Demand Response Emerging Markets and Technology Program

Semi-Annual Report: Q3 – Q4 2025

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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
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
DERMS	Distributed Energy Resource Management System
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
DRRC	Demand Response Research Center
DSM	Demand-Side Management
DSRIP	Demand Side Resource Integration Platform
EE	Energy Efficiency
EEC	Energy Education Center
EERP	Energy Efficient Retrofit Packages
EMIS	Energy Management Information Systems
EM&T	Emerging Markets & Technology
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	Energy Transition 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
MIDAS	Market Informed Demand Automation Server
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
OCST	Occupant-Controlled Smart Thermostat
OEM	Original Equipment Manufacturer
OP	Ordering Paragraph
OADR	Open Automated Demand Response

PCM	Phase Change Material
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	Supplemental 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 Q3 – Q4 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]

OVERVIEW

The SCE DR EM&T program, in compliance with CPUC directives, accelerates the commercial 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 program conducts activities related to technology research, market studies, the intaking of emerging consumer technologies, scaled demonstrations, equipment field trials, and laboratory tests. These activities help enable the high-tech and consumer market participants to adopt methods and standards for customer participation in DR programs, and the program also advocates with stakeholders to enhance emerging markets for the continuous improvement in DR technological innovation.

The benefit from these investments in DR research enables customers in all sectors and income levels to meet their future energy needs in a cost-effective manner that ultimately results in enhanced grid reliability and affordability for all. These benefits can accrue in the near term for local grid needs, and through the development of new models of programs and technologies, help develop the foundational capabilities required for the longer-term future needs of the California electric system.

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

The EM&T program activities are also designed to identify and mitigate non-technology barriers that impede or restrict SCE customers and the overall consumer industry from understanding and adopting effective DR behaviors and performance 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, innovative codes and standards adopted by the California Energy Commission (CEC) that now bring DR-enabled products to market and support the overall cost savings benefits for participants and non-participants alike.

INVESTMENT CATEGORIES

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 five EM&T core investment strategies are as follows:

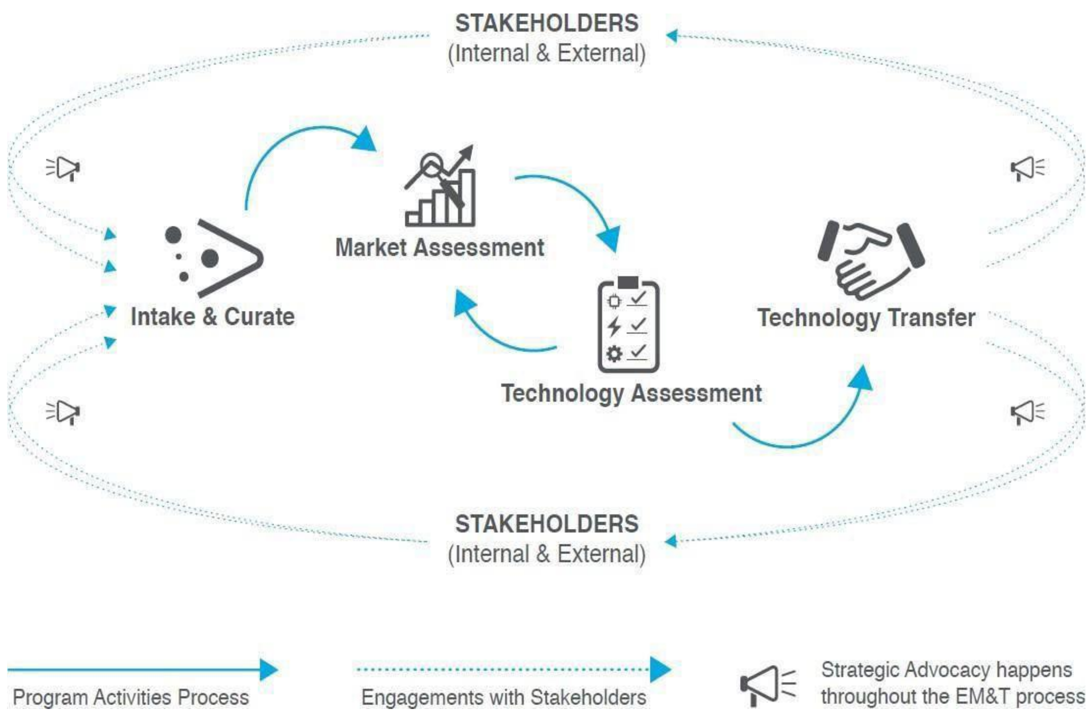
- Intake and Curation: Identifies studies, projects, or collaborations for inclusion in EM&T's portfolio and selects which ones to fund based on a well-informed understanding of the broader industry context. Many of these intakes are curated through engagement with start-up companies and established industry stakeholders developing new products and services.

