrating with utility local grid control systems across diverse end-uses.

The Smart Panel Field Study ("Study") is designed to test and evaluate the capabilities of advanced circuit-level load management technology in residential settings, focusing on homes participating in SCE's Low Income Building Electrification (BE) pilot and the Energy Coalition's Bassett-Avocado Advanced Energy Community (BAAEC) initiative. The Study is part of an overall strategy to evaluate opportunities for residential "grid edge" technologies to enable and support the impending increase in electric transportation and other electric loads, in tandem with the local electric distribution system and future models of demand flexibility and dynamic pricing.

Bassett-Avocado Advanced Energy Community (BAAEC)

The Study will deploy in its first phase up to 18 smart panels of various designs in homes with existing or planned electric appliances and/or DERs. Each installation will be tailored based on a detailed review of site characteristics, existing panels, breaker configurations, and load mapping. EPRI, serving as technical advisor and project manager, will guide smart panel selection, coordinate with original equipment manufacturers (OEMs), and support local permitting approvals. Circuit-level monitors will be installed at each site for at least one year to track energy

consumption and peak load contributions by end use. The study will analyze these data to quantify demand flexibility potential, evaluate load-limiting performance, assess demand response integration opportunities, and develop strategies for customer engagement and future program design.

Collaboration

EPRI is leading the technical advisory and project management activities, working closely with SCE's Low Income Building Electrification team and the Energy Coalition. SCE will identify candidate homes, provide site access and AMI data, and handle procurement, permitting, and installation of the panels. EPRI will recommend appropriate smart panel models for each site, coordinate with OEMs, support permitting, and facilitate installer training. Additional collaboration includes integrating circuit-level monitoring, developing data collection infrastructure, and aligning the project with broader demand-side management strategies. As part of the market assessment, EPRI will also provide a tech assessment of any new products that become available during the current Study.

Results/Status

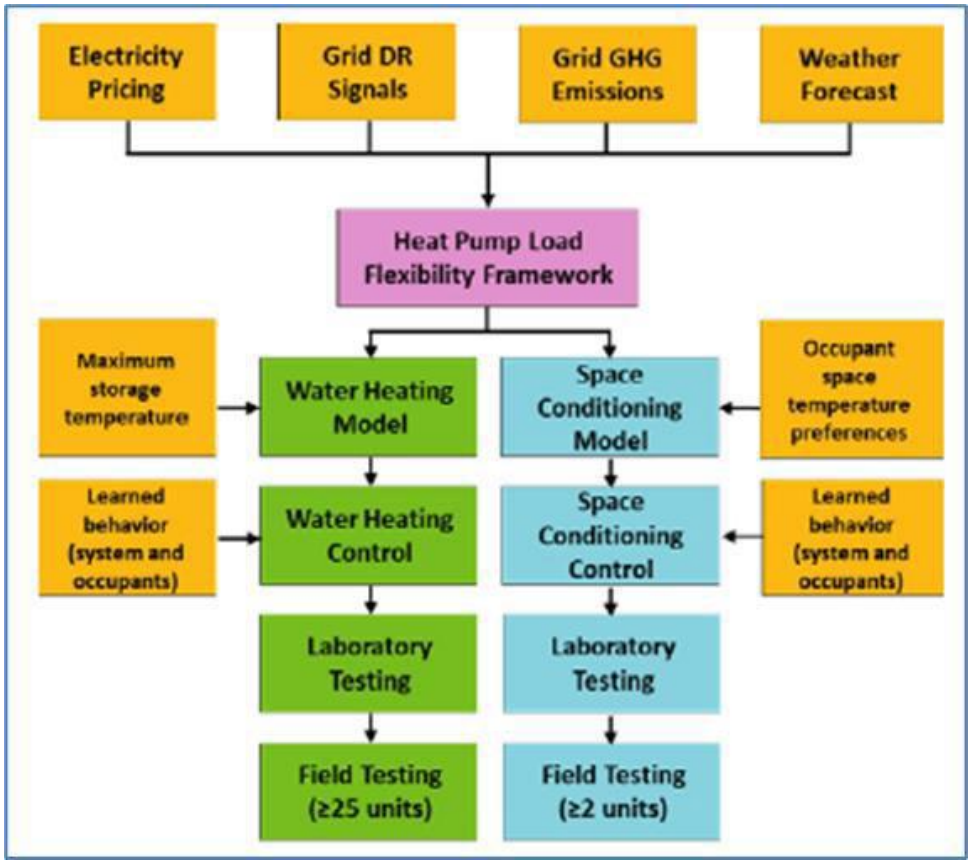
The project has begun identifying both the availability of smart panel technologies and will be assessing customer applicants in Q2 2025. Initial tasks include reviewing candidate sites and technology eligibility, selecting and specifying smart panel models with breaker and circuit mapping, and supporting permitting authority acceptance. Analyses will quantify demand response potential, assess customer engagement opportunities, test features and capabilities of each panel installation with the customer's end uses, and generate recommendations for possible future program integration with dynamic rates and grid operations. As of project kickoff, site review and intake processes are being developed, timelines for installation are under discussion, and coordination with OEMs and permitting bodies is underway.

2. Projects Continued Q1 – Q2 2025

DR19.11 LOC-GFO-19-301-4 Optimizing Heat Pump Load Flexibility

Overview

This CEC EPIC project which was awarded to UC Davis and which SCE is co-funding will develop, test, and demonstrate an open-source framework for heat pump load flexibility controls that will be employed for both Advanced Water Heating Controls (AWHC) and Advanced Space Conditioning Controls (ASCC). The goal is to provide a common platform that can be leveraged to manage residential electricity use across multiple types of equipment and devices. The control system optimizes heat pump operation based on: 1) Building owner/occupant preferences, comfort, and use patterns; 2) Electricity pricing, including time-of-use schedules and/or hourly or sub-hourly price signals; 3) Electricity grid needs, which may be reflected in ways other than price signals (e.g. demand response (DR) signals; 4) Electricity grid real-time greenhouse gas (GHG) emission rates; and 5) Weather data (current and forecasted).



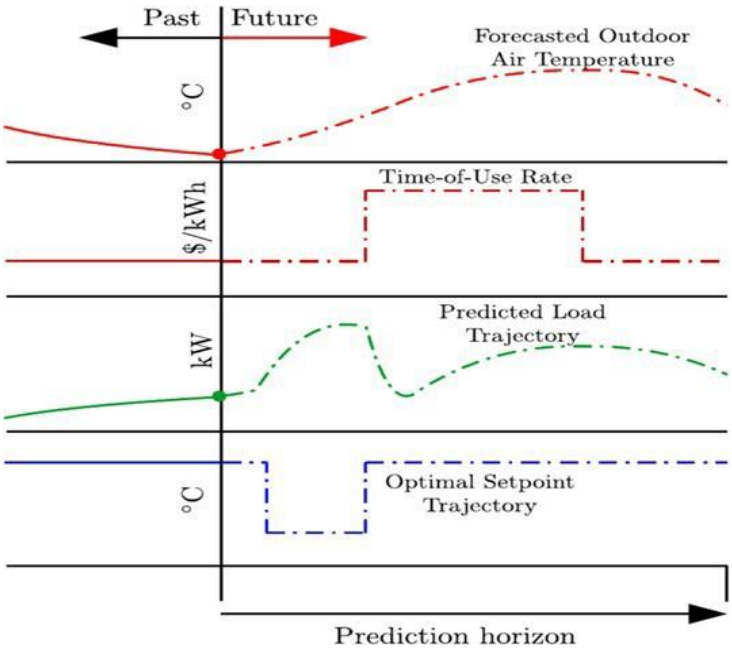
Overview of Heat Pump Load Flexibility Framework

Tackling both space conditioning and water heating controls from a common

framework is useful and efficient, as most of the data needed for a heat pump load controller (e.g., electricity pricing, grid DR signals, grid emissions, weather) are not specific to the heat pump end-use type. By applying one framework to both water heating and space conditioning equipment, the project will demonstrate the scalability and futureproofing of heat pump load control systems that are compatible with future investments in synergistic technologies. In this way, designing both water heating and space conditioning controls within a single framework will facilitate future integration of additional equipment and simplify the process of obtaining, configuring, and monitoring advanced controls.