- 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. These include mass market consumer smart technologies and behind the meter distributed energy resources (DERs) such as heating and cooling systems, batteries, and electric vehicles.

- 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. Due to the nature of specific DR program performance needs, many DER systems have the ability to both provide their core functionality as well as added value as a DR resource.

- 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 planning, 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 learnings and results from each activity, study, and assessment type are made publicly available via regulatory filings and academic and industry white papers. Additional details about the research are effectively disseminated via virtual presentations and in person summits and forums to a broad audience of energy market stakeholders and others who can review the findings and act upon these results (including start up investors, technology developers, customer advocacy groups, local governments, and policymakers).

CURRENT EM&T INVESTMENTS

The following table lists the individual EM&T projects described in this report that were initiated, in-progress, or completed during the Q3 – Q4 2025 period. The table also identifies the type of EM&T Investment Category that each project addresses in alignment with the research strategy to facilitate the continued development of DR emerging technologies:

Project ID	Project Name	EM&T Investment Category
Projects Initiated		
DR25.03	EPRI IAW FlexHub SPA (GFO-23-316)	Technology Assessments Technology Transfer
DR25.04	EPRI LAUSD-FLEX SPA (GFO-23-309)	Technology Assessments Technology Transfer
DR25.06	EPRI FLEX DR 2.0 SPA	Market Assessments Technology Assessments
DR25.12	EPRI Flex Refrigeration SPA (GFO-23-301)	Technology Assessments Technology Transfer
In-Progress Projects		
DR22.02	HP-Flex: Next Generation Heat Pump Load Flexibility DR (GFO-19-301)	Market Assessments Technology Assessments
DR23.01	DR-TTC Dynamic HVAC Test Chamber	Technology Assessments Technology Transfer
DR24.01	Behind the Meter Optimization of Load Technologies (BOLT) Study	Market Assessments Technology Assessment
DR25.07	EPRI Smart Panel Field Study SPA	Market Assessments Technology Assessments
Projects Completed		
DR23.03	Achieving Integrated and Equitable Decarbonized Loads with the CalFlexHub (GFO-19-309)	Market Assessments Technology Assessments

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 operates in parallel with the EM&T program. The EM&T program has successfully collaborated on projects and research funded from the California Energy Commission's Electric Program Investment Charge (EPIC) program, the Department of Energy's (DOE) Building Technology Office (BTO), Lawrence Berkeley National Laboratory (LBNL) and other research organizations and their activities conducted in the United States and overseas.

The SCE Customer Solutions (CS) organization at SCE oversees the EM&T program's activities, managed under the Demand Response Products Group. The EM&T program is now continuing with the CPUC's four-year (2024-2027) 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 July 1, 2025, and December 31, 2025, for Q3 & Q4 of program year 2025.

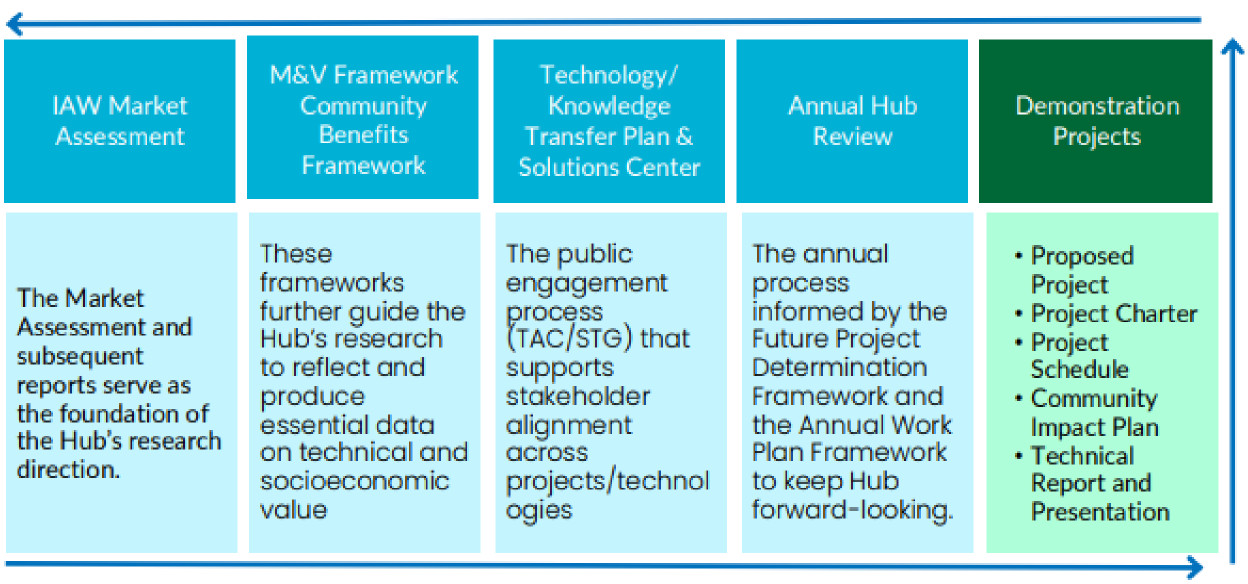
1. Projects Initiated Q3 – Q4 2025

DR25.03 EPRI IAW FlexHub SPA (GFO-23-316)

Overview

SCE is partnering with the Electric Power Research Institute (EPRI) to support the CEC's Industrial, Agricultural, and Water (IAW) FlexHub, funded under EPIC Grant Funding Opportunity GFO-23-316. The FlexHub project, administered by Momentum, will convene leading research organizations—including EPRI, UC Davis, LBNL, Stanford University, Fresno State, and others, to advance pre-commercial demand flexibility (DF) solutions for California's IAW electric customer sectors.

The IAW customers in California represent some of the largest and most energy intensive energy loads in the state, offering significant potential for DF orchestration. Yet the adoption of DF technologies has historically lagged due to limited cost-benefit analyses and experience, and a lack of sector-tailored energy controls. The FlexHub aims to address these gaps by demonstrating scalable, cyber-secure DF technologies that can provide real-time response to price, grid, or emissions signals and help customers reduce their operating costs.



IAW FlexHub Lifecycle

SCE is participating as both a research collaborator and cost-share partner, committed to supporting the field demonstrations within SCE territory. The partnership directly supports statewide and utility-specific objectives for statewide flexible load integration, including California's statutory goal to achieve 7,000 MW of load shift by 2030.

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

EPRI, under contract to SCE, will lead several large-scale demonstration efforts within the FlexHub, focusing on developing and validating DF enabling technologies across multiple IAW subsectors—such as wastewater facilities, food processing and cold storage, industrial manufacturing processes, and agricultural farming and irrigation pumping operations.

SCE will collaborate closely with EPRI and Momentum in the following areas:

- Identifying IAW customer sites within SCE territory suitable for initial demonstrations
- Work with the FlexHub Future Demonstration Project Determination Framework to guide annual project selection
- Providing load metering and operational data, where permissible, to support load shape analyses and DF potential modeling
- Participating in stakeholder working groups, including local community, industry, and manufacturer discussions
- Reviewing project scoping, installation plans, evaluation frameworks, and reporting deliverables to "fast track" lessons learned
- Ensuring alignment with SCE's customer relationship priorities, including resilience, affordability, and customer equity

This collaboration leverages EPRI's technical expertise and SCE's demand flexibility team to accelerate adoption of cost-effective DF solutions across high-load industrial, agricultural harvest systems and pumping, and water-related processing operations.

Results/Status

During Q3 – Q4 2025, the project teams were identified and foundational planning and early execution milestones were advanced, including:

- EPRI and Momentum initiated scoping for five planned demonstrations in SCE territory, consistent with early FlexHub planning assumptions.