The project vision is to develop AHWC and ASCC based on a model predictive control strategy and compare their performance to basic and advanced rule-based controls. Model predictive controls (MPC) are a state-of-the-art control optimization system. In contrast to rule-based controls, MPCs have a dynamic model that represents the specific system they control and can be adapted over time, based on site-specific data.

The MPC system uses the dynamic model to predict how the system will need to operate over a given time horizon in response to exogenous inputs, such as a local weather forecast. The MPC then calculates the optimal process control outputs based on the specified optimization objective (e.g., minimize cost, GHG emissions), which includes constraints for occupant preferences and equipment limitations.



Modelling Predictive Control Optimization

This project will develop an open-source turn-key MPC system that will be easy to use and will eliminate the need for installers or end-users to have subject matter expertise in MPC or heat pump systems. The proposed data model framework (DMF) will simplify the configuration, setup, and maintenance process for new heat pump

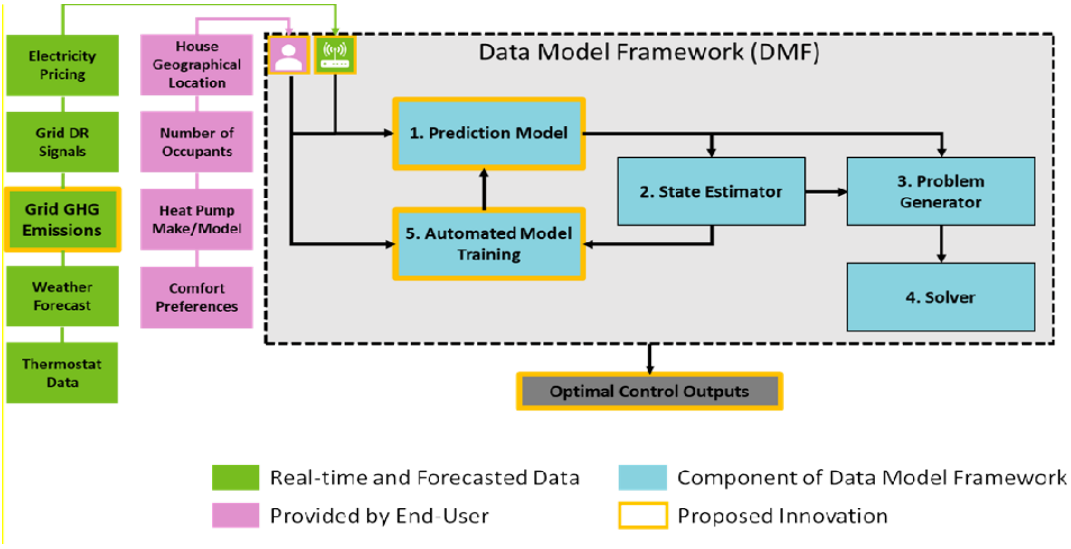
systems that will have load flexibility capabilities. Load flexibility controls offer a way for customers to shift consumption to times of day with lower rates without compromising their comfort. For load flexibility controls to be widely adopted, building occupant preferences must be satisfied.

The AWHC control modulates hot water tank storage temperature to store thermal energy and achieve the optimal system performance, where the optimization is based on a utility price schedule or signal, a GHG emission signal, and a utility DR signal. The ASCC will modulate the housing unit's temperature setpoint to store thermal energy and achieve the optimal system performance, where the optimization is based on utility price schedules or signals, GHG emission signal, and utility DR signals.

Demonstration of the technology will occur at two all-electric, low-income housing communities located in different California climate zones The project will test and demonstrate the AWHC with at least 25 heat pump water heaters split between the two demonstration sites. The project will also test and demonstrate the ASCC with at least two space conditioning heat pumps, where the two housing units will be selected from the group participating in the AWHC demonstration.

As part of the CEC EPIC project, there are six technical tasks specific to this project:

1. Market Characterization
2. Develop Advanced Water Heating Controls
3. Develop Advanced Space Conditioning Controls
4. Test and Demonstrate Advanced Water Heating Controls
5. Further Research in Advanced Space Conditioning Controls
6. Market Barriers and Commercialization Assessment.



Project Data Model Framework

The overall project is designed to evaluate load flexibility technologies' ability to successfully shift, shed, shape, and shimmy demand of advanced, high efficiency heat pumps for space conditioning or water heating in response to grid needs, building owner/occupant preferences, utility pricing, and DER availability. The project team will

demonstrate the ability to automate and optimize the shifting of space conditioning or water heating heat pump load out of the evening ramp-particularly in the Spring and Fall when the ramps are steepest—or away from times when the generation mix is producing the highest level of GHG emissions. The field testing will demonstrate heat pump operational flexibility, combined with other technologies and strategies (e.g., demand response, DERs such as advanced on-site storage, etc.), to provide grid support under current and future generation.

The project was funded under the EM&T Market Assessments and Technology Assessments investment categories, as there are elements of both research goals in this study. The Market Assessments category is designed to create a better understanding of the emerging innovation and developments of new consumer markets for DR-enabling technologies and an awareness of consumer trends for smart devices. The Technology Assessments category assesses and reviews the performance of DR-enabling technologies through lab and field tests and demonstrations designed to verify or enable DR technical capabilities.

Collaboration

The EM&T program is co-funding the project through a Letter of Commitment for the CEC EPIC contract that is led by the UC Davis's Western Cooling Efficiency Center (WCEC) with other grant partners. While the EM&T program is co-funding the project through a contract with WCEC, SCE is also leveraging its access to CEC EPIC projects with learnings and best practices from other EPIC research activities Also, as a founding member of WCEC, SCE has insights and access to ongoing research at UC Davis and leveraging that research to assist in this study and other efforts at SCE.

Results/Status

Field testing of the advanced water heating control demonstrations, initiated in Q3 2024, have concluded in Q2 2025. Data were collected on the system performance, and post-deployment surveys have been completed as well, offering insights into the occupant, maintenance staff, and building owner's experience and system performance. These results are being summarized and tabulated as a first step towards future refinements to the AWHC optimization strategy.

The ASCC protocols for space conditioning began field testing in Q1 2025 and activities will continue through the end of the year. Initial deployment of the hardware at the sites has progressed as planned, with ongoing performance monitoring and data collection designed to compare the efficacy between model predictive and rule-based control strategies.

Participation in the total number of field demonstrations decreased from 26 to 19 households, primarily due to resident moveouts. Despite this reduction, the project

continues to collect robust Measurement and Verification (M&V) data across both demonstration sites. Baseline surveys for water heating and space conditioning were completed earlier in the project, AWHC follow-up surveys were completed, and the ASCC-related surveys will be conducted later in 2025.

Next Steps

In the second half of 2025, the project will focus on completing the field testing of the ASCC systems, which began in Q1 2025 and is scheduled to continue through Q4 2025. Data collection and performance monitoring will remain ongoing throughout this period, with post-deployment surveys planned for Q4.

Analysis of field data from both the AWHC and ASCC demonstrations is currently underway. Findings from this analysis—including performance metrics, occupant feedback, and system optimization results—will be included in the next reporting cycle.

Additional milestones expected in the coming months include:

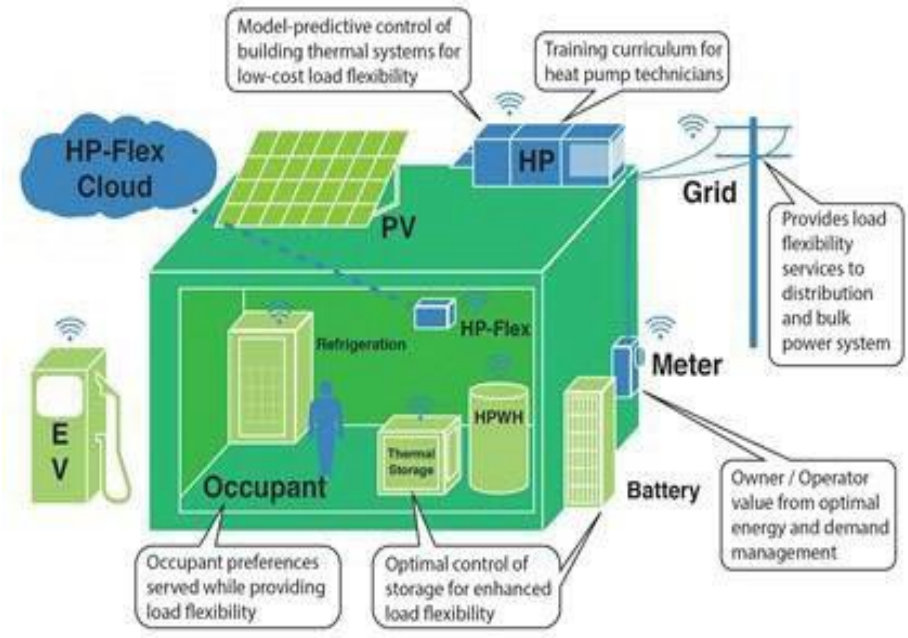
- Recovery of M&V equipment from the climate zone 4 field site (Q3 2025)
- Completion of ASCC post-deployment surveys (Q4 2025)
- Final task reports for the field testing of AWHC and ASCC, which will include the comparative analysis of model predictive controls vs. rule-based controls for AWHC and ASCC, respectively (Q4 2025–Q1 2026)
- Recovery of M&V equipment from the climate zone 12 field site (Q1 2026)
- Preparation of project final report and recommendations (Q1 2026)