- Site pre-screening began for industrial and water sector customers who may participate in project installations beginning in mid-2026.
- Initial drafts of the FlexHub's Load Shape Data Plan and Market Assessment Framework were reviewed by SCE staff, aligning with broader statewide analysis activities.
- EPRI initiated technology assessment reviews for candidate DF technologies, including flexible motor controls, process load modulation systems, thermal storage for industrial refrigeration, optimized agricultural pumping strategies, and secure multi-asset control platforms.
- SCE, EPRI, and Momentum began preparations for developing the Future Demonstration Project Determination Framework, that shall guide annual project selections for Years 2 – 5.

At this stage, the project is progressing on schedule, with technical risk reviews, stakeholder engagement planning, and Year 1 research coordination underway. Demonstration site selection and contracting activities are expected to continue into early 2026. SCE has four of the first five sub-projects that have been identified in its service territory, but the learnings will be shared with all Momentum stakeholders as this is a statewide activity. The current projects that are in the development include the following:

Industrial Load Flexibility Scheduling Algorithm (ILFSA) Demonstration

•Developing algorithm and decision support tool to minimize operational risks and scheduling complexities typical with DR measure adoption and load flexibility (LF) participation in industrial facilities.

Development of Tariffs to Incentivize Load Shifting in the Water Sector and Beyond

•Developing flexible demand management strategies for increasing useful electric load during periods of excess renewable energy within the electric wholesale markets

Flexible Load and DF Control Platform Demo at an All-Electric Factory

•Developing cost-effective multi-asset demand flexibility and utility cost management at a large all-electric, new manufacturing facility of low-voltage electrical equipment.

Demand Flexibility Tools for Water Utilities

•Developing a set of digital tools that enable water utilities to value, assess, and deploy energy demand flexibility.

Enhanced Demand Flexibility for Cold Storage

•Developing a Model Predictive Control (MPC) System for cold storage systems in food distribution and processing facilities to enhance energy efficiency and load shifting.

Next Steps

In the first half of 2026, the overall project team leads will advance detailed technical design, customer engagement, and demonstration planning for each of the sub-projects. Key activities include:

- Finalizing the scope for each of the candidate demonstration sites within SCE service territory across priority IAW subsectors
- Completing the Year 1 Annual Technology Portfolio and Work Plan, including detailed scopes for SCE-funded demonstrations
- Developing site-level Community Impact Plans and evaluation plans in alignment with Hub frameworks
- Coordinating with SCE on site permitting, data access procedures, and customer readiness assessments
- Launching stakeholder engagement groups and integrating early feedback into demonstration design
- Supporting Momentum in developing Year 1 – 5 Future Research Recommendations that align statewide priorities with SCE's grid needs

Demonstration deployments are anticipated to begin in mid-2026, with technology installation, commissioning, and early operational data collection expected shortly thereafter. SCE's involvement is expected to continue through 2027, based on the current funding authorization of the EM&T program.

DR25.04 EPRI LAUSD-FLEX SPA (GFO-23-309)

Overview

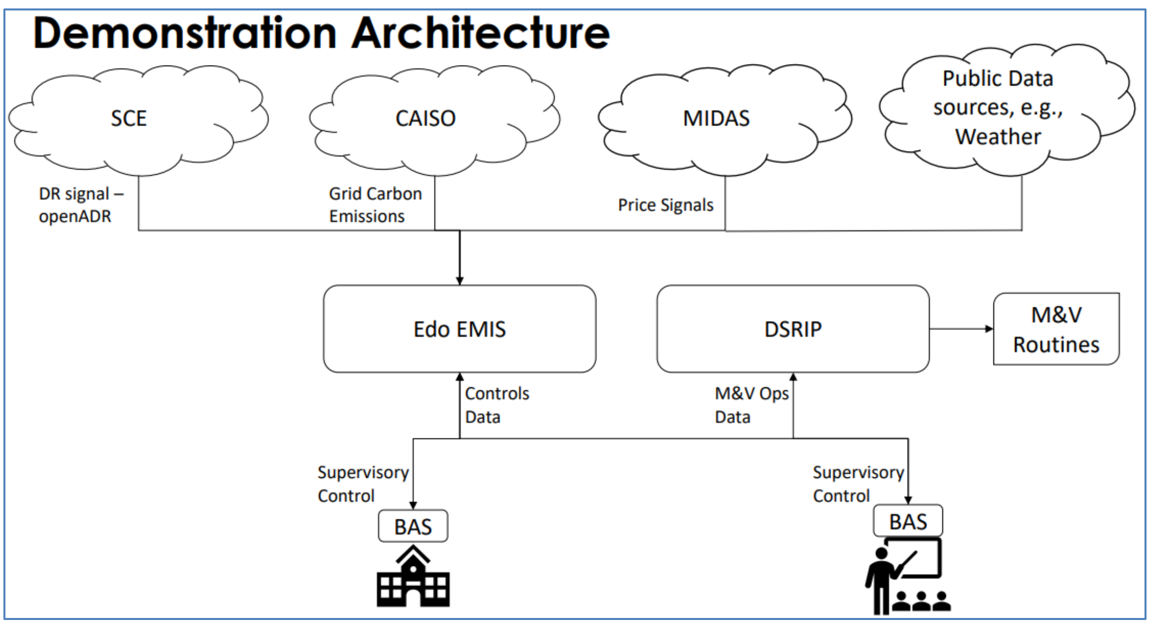
The LAUSD-FLEX project is designed to demonstrate, at a school-district scale, the capability of interoperable energy management systems (EMS) delivering repeatable, standards-based demand flexibility across large commercial campuses—without locking facilities into proprietary EMS platforms. By focusing on interoperability and open standards (e.g., BACnet 135 for building systems; OpenADR 2.0B and IEEE 2030.5 for automated signaling), the demonstration aims to create a replicable template that other public-sector portfolios can adopt. The effort is funded under the CEC's VPP-FLEX (GFO-23-309) Group 2 and managed by EPRI to address the market's current fragmentation and to show how a common, standards-aligned approach can broaden participation in utility demand flexibility.

At its core, the project will evaluate whether an interoperable EMS can coordinate major controllable end uses in schools—HVAC, lighting, and EV charging—to meet programmatic performance thresholds (≥10% summer peak-hour reduction; ≥5% winter peak-hour reduction) while staying within operational constraints and preserving occupant comfort. The project also requires mature technologies and enrollment in an IOU demand response program by project completion, ensuring the work translates into real, grid-connected operations. This makes LAUSD-FLEX as much a market enablement project as it is a technology integration one.

Maywood Center for Enriched Studies

Large school facilities consist of significant, schedulable loads with predictable occupancy patterns, increasingly paired with on-site PV and EV charging. Orchestrating these resources via an interoperable EMS provides a scalable pathway to load shaping, shifting, and shedding—and to carbon-aware operation—without bespoke integrations at every site. The project's focus on standards-based signaling and open interfaces is intended to catalyze district-wide and, ultimately, statewide replication, while offering a realistic playbook for program enrollment, tariff alignment, and coordination with utility platforms.

From an equity perspective, the project is also structured to deliver benefits in disadvantaged communities and low-income communities (DAC/LIC). Beyond near-term bill management and peak demand relief, the demonstration is expected to identify cost-to-benefit drivers, highlight adoption barriers (technical and business-model), and document best practices for interoperable EMS deployment in the public-sector building context. Those insights will support broader policy and market developments—including the potential alignment with emerging building performance policies cited in the project objectives.



LAUSD Project Demonstration Architecture

Finally, LAUSD-FLEX is intentionally positioned as a bridge-to-scale effort: it tests utility-compatible automation (standards-based communications, utility DR enrollment) while codifying integration and operational patterns that facilities teams and solution providers can re-use across portfolios. By centering on interoperability and repeatability, the project seeks to de-risk district deployments and accelerate commercial pathways for EMS-based demand flexibility in California's education sector and beyond.

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

EPRI serves as prime for the CEC EPIC contract and leads the project design, coordination, and tech transfer; Edo provides the enterprise DERMS/EMIS integration layer; Kliewer & Associates leads M&V and data analysis; New Buildings Institute (NBI) supports technology transfer; LAUSD provides sites and facility access; Brotherhood Crusade engages as a community-based organization; and SCE supports program alignment and site enrollment in DR/Auto-DR, data interfaces, and overall utility coordination under the EM&T program.

The demonstration architecture integrates SCE's DR signaling (OpenADR) and price/carbon data from the CEC and others (e.g., MIDAS, CAISO marginal emissions) with a grid-edge DERMS, which supervises building-level EMS/BAS to actuate HVAC, lighting, PV-adjacent operations, and EVSE in response to DR, pricing, and emissions objectives. EPRI functions as the data aggregator and system of record for M&V, with routines to evaluate control efficacy and measured load impacts.