SCE and the UC Davis WCEC team will continue coordination on technology transfer, stakeholder engagement, and dissemination of findings to support future integration of load flexibility technologies.

DR22.02 HP-Flex: Next Generation Heat Pump Load Flexibility DR

Overview

Lawrence Berkeley National Laboratory (LBNL) submitted a proposal to the CEC in response to Electric Program Investment Charge (EPIC) solicitation GFO-19-301, Group 4. The proposal was awarded a contract agreement (EPC-19-013) by the CEC for a $3,000,000 grant to fund the development and field site evaluation of an open-source, scalable, low-cost control flexible heat pump solution (HP-Flex) for optimal demand management of high-efficiency heat pumps in small and medium commercial buildings. Southern California Edison (SCE) provided a Letter of Commitment in support of LBNL's proposal, with a proposed cost share of $300,000 ($150,000 / $150,000 from EE & DR emerging tech funds).



HP-Flex: Next Generation Heat Pump Load Flexibility

The goal of the project is to develop open-source control algorithms and educational curricula to train the next generation of engineers and technicians, to help promote the large-scale deployment of replicable, demand- flexible heat pump installations in small to medium-sized commercial buildings, and to increase benefits to both individual building owners and the distribution grid by enhancing heat pump demand flexibility. This system will minimize energy use while allowing buildings to effectively participate in flexible DR programs and dynamic pricing tariffs, to provide reliable and cost-effective load flexibility to the grid.

The project objectives are:

- Develop an advanced, integrated, open-source control system to cost-effectively provide energy optimization and load flexibility to heat pumps in small and medium commercial buildings.
- Verify that flexible heat pumps can meet the following criteria:

    1) Achieve a 20% reduction in site peak energy costs compared to a traditional heat pump with scheduled thermostatic control.
    2) Provide 50% load shed during summer or winter peak-load events.
    3) Provide 20 kWh of daily load shift capacity for a typical commercial building during the shoulder seasons.
    4) Provide "shimmy" services equivalent to 10% continuous response of average baseline load.
    5) Enable 25% of the baseline load to respond to dynamic prices to shape daily load profile in summer and winter.
    6) Meet a financial payback period of 2 years.

- Integrate and control a thermal energy storage system with a heat pump optimized with HP-Flex.
- Develop educational curricula to train engineers and technicians on the design, installation, and maintenance of load-flexible heat pump systems.

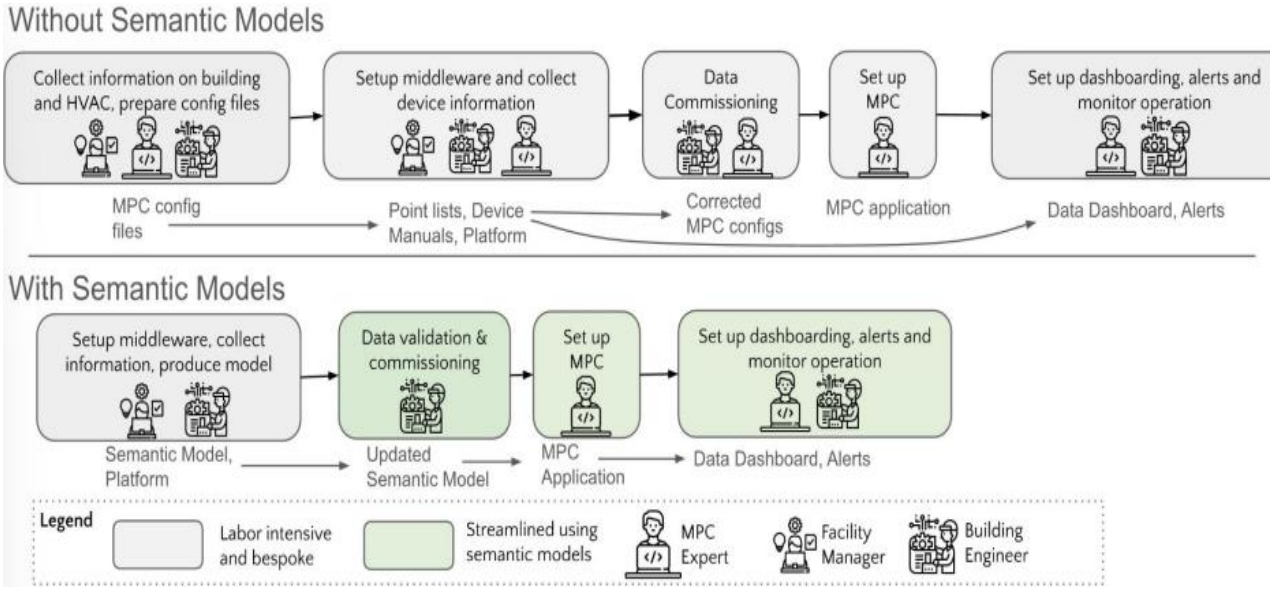
The project was funded under the EM&T Market Assessments and Technology Assessments investment categories, as there are elements of both research goals in this study. The Market Assessments category is designed to create a better understanding of the emerging innovation and developments of new consumer markets for DR-enabling technologies and an awareness of consumer trends for smart devices. The Technology Assessments category assesses and reviews the performance of DR-enabling technologies through lab and field tests and demonstrations designed to verify or enable DR technical capabilities.

Collaboration

The project is being co-funded by the SCE Emerging Markets and Technologies and Emerging Technologies Program and is supplementary to work at LBNL funded by the CEC Electric Program Investment Charge (EPIC). SCE is working with LBNL as a co-funding partner and active reviewer of the work in progress. SCE engages other industry stakeholders and subject matter experts that serve on the Technical Advisory Committee (TAC) establishing direction for the research team and to ensure that SCE is receiving the learnings from the project that are most valuable to its customers.

Results/Status

Several project coordination meetings were held through Q1-Q2 2025, and preliminary results shared to SCE stakeholders. The LBNL team has since completed development of a software platform with environment management and API documentation that can easily port algorithms to commercial partners platforms and manage across multiple projects. Accompanying this, staff developed a semantic HPFLEX workflow that enables adoption via a guided spreadsheet survey-based process for deploying the MPC.



HP-Flex: Software Platform Workflow

There are currently 3 sites with preliminary field results. A fourth site has begun data monitoring and initial testing but does not have available preliminary data yet. Two other sites are still pending; Site 5: HVAC, control, and monitoring equipment has been installed, controls development is ongoing. Site 6: HVAC installation is pending panel upgrade which is being scheduled. The research team has now completed testing for the winter season and begun analysis to infer the impacts at scale across the various sites. Notably, the comfort degree hour reduction parameter metric was observed as a highly optimized benefit provided by the HP-FLEX implementation.

LBNL is coordinating timeline and deliverables updates with SCE, and updated project completion is now expected by end of 2025 with possible CEC contract extension.

Next Steps

LBNL and SCE will continue to coordinate on updating the project timeline and reviewing and finalizing interim testing results and deliverables. LBNL project team will continue with summer season testing of the six sites leveraging lessons learned from UC Davis, testing hardware retrofit compared to software-only upgrade, testing the portability of open-source software to commercial partners, and testing longer series and other types of prices.