Results/Status

During Q3 – Q4 2025, the project progressed on foundational planning and early execution milestones, including:

- Design & site integration planning: EPRI and Edo developed site-specific requirements, connectivity and interface designs, and signaling specifications for EMS/BAS integration; Site Assessment and Site-Specific EMS reports were produced to inform implementation.
- Data & enrollment preparation: SCE collected data for LAUSD pilot sites; DR program participation history was shared; and the team reviewed API and overview information for the Flexible Rate Pricing pilot and dynamic rates for potential site enrollment. A rate review confirmed the tariffs that the LAUSD pilot sites are currently on.
- EV integration readiness: EPRI drafted an EVSE utilization survey to inform the design of the EMIS-controlled EV charging integration.

- Workforce & community: An initial workforce training and community engagement summary was prepared for stakeholder review and alignment.
- Site access & M&V baseline: The team is coordinating with LAUSD to finalize site access agreements and clearances needed to initiate baseline M&V; completion is expected shortly.

Next Steps

The project will endeavor with the following activities for the first quarter of 2026:

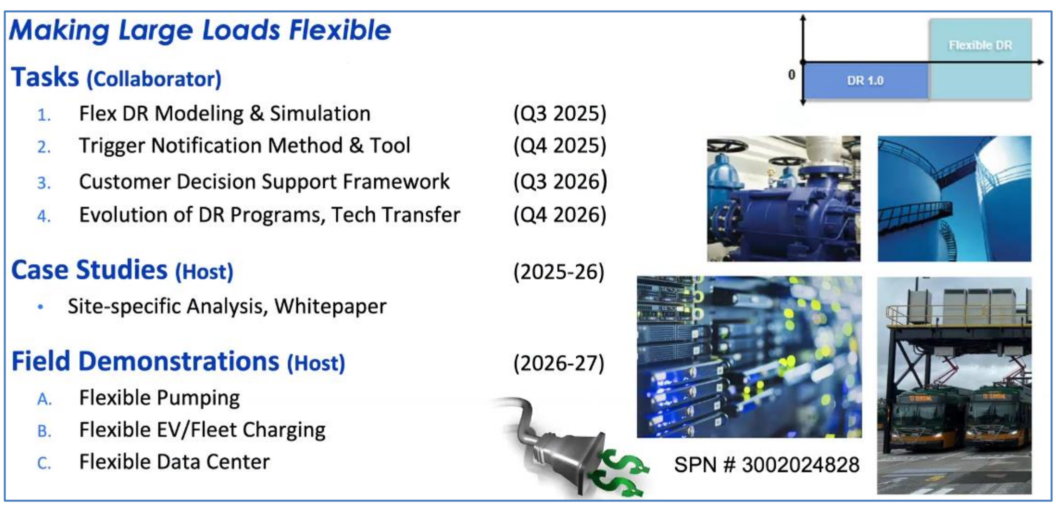
- Finalize Access Agreements & clearances with LAUSD and initiate M&V baseline at both pilot sites; complete the M&V test plan and instrumentation specs for quantifying load shift/shed impacts.
- Technology installation & commissioning planning, including EMS/BAS enablement for OpenADR VEN, DSRIP integrations, and controls testing across HVAC, lighting, and EVSE.
- Program enrollment path: confirm demand response program eligibility and enrollment steps and evaluate research-focused dynamic pricing options recognizing the current SCE tariff eligibility constraints; continue coordination with SCE program teams on customer rate/program alignment.
- Tech Transfer & TAC: prepare TAC #1 pre-read materials, technology transfer plan, and stakeholder collateral; coordinate with NBI to leverage industry groups and dissemination channels.
- EV integration: distribute and collect EVSE utilization survey and finalize EVSE control plan for a high school pilot site within the EMIS/DERMS orchestration.

DR25.06 EPRI FLEX DR 2.0 SPA

Overview

SCE is participating in EPRI's Flexible Demand Response (Phase 2) Collaborative to develop, validate, and demonstrate flexible demand response (Flex DR) as a dependable hybrid resource—explicitly encompassing both "Power Down" (load reduction for grid needs) and "Power Up" (beneficial load increase during surplus renewable generation). The initiative in Phase 1 was originally focused on large water pumping loads—including well extraction, booster, influent/effluent, and filtration pumps—which typically range from ~100 kW up to 1 MW.

Phase 2 of the EPRI collaborative is structured to demonstrate Flex DR capability and value at scale with much larger loads, and to define how Flex DR should be represented in system planning and grid operations. Beyond proving technical feasibility, the work targets programmatic and operational challenges that have historically limited customer participation in demand flexibility, namely uncertainty in response characteristics and persistence over time. The scope embraces a two-sided flexibility paradigm in which large loads respond not only to peak-reduction needs but also to absorb clean energy when renewable energy is being curtailed, enabling balancing during steep ramps and unlocking new customer cost-management strategies with the availability of lower energy prices.



Flex DR Collaborative Phase Two Overview

To achieve this, the Collaborative combines analytical development with field-proximate activities. First, EPRI extends Flex DR models and simulations originally developed in Phase 1, refining resource attributes so they can be scheduled and dispatched with confidence in production-cost, resource-adequacy, and market-operations contexts. Second, site-specific case studies evaluate Flex DR strategies at candidate pumping facilities and prototype an operator decision-support concept that translates grid requests into actionable plant-level operating modes. Third, hosted demonstrations progress Flex DR from analysis to practice, aligning test plans to system flexibility requirements and documenting realized value streams and operational learnings. Taken together, these tracks create a pipeline from model → tooling & procedures → demonstrated operations.

The modeling outputs emphasize parameters essential to grid use of flexible loads: minimum/maximum power levels, ramp rates, response times, event duration, near-term predictability, and long-term persistence. These attributes are being calibrated to real-world operations and translated into modeling formats recognized by planners and operators, so Flex DR from large pumps can be co-optimized alongside supply-side resources. The anticipated system benefits include reduced renewable curtailment, improved capability to follow variable output ramps, lowered emissions, and customer cost savings, all anchored in standardized model forms that can be reused across utilities.

A key innovation in Phase 2 is the Trigger Tool demonstration, designed to provide automated, advance notifications of Flex DR events to customers based on both grid needs and customer-expressed operating preferences. The tool ingests market and public data—such as anticipated negative prices, weather conditions, or marginal emissions indicators—to forecast Flex DR opportunities within operator-relevant timeframes. Publishing the requirements and data-processing approach demystifies how signals are sourced and translated, lowering the barrier for utilities and site operators to adopt repeatable, automated pre-event workflows.

In parallel, the Collaborative is developing a Customer Decision Support Framework that abstracts common operating considerations for water and wastewater plants into a generalized operator interface. The framework presents the capability and limits of plant systems for Power Down and Power Up participation, links those to program/rate constructs, and supports safe, repeatable responses that respect process constraints, water-quality requirements, and service levels. By codifying these decision patterns across different program designs and regional grid conditions, the framework aims to make Flex DR scalable and portable across agencies and utility territories.

SCE’s co-funding commitment supports delivery of Phase 2 milestones and ensures the insights to directly inform SCE DF strategies. The period of performance will span through 2026, with major task targets including the completion of the technology-transfer deliverables and the development of the Customer Decision Support Framework, reflecting ongoing refinement of operator-facing concepts as demonstration lessons are synthesized.

Finally, while large water service pumps were the primary focus of demonstrations, the Collaborative developed a framework that is extensible to other large, schedulable loads—including electric bus depots and data centers—where Flex DR can be shaped around predictable operating windows and storage-like flexibility. This broadens the pathway for utilities to source customer-side flexibility that complements traditional DR and broadens the opportunities for grid-aware DF.

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

EPRI leads project design, analytics, coordination, and knowledge transfer; EPRI Collaborative members (including SCE) participate in quarterly review meetings, help prioritize use cases, and provide program information and potential host-site introductions. Deliverables will be shared with SCE water customers in a accelerated technology-transfer approach intended to support rapid adoption across utilities and large-load customers.

Results/Status

During the second half of 2025, the Collaborative advanced from analytical development into applied validation and programmatic readiness. Modeling and simulation work—which establishes Flex DR resource representations for operations and planning—has already been completed in earlier phases and shared across the Collaborative. EPRI then focused on Trigger Tool demonstration milestones targeted for 2025 (e.g., data ingestion, event prediction windows, and notification workflows) and began organizing inputs for the Customer Decision Support Framework. In parallel, participants continued case study scoping for large pumping sites and reviewed program design considerations (availability windows, response duration, and persistence) that influence how these loads can be scheduled as flexibility resources in utility operations.