DR23.01 DR-TTC Dynamic HVAC Test Chamber

Overview

SCE Technology Test Center (TTC)

The SCE's Technology Test Center (TTC) evaluates a variety of technologies in controlled environments that mirror real-world conditions and customer experiences. This generates comprehensive performance data and innovative test methods which are used by SCE customers, policymakers, and utility programs to make informed decisions regarding the investment and application of cleaner technologies. The TTC is pursuing a major renovation project to the facility layout and is pursuing updates to its testing capabilities.

Dynamic testing or load-based testing is necessary to better characterize the performance of the actual advanced controls of these heat pump systems. Current TTC HVAC lab test capabilities are limited to steady state methods that disable native HVAC controls. A dynamic test method in the lab produces metrics/results that include the operation of native controls. It is important to assess test methods that can provide ratings representative of field performance when equipment is operated under its own controls and under loads that vary with ambient temperature. Additionally, the test chamber could also be used to test other small commercial self-contained refrigeration equipment.

Project objectives are:

- Construct an environmental test chamber capable of advanced dynamic HVAC testing.
- Demonstrate a dynamic test and generate sample test data.
- Identify and prioritize near-term potential test projects, which may include but is not limited to the Advanced Heat Pump Coalition's Heat Pump Rating

Representativeness Validation Project, LBNL CEC projects to supplement laboratory testing, F-Gas Reduction Incentive Program (FRIP), and parallel EPRI laboratory testing.

The project is co-funded under the EM&T Technology Assessments and Technology Transfer investment categories, as there are elements of both research goals in this study. The Technology Assessments category assesses and reviews the performance of DR-enabling technologies through lab and field tests and demonstrations designed to verify or enable DR technical capabilities. The Technology Transfer category advances DR-enabling technologies to the next step in the adoption process by raising awareness, developing capabilities, and informing stakeholders in initial stages of emerging technology development for potential DR program and product offerings.

Collaboration

The project is being co-funded by the SCE Technology Test Centers, the SCE Emerging Technologies program, and the SCE Codes and Standards program. The completion of this test chamber will enable a wide variety of future project partnerships to support programs/activities such as the California Statewide Electric Emerging Technologies Program, Building Electrification, Codes and Standards, CEC EPIC, CARB - FRIP, and CalFlexHub.

Results/Status

In Q1 – Q2 of 2025, the Technology Test Center team initiated activities with its facilities and procurement groups to onboard vendors as well as establish and execute planning for upgrading site electrical infrastructure and verifying roof structural requirements. In parallel, the team is beginning the next phases of test chamber equipment procurement, installation and commissioning.

Next Steps

The team will continue activities through Q3 – Q4 2025 for site electrical infrastructure upgrades, roof structural requirements verification, and equipment procurement/installation/commissioning. The team expects to better understand expected uncertainties with site analyses and upgrades, as well as equipment availability and supply chain issues. The overall test chamber completion is targeted for completion in mid-2026.

DR23.03 Achieving Integrated and Equitable Decarbonized Loads with the CalFlexHub

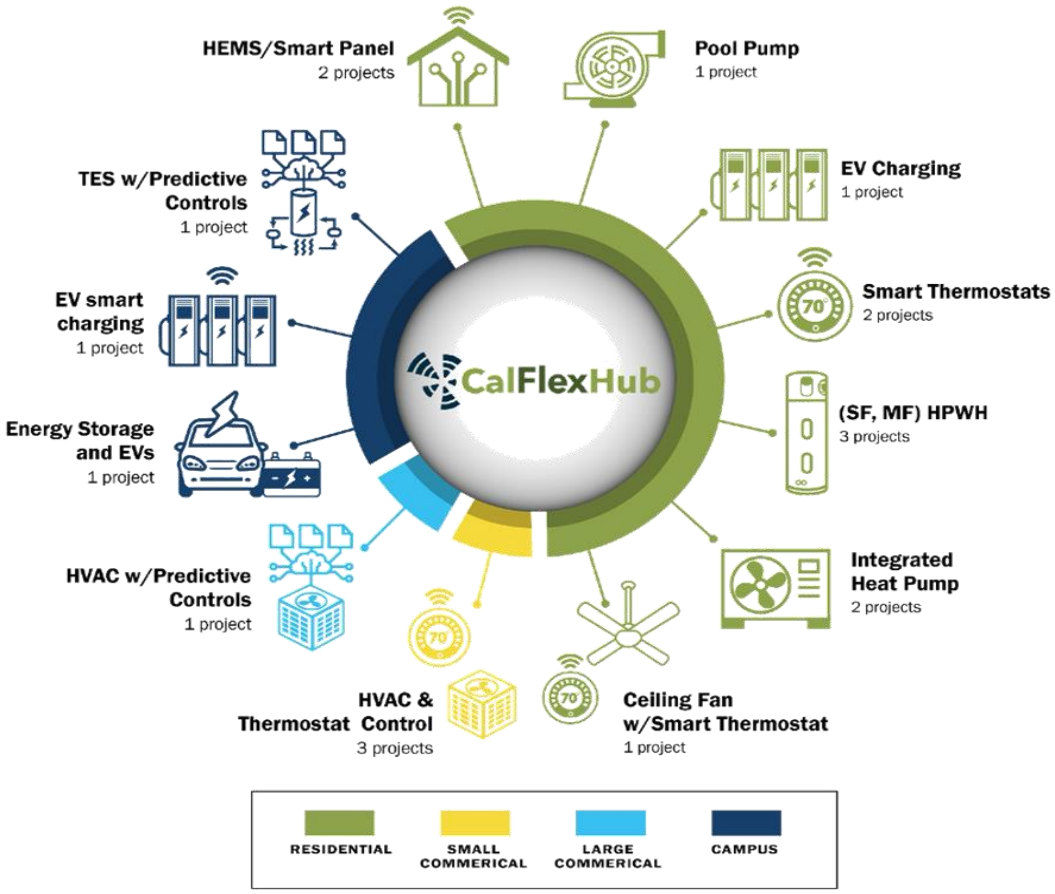
Overview

Lawrence Berkeley National Laboratory (LBNL) submitted a proposal to the California Energy Commission (CEC) in response to Electric Program Investment Charge (EPIC) solicitation GFO-19-309. The proposal was awarded a contract agreement (EPC-19-309) for a $16,000,000 grant to fund the California Load Flexibility and Deployment Hub. Known in short as the CalFlexHub, its goal is to accelerate the understanding of how customer electrical end-use loads could provide dynamic load flexibility. CalFlexHub will achieve this understanding by demonstrating the technologies and incentives needed to provide that flexibility, and then increasing knowledge and understanding of specific customer needs through field research and customer surveys.

The EM&T program provided a Letter of Commitment (LOC) in support of LBNL's proposal for the EPIC GFO 19-309 solicitation. As stated in the LOC, SCE's participation in this project includes technical advisory support, active peer review of LBNL's applied research and development (ARD) activities during the project schedule, and match funding of $600,000 to provide supplemental funding for SCE-specific projects in SCE territory or in SCE facilities.

In addition to the cash commitment of approximately $150,000 per year for four years, SCE is also including its Energy Education Centers (EECs) and its Technology Test Centers (TTCs) as training and workshop resources (based on availability) for CalFlexHub interactive displays and exhibits, technical consultations, classes, seminars, and test beds to conduct small-scale testing in SCE laboratory settings.

The CalFlexHub program at LBNL will develop, demonstrate, and evaluate complementary technology platforms to actuate flexible loads using technology compatible with the CEC's Load Management Standards (LMS) platform, which will be used to communicate the prices, grid signals, and greenhouse gas (GHG) emissions signals. The LBNL team will pilot test and demonstrate innovative technologies compatible with the LMS platform to enable affordable flexible loads. Once technologies are pilot tested and usability research is complete, CalFlexHub will support commercialization of load flexible (LF) technologies that are proven to be usable and effective through completed field research.