Next Steps

In the early part of 2026, the project will commence the following activities:

- Finalize Trigger Tool field validation with participating hosts and document requirements for automated, advance Flex DR notifications tied to grid needs and customer operating constraints.

- Advance the Customer Decision Support Framework, including a generalized operator dashboard concept and guidance for integrating program/rate elements with operational limits at pumping facilities.
- Continue case study and demonstration planning for large pumps (and other large loads where applicable), with emphasis on quantifying Power Up/Power Down value streams and incorporating results in final technology-transfer materials.

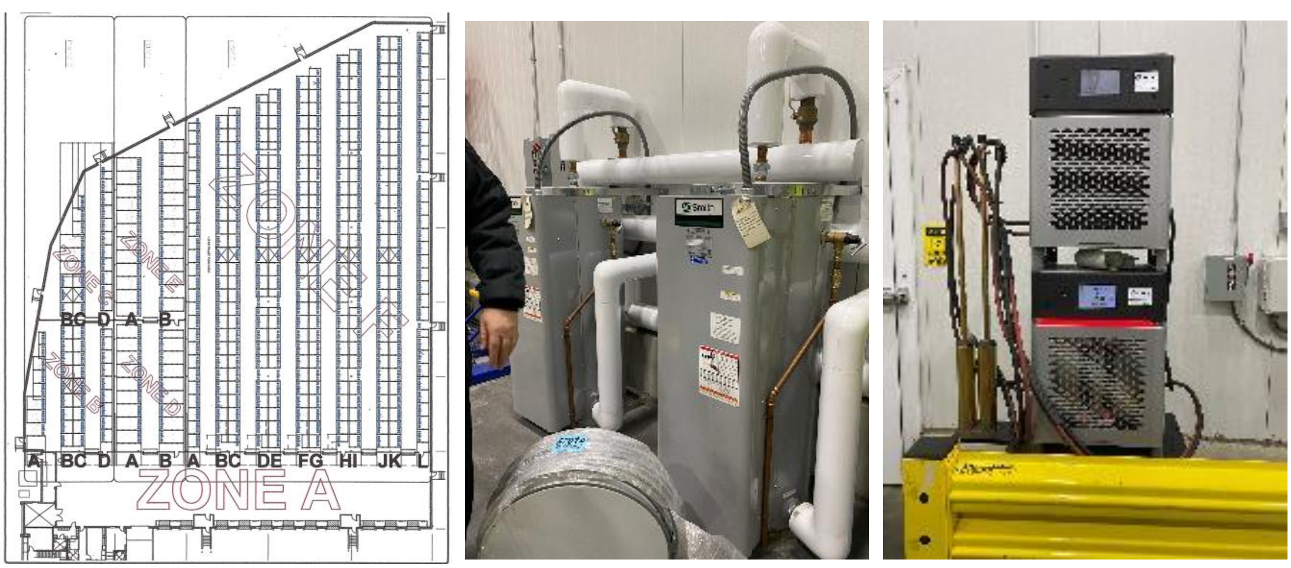
The Flex DR Collaborative will hold regular updates each quarter via webinar throughout 2026 and will also conduct in-person meetings to be scheduled in alignment with the EPRI bi-annual advisory meetings.

DR25.12 EPRI Flex Refrigeration SPA (GFO-23-301)

Overview

SCE is collaborating with EPRI on a technology field demonstration funded by the CEC under an EPIC award to EPRI through GFO 23-301. The project integrates industrial refrigeration controls, thermal energy storage, floor-slab heating controls, and managed charging for electric forklifts at a large, refrigerated warehouse to deliver demand flexibility and emissions reductions. The demonstration—referred to as "IndFlex"—focuses on a 45,292-square-foot cold-storage facility in Southern California, with a site peak demand of approximately 466 kW, providing a meaningful testbed for peak load management and load-shifting strategies that preserve product integrity and operational reliability.

The project will deploy advanced refrigeration system controls capable of receiving grid signals through a gateway or virtual end node, integrated phase-change material (PCM) thermal storage to buffer refrigeration