CalFlexHub Overall Project Portfolio

LBNL intends to achieve the CEC's goals with a focus on the following objectives:

- Identify, develop, evaluate, demonstrate, and deploy cost-effective, scalable, load-flexible technologies that are consistent with building energy efficiency, appliance, and load management standards, to provide continuous load shaping from dynamic prices and GHG signal response.
- Create a portfolio of LF RDD&D technology projects across various building types and sizes including single family residential, multi-family, commercial buildings, and integrated campuses. Evaluate the performance of integrated control and optimization of these technologies to reduce customer bills and GHG emissions.
    - These technologies include building electric end-uses and other DERS such as PV, thermal and electric storage, and EVs.
- Deploy LF technologies to demonstrate the ability for electric customers to receive the LMS price and marginal GHG signals at five-minute increments and report statistically significant effects. Demonstrate that load-responsive technologies can receive and respond to signals via open secure protocols.

- Identify ways to improve usability of technology solutions to increase customer benefits. During deployment, score the usability of each LF technology on a statistically supportable sample of customers using the System Usability Scale (SUS) and collect input from customers and end users to develop strategies to improve device usability and customer engagement strategies.
- With an Equity First strategy in CalFlexHub, evaluate and demonstrate key technologies for disadvantaged and vulnerable communities to overcome financial and health burdens, and develop plans to build scalability through innovation and targeted deployment of those technologies.
- Develop a database of key performance metrics, including the usability for flexible technology and strategy pathways and generate these metrics for 2025, 2030, and 2040 scenarios. Publish summaries as part of the annual report for CalFlexHub stakeholders. Evaluate how these technologies perform in the CalFlexHub field tests.
- Develop and deploy the CalFlexHub Solutions Center website and a clearinghouse to disseminate information, technology reports, and case studies to report on "what works," sharing California and national RDD&D. Create a sustainable partner engagement platform and stakeholder engagement ecosystem and develop a Technology Transfer Best Practices Manual for CalFlexHub Innovators.

SCE will work with the LBNL team on the scope of individual activities that are specific to SCE's strategic load management interests. While SCE is included in the project's Technical Advisory Committee (TAC) meetings as part of their role in the project along with other qualified professionals in accordance with the CEC's contract with LBNL (EPC 19-309 Agreement), SCE will also actively facilitate a dynamic "real time" technology information transfer of the knowledge gained, experimental results, and lessons learned from the project.

SCE will receive early-stage drafts of any project related documents and deliverables, specifically those documents that will help SCE bring these technologies into their program offerings. Specifically, SCE will receive the following during the execution of the project:

1. Copies of the monthly progress reports submitted to the project's Commission Agreement Manager (CAM), per EPC 19-309, Task 1.5
2. Drafts and final copies of reports as specified in the SCE Specific Deliverables
3. Meetings and online seminar updates as specified

SCE will also receive three to five project updates, preliminary findings, and completion meetings, via online seminar in accordance with a schedule mutually

agreed between the LBNL project team and SCE to support the technology transfer of project activities for SCE's internal stakeholders.

SCE is interested in identifying "off the shelf" measures in the Technology Demonstration and Deployment (TDD) projects. The research performed by the CalFlexHub in the TDD stage should focus on technologies with a current technology readiness level (TRL) between 6 and 8. TRL 6 is used as the level required for technology insertion into system design and normally the last stage where technology has been demonstrated in the engineering/pilot scale in the relevant environment.

The goal of CalFlexHub is to move these technologies up one or more readiness levels by the end of the project. TRL 8 is the actual system operational and qualified through demonstration, wherein the technology has been proven to work in its final form and under expected conditions. SCE engineering staff will assist with the step up from laboratory scale to engineering scale and the determination of scaling factors that will enable the operating system's design.

The project is funded under the EM&T Market Assessments and Technology Assessment investment categories, as there are elements of both research goals in this study. The Market Assessments category is designed to create a better understanding of the emerging innovation and developments of new consumer markets for DR-enabling technologies and an awareness of consumer trends for smart devices. The Technology Assessments category assesses and reviews the performance of DR-enabling technologies through lab and field tests and demonstrations designed to verify or enable DR technical capabilities.

Collaboration

SCE is working with the LBNL CalFlexHub research team, with SCE staff acting as advisors and active reviewers of the work in progress. To facilitate enhanced knowledge transfer, key members of SCE's project team will collaborate with LBNL engineering staff and researchers to provide insight into and influence over each project's initial design and direction throughout its duration.

SCE engages other industry stakeholders and subject matter experts to serve on the Technical Advisory Committee (TAC) establishing direction for the research team and to ensure that SCE is receiving the learnings from the project that are most valuable to its customers. In addition to the TAC meetings, SCE will receive more timely updates for ongoing consultation and access the reports and deliverables produced for the CEC contract advisors.

Results/Status

Monthly CalFlexHub check-in meetings were held during the first two quarters of 2025 and SCE was provided the expected project deliverables as per the LBNL master agreement task order.

- Key Updates presentation with summary overview of the CalFlexHub overall project, its goals, and specific tasks planned for research.
- Project Deliverables Memo 1 was provided, documenting developments and current findings made by the research team in each of the sub-projects.
- Five established projects specific to the SCE collaboration effort have continued through Q1 and Q2 of 2025. LBNL continues to coordinate on deployment and testing of each of the projects' scopes. These projects are as follows:

Project #1: Elexity Model Predictive Control

Objectives:

- Demonstrate AI software's ability to help small to medium commercial facilities shift load in response to hourly electricity prices.
- Expand beyond the demonstration scope currently in CalFlexHub by including EV charging and/or stationary battery in AI-load-flexibility-software-managed loads.

PROGRESS: From the Spring testing round, the EMS demonstrated ability to accurately schedule HVAC cooling setback and precooling actions to take advantage of the largest hour-to-hour price differential each day based on day-ahead price signal. The longer operating hours of control system allowed for significant load shed from price-based setback control during the peak price hours. These reductions translate to 0.23 and 0.42 W/sf in normalized metrics.

For the second objective, the study implemented a strategy curbing EV charging rate to 50% (~ 6 kW) during the 5-7 PM highest price 2-hour period, while permitting unrestricted charging for all other hours. The team will conduct another two weeks of A/B testing utilizing CalFlexHub multi-day hourly dynamic pricing signals for the summer season.

Project #2: Heat Pump Water Heaters Training Center Support/Demo

Objectives:

- Connect HPWHs in SCE's Energy Education Center testing facility to advanced load shifting controls.
- Prepare demonstration and educational materials for SCE to use in training seminars.

PROGRESS: LBNL has provided near-final drafts of a workforce training module that educates contractors and designers on HPWHs

sizing, the various operating modes, load shifting benefits, and more. Multiple rounds of review and feedback were completed with the SCE Energy Education Center and DSM QA/QC teams. Final versions of the training materials are being recorded for transition to the EEC. LBNL will also examine existing open-source CTA-2045 communication tools and start development of a Python tool for sending individual load shifting signals.

Project #3: Gateway with Universal Devices

Objective:

- Demonstrate a working prototype multifunctional gateway that takes in prices with OpenADR 3.0 over a cellular connection (5G) and develop functional control of connected devices to provide load flexibility. This will be based on a current vendor gateway that currently supports Wi-Fi, Bluetooth, Zigbee, and Z-Wave.

PROGRESS: Two fundamental mechanisms for gateway communication with end-use loads were developed by the team's proof-of-concept demo: local broadcast of prices over OpenADR 3, and optimization to the prices within the gateway. The team completed building a fully certifiable Python VEN client, then exceeded the project goal by controlling four devices with in-gateway optimization using a Highly Dynamic Price (HDP) profile. Exemplifying the device response, the gateway signaled the thermostat via 5G internet and its algorithm incrementally increased the cooling setpoint by one Fahrenheit degree for every $0.10-$0.20 price increase, with baseline at 70 degrees.

UDI and LBNL further devised a novel optimization for OADR 3.0 signaling where successive prices and GHG values can be encoded within a single interval construct. This work became an improvement adopted by OpenADR Alliance for the OpenADR 3.1 Standard.

Project #4: Identifying Target Markets and Key Drivers to Encourage Market Adoption of Thermal Energy Storage

Objectives:

- Determine the potential opportunities and obstacles associated with using large thermal energy storage (TES) systems in SCE territory for responding to prices and other demand flexibility events.
- Develop, deploy, and test advanced control algorithm modeling to better understand TES effectiveness in delivering demand flexibility.

PROGRESS: LBNL finished an in-depth market analysis which identified how lack of market awareness is a key barrier for thermal energy storage, and publicizing the existence and benefits would support adoption. A second barrier revealed is manufacturers perceive the market as niche, perhaps due to low market awareness, thus limiting their interest in developing new products.

- Despite the limitations, few growth areas for TES were found. LBNL identified that small/medium commercial buildings present more

load shifting potential than large commercial buildings, and new product(s) are being targeted at these segments. Indoor agricultural spaces are also beginning to leverage TES both to extend the growing season and to increase the energy efficiency of the heating and cooling systems. Other new application areas identified that could drive future growth for TES are greenhouses, district energy networks, data centers, and cold storage facilities.

LBNL has developed simulation models capable of evaluating the performance of thermal storage (specifically ice-storage for chillers) in large commercial buildings and a variety of climates in preparation to perform an in-depth modeling study.

- One model developed by this project enables studying the effects of shifting cooling loads in large commercial buildings (combination HVAC system of chillers and ice storage). Two similar models are in development targeting small office buildings and retail stores (both simulating rooftop HVAC systems with TES).

Project #5: Price-response Business Models

Objectives:

- Review existing HVAC control products and third-party software platforms available in the market that can respond to price signals and analyze their compatibility with SCE infrastructure.
- Establish new requirements for price-responsive communication and control interfaces, which can serve as eligibility criteria for products participating in SCE programs.

PROGRESS: Using CalFlexHub Stakeholder Needs Assessment Reports, LBNL found that policy uncertainty, high business costs, and varied customer motivations complicate investment in and adoption of load flexibility technologies, limiting broader participation.

LBNL identified from CPUC dockets and the Track B Working Group that stakeholders with business models likely to be directly affected by California's shift to dynamic pricing (19 of 51 participants) saw promise in automation & smart devices but also faced barriers such as customer recruitment challenges and unclear monetization pathways.

Next Steps

Close coordination will continue between LBNL and SCE as projects undergo analysis and reporting. Near-term deliverables include project check-in/completion meetings, quarterly progress reports, and midpoint data reporting.

- Next steps for Project 4 involve finalizing the validation of the rooftop unit system with storage, to make sure it works accordingly with the EnergyPlus model and running a financial study to take into account the TES investment and maintenance costs to calculate the impact of using storage (internal rate

of return, duration of return, levelized cost of energy, etc.).

- Project 5 will initiate Phase III, conducting structured interviews with key stakeholders using a standardized instrument developed with input from SCE and approved by the Berkeley Lab's Human Subjects Committee.

This overall CalFlexHub Project contract with SCE at Lawrence Berkeley National Lab along with SCE advisory and project management participation is scheduled to continue through the end of 2025. Final reports and presentations of the results of the work will be delivered to EM&T stakeholders in Q1 of 2026.

DR24.01 Behind the Meter Optimization of Load Technologies (BOLT) Study

Overview

The Emerging Markets and Technology (EM&T) program examines emerging markets and assesses technology advancements to develop a forward-thinking approach to cost-effectively revolutionize Southern California Edison's (SCE) future demand response (DR) customer programs. In 2024, the EM&T program has developed the Behind the Meter Optimization of Load Technologies (BOLT) study to explore innovative DR system approaches to capture a wide range of residential consumer technologies, such as emerging" smart house" end uses and appliances, to significantly enhance both customer benefits and grid performance.

This strategic assessment study will investigate emerging consumer technologies that have load management capabilities, including electric vehicles (EVs), behind-the meter (BTM) batteries, heat pump water heaters (HPWHs), pool pumps, and other potentially flexible, dispatchable appliances and systems. The BOLT study will also design and test new incentive models that are specifically crafted to boost customer participation and performance of these advanced technologies in new models of demand response. By also conducting a field assessment of these cutting-edge technologies alongside attractive incentives, the BOLT study intends to demonstrate the efficacy of load management measures utilizing an innovative comprehensive operational model structured to manage a diverse load management end use portfolio.

Research questions for the study include the following:

Primary Design Issues:

- What are the demand reductions (for development of deemed savings) that can be delivered by various end uses, individually and as a bundle?
- What are the reductions per SCE customer and per device under different scenarios/planning conditions?
- How does the magnitude and duration of dispatchable demand vary as a function of controllable end uses, weather conditions, event start, and hours into the event?
- How do incentive levels, modes of communication, and intensity and channel of marketing influence participation rates?
- What end uses and devices are most cost-effective for participation?

Secondary Operational Factors:

- How many sites should SCE enroll in BOLT to ensure it can accurately estimate load impacts?
- What are the identifying characteristics of customers who enroll in BOLT?

- What is the current saturation and geographic location in SCE territory for specific types of connected devices applicable for BOLT?
- How large (connected kW) are the end use loads, and how coincident are their annualized load shapes with SCE and CAISO peak loads?
- What communication protocols are used by the connectable devices, and are they compatible to receive DR signals and dispatches?

A key research objective for the BOLT study is to investigate how SCE can enhance the customer experience through a unified program tariff for multiple load management technologies at one service location. This new model has the potential for simplifying the enrollment process, providing customers with seamless experience and clear insights into potential earnings from their participation in load management programs. It will allow customers to enroll multiple load management technologies under a single program, replacing the current system where different technologies require separate enrollment processes. This streamlined approach is poised to transform how customers interact with load management programs, making it easier and more rewarding to participate in reliability programs and demand flexibility.

The project is funded under the EM&T Market Assessments and Technology Assessments investment categories, as there are elements of both research goals in this study. The Market Assessments category is designed to create a better understanding of the emerging innovation and developments of new consumer markets for load management-enabling technologies and an awareness of consumer trends for smart devices. The Technology Assessments category assesses and reviews the performance of load management-enabling technologies through lab and field tests and demonstrations designed to verify or enable DR technical capabilities.

Collaboration

To implement the study, SCE will be working with internal teams and an external evaluation contractor to develop the study design, operations, M&V, and go-to-market strategy. The first phase of the study will be to conduct residential customer surveys to assess the range of customer interest in different incentive structures, options for dispatch timing and durations, and availability of in-home technologies.

In addition, there are other technology and software providers who already manage groups of SCE customers for demand management services and other value streams. These providers and other automation service providers (ASPs) will be engaged to collaborate with SCE in assessing the technologies as they are integrated in the field.

SCE is continuing to engage other innovative partners interested in collaborating with the study. SCE expects that these partners can provide consulting and technical services in the areas of market and grid operations, licenses for automated service

platforms, economic reviews, and system impact analyses (e.g., avoided cost calculations), and the estimation of load shift impacts and energy reduction savings.

Results/Status

The BOLTs Study had successfully transitioned from planning and preparation into operational readiness. Contracting was completed with three key vendors—who will support customer recruitment and device integration. Each vendor also finalized agreements allowing the use of Southern California Edison (SCE) branding in their customer-facing materials. The BOLT study was also stood up in SCE's internal dispatching systems. This integration confirmed that the platform can now handle core functions such as customer enrollment, reporting, and the delivery of event dispatch instructions. Vendors subsequently completed testing to ensure they could receive dispatch signals and successfully connect with customer devices, including batteries, electric vehicles, and smart thermostats.

Marketing and outreach preparations advanced significantly in Q2. Vendor enrollment websites were reviewed and approved to meet SCE's branding and accessibility standards, and custom web links were created to provide customers with a seamless path from SCE communications to vendor enrollment pages. Analytics tools were also embedded to allow SCE to monitor customer engagement, such as clicks and sign-ups. Customer email campaigns were completed in June and scheduled to launch in mid-July, marking the start of direct recruitment. In parallel, customer participation agreements and terms were posted on vendor sites. Together, these achievements marked the completion of BOLT's foundational workstreams and established the systems, processes, and customer pathways needed to begin live operations.

Next Steps

With readiness activities complete, the focus in the third quarter of 2025 will shift toward completing customer enrollment and scheduling live event dispatching. Outreach campaigns will commence in July, targeting eligible customers with coordinated email communications and vendor sign-up pages. Enrolled customers will be randomly assigned into groups to ensure fair comparisons across different technologies and strategies.

Event dispatches are expected to begin in mid-August. Vendors will be allowed to start once they have reached enough enrolled customers, though SCE and its research partner, Demand Side Analytics, plan to call early test events even before full enrollment targets are met. This approach is designed to collect insights more quickly and accelerate learning throughout the summer.

Customer engagement will also be a focus in the months ahead. To avoid over-communication, especially during wildfire season or public safety power shutoffs, outreach will continue to be coordinated directly through SCE. Additional educational materials are being developed to increase customer awareness of the study, clarify benefits, and encourage enrollment. Finally, external visibility for the BOLTs Study is being advanced through a proposed feature in Edison Energized.

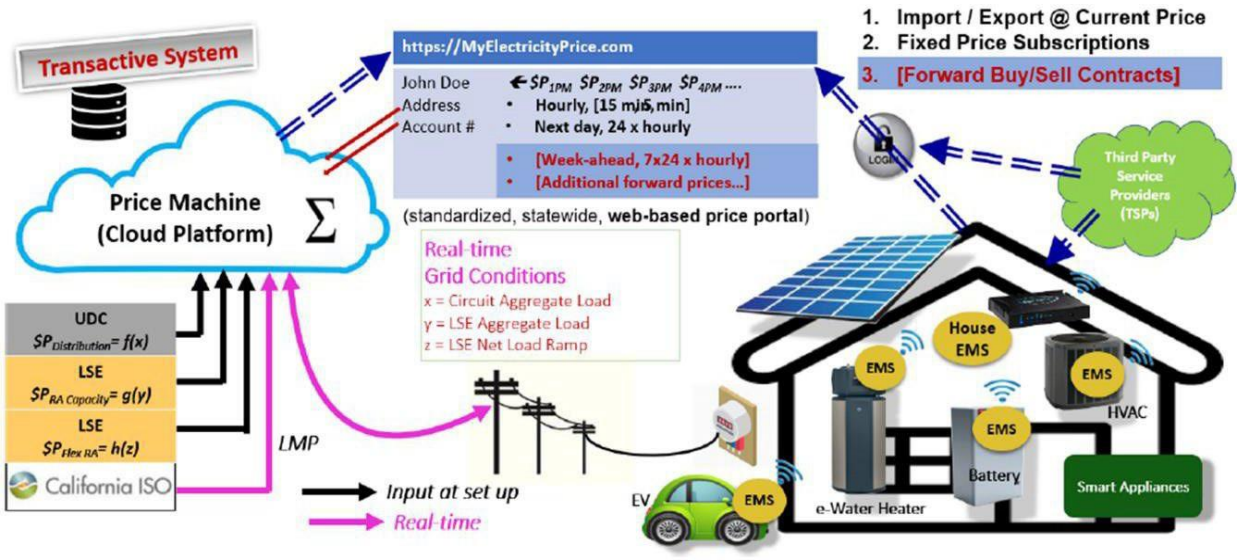
Together, these next steps will transition BOLTs from design into execution, marking the beginning of live field testing. The insights gathered will inform the design of future programs that make it easier for customers to participate in demand response and help ensure the reliability of California’s electric grid.

3. Projects Completed Q1 – Q2 2025

DR21.03 Dynamic Rate Pilot

Overview

In response to Gov. Newsom's emergency proclamation to "ensure the reliability of electrical service during extreme weather events," the California Public Utility Commission (CPUC) authorized SCE to demonstrate how the RATES/UNIDE framework proposed by TeMix can help meet reliability needs for the summers of 2023 and 2024. The demonstration was approved by the CPUC in D.21-12-015 and is designed to "conduct comprehensive studies that fully assess the costs and benefits of real-time rates, including the required infrastructure, manufacturer interest, and customer impacts." The Pilot combines real time pricing design and transactional subscription elements from both the RATES and UNIDE tariff concepts. The Pilot also investigates how customer based distributed energy resources can act as both flexible assets and grid interactive resources when these new pricing signals are transmitted to end use customers as proposed in the UNIDE model.



CalFUSE Concept for Dynamic Rate Design

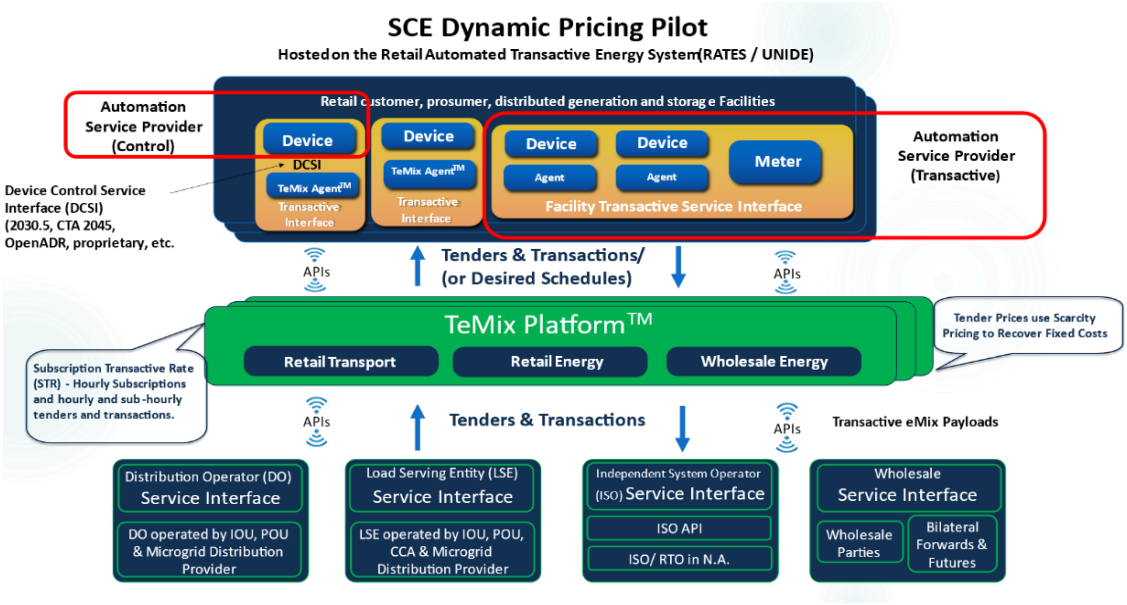
The key operational tasks of the Pilot are to automate the creation of dynamic prices for the generation and delivery components of a transactive tariff and present these composite dynamic hourly prices via an internet-based secure pathway to be accessed by retail customers, wholesale market participants, and automated services platforms for distributed energy resources (DERs). Customers and their end use devices would be connected to the TeMix cloud platform to receive price tenders either directly, via local management, or from aggregated management signals from third-party automated services platform clouds via Internet/Wi-Fi/LTE to the secure

receivers at the customer site. The decision instructs SCE to administer this demonstration under SCE's EM&T program.

SCE was encouraged to enroll residential, commercial, and industrial customers in this exciting demonstration. SCE works through reputable Automation Service Providers (ASPs) with existing relationships with these customer types and previously installed automation software or hardware at these customers' dwellings to streamline customers' involvement. This demonstration in 2022 was then modified to align with the CPUC's CalFUSE concept that brings more definition and functional scope to the original UNIDE framework as proposed in the Reliability Proceeding.

Under the CalFUSE design, each customer is provided with a tailored subscription for their monthly electricity use based on an analysis of their historical usage. During the pilot, the customer receives highly dynamic energy rates via their ASP that reflect grid conditions and will be able to make either buy or sell transaction leveraging this subscription to better match their operational needs against the needs of the local grid conditions.

The Pilot combines real-time pricing design and transactional subscription elements from the CalFUSE tariff architecture. For the CalFUSE hypothesis to be fully examined, the Pilot metrics are structured to develop a series of empirical analyses to assess the costs and benefits of real-time dynamic rate communications, with the ultimate objectives of transferring the research investments from the earlier CEC EPIC studies under GFO15-311 into flexible customer demand side opportunities that can accelerate solutions for system reliability for the summers of 2023 and 2024. Below is the current Pilot system technology overview that includes the price machine, ASPs, and data flows for implementation.



SCE Dynamic Rate Pilot Overall Architecture

The project was co-funded under the EM&T Technology Assessments and Technology Transfer investment categories, as elements of both research goals are in this study. The Technology Assessments category assesses and reviews the performance of DR-enabling technologies through lab and field tests and demonstrations designed to verify or enable DR technical capabilities. The Technology Transfer category advances DR-enabling technologies to the next step in the adoption process by raising awareness, developing capabilities, and informing stakeholders during the initial stages of emerging technology development for potential DR program and product offerings.

Collaboration

To implement the Pilot, SCE has executed a service contract with TeMix as the price platform software service. The platform transmits dynamic tariff prices securely to participating SCE retail customers during the Pilot and also records these dynamic pricing tender transactions for settlement purposes via a "shadow bill" approach. The ASPs integrate with the TeMix platform on behalf of their customers.

SCE is working with other stakeholders such as major electric vehicle (EV) manufacturers and/or smart charger service providers, solar/battery aggregators or service providers, and others with the capability to directly receive dynamic price tenders from TeMix and optimize (on behalf of the customer) end use flexibility strategies (such as EV and storage charge and discharge schedules). TeMix provides optimization agents for vendors to assess their applicability for eligibility, security, and compatibility with current APIs (reducing the need for software development).

In addition, there are other technology and software providers who already manage groups of SCE customers for demand management services and other value streams. These providers and other ASPs are engaged to collaborate with SCE and TeMix and are included in the project team as providers and advisors. SCE has established a technical advisory committee of industry experts and parties interested in the tariff design and transactive energy model of the CalFUSE concept to provide a communication platform for technology transfer as well as feedback for expert review of the Pilot activities.

SCE is continuing to engage other innovative partners interested in collaborating with the Pilot. SCE expects that these partners can provide consulting and technical services in the areas of market and grid operations, licenses for automated service platforms, economic reviews, and system impact analyses (e.g., avoided cost calculations), and the estimation of load shift impacts and energy reduction savings.

Results/Status

The original CPUC Decision that authorized the Pilot also ordered SCE to "conduct a mid-term and final evaluation of its dynamic rate pilot…to assess the costs and benefits of real-time rates, including required infrastructure, manufacturer interest, and customer impacts..." The Decision indicated that the evaluations shall include the following elements:

1. An evaluation of load responsiveness.
2. The monthly bill impacts of the Pilot dynamic rate in comparison to a customer's otherwise applicable tariff (OAT).
3. An evaluation of the cost recovery to assess the impact of any under-collection of revenues associated with the Pilot.

That report has been completed on March 31, 2025. Below is summary of the results:

Final Report Summary

The hourly dynamic rate design in the Pilot employed a "two-part" pricing method, in which the customer is provided a subscription of a fixed quantity of electricity (the "subscription" load) priced at an "otherwise applicable tariff" (OAT) equivalent rate and based on historical customer usage from the year prior. The subscription method provides the customer with protection, flexibility, and predictability. Customers in the Pilot stayed on their current OAT and were converted to monthly calendar billing cycles to align with the subscription energy load profiles. A customer "shadow bill" was then calculated each month, reflecting the amount that would be owed or saved under the Pilot pricing method.

SCE bundled customers participated in the Pilot via Automation Service Providers (ASPs) who installed automated technologies to manage selected electrical end uses at customer sites. SCE did not market the Pilot to customers or directly enroll them into the Pilot and participants were often customers of the ASPs prior to enrollment. This minimized SCE's recruitment costs. Multiple ASPs were engaged during the Pilot's development and deployment, but only three ASPs actively enrolled customers in the Pilot, with that customer data contributing to the report.

SCE partnered with TeMix, Inc., a third-party market consultant and application software platform services provider, to host their software-as-a-service (SaaS) transactive platform (TeMix Platform™) for delivering the Pilot's dynamic pricing to ASPs. TeMix also provided analytical design support, application reviews, and operational services for various technical aspects of the Pilot. Their consulting services included collaborating with SCE's Rate Design Team on dynamic price designs and determining hourly price values. These values were calculated by the TeMix Platform and transmitted to the ASPs on a day-ahead schedule so that the ASPs could manage

the end uses on behalf of their customers.

SCE contracted with another third-party consultant, GridX, to provide TeMix dynamic circuit load forecast models published daily for the SCE distribution circuits that serve the specific participants in the pilot. That information was used in the calculation of the hourly dynamic prices as a component of the energy value from the marginal local capacity of the participant circuits.

SCE directly contracted with the customer ASPs, who developed machine learning Agents to manage customer loads in response to the day-ahead dynamic prices communicated by TeMix using its protocols. The ASPs interact with the TeMix Platform to manage electric end-use technologies at customer sites, while integrating dynamic rates into the end-use technology operating schedules. TeMix and the ASPs managed the Agents to schedule the operation of devices based on the hourly dynamic prices, weather inputs, other data, and the devices' physical constraints. This schedule is then used to manage the hourly pricing transactions during each day to optimize the customer's electrical costs.

During the Pilot, participating customers continue to receive and pay their OAT bill each month on a calendar basis. Additionally, the TeMix platform calculates a "shadow bill" each month, reflecting the customer's energy costs associated with the Pilot pricing method. However, this shadow bill is not settled with the customer's OAT bill each month. Instead, at the end of a full year of Pilot participation, the total OAT bill over twelve months is compared to the total shadow bill over the same period for settlement. If the shadow bills are lower than the OAT bills, the customer receives an incentive payment for the difference. Conversely, if the shadow bills are higher than the OAT bills, the customer does not owe any additional payment to SCE.

There were 38 Pilot participants that participated at some point through September 2024 (one opted out in 2024). July 2023 was the first month in which a customer became eligible to receive shadow bill credits after one year of Pilot participation, though most of the customers' eligibility began later in 2023. Twenty-two of the enrolled customers had validated shadow bills available for inclusion in this report, with 4 to 15 months of available data within the July 2023 through September 2024 timeframe.

<u>Key Evaluation Takeaways:</u>

1. The evaluation of load responsiveness found the following:

   The ASPs in the Pilot reported the ability to successfully respond to the hourly dynamic price signals from TeMix. ASPs were able to integrate technologies (primarily smart thermostats) in the Pilot that responded to the ASP Agent schedules based on the day-ahead price signals without customer intervention. The

analysis did not find evidence of consistent and/or large changes in hourly energy usage due to customer price response. Possible explanations for this finding include:

- Extended time required to set up and implement Pilot activities, including time for the ASPs to refine their response algorithms, time to acclimate customers to the Pilot (e.g., ensure they understand the kinds of changes they can expect to experience as their AC units respond to prices), and time to produce information that provides ASPs and customers with feedback to understand the value of their participation and evaluate how they can improve performance.

- The shadow bill credit methodology gives customers an incentive to simultaneously pay attention to OAT rates and dynamic prices. It is possible that the ASPs prioritized reducing costs from the OAT during the Pilot period as those were more visible monthly to customers (shadow bills were not). Because of the "dual incentives" issue, the Pilot was not designed to obtain statistically valid estimates of customer response to dynamic prices.

- Hourly price differences from the dynamic rates may not have been high enough to induce significant price responses. At a given time, ASPs and customers may have prioritized maintaining comfort over the possible shadow bill savings available from shifting air conditioning loads.

2. The range of bill impacts varied from customers who receiving credits from the shadow bills to some customers not receiving any credits.

3. The evaluation of cost recovery concluded that the customer's subscription load profiles were the most important factor in determining whether a customer was due a shadow bill credit. The optimal method of subscription pricing (e.g., whether/how to update quantities over time, how to deal with NEM and electric vehicle adoption) is a topic worthy of in-depth research that is beyond the scope of this study.

Next Steps

The Pilot is now closed and decommissioned as of December 31, 2024. The final report can be found at https://www.dret-ca.com/wp-content/uploads/2025/03/PUBLIC-SCE-DRP-Final-Evaluation-Report.pdf

4. Budget

The following table represents the total expenditures for SCE's 2023 - 2027 EM&T authorized budget as of June 30, 2025. These values are based on the authorized funding and expenditures as reported in SCE's Monthly Report on Interruptible Load Programs and Demand Response Programs, Table I-2, SCE Demand Response Programs and Activities Expenditures and Funding submitted on August 1, 2025.

The values in the table below do not reflect forward budget commitments for internal labor, support contractors, or project costs, including those described in this report. The budget commitments may have been scoped and contracted, but not yet executed or monies have not yet been spent.

Southern California Edison's Emerging Markets and Technology Program 2023 – 2027	
Authorized Budget	$25,743,335
Budget Spent to date	$9,104,783

NOTE: The "Authorized Budget" amount in the table above also includes the 2022 funding authorized for the DR21.03 Dynamic Rate Pilot approved in D.21-12-015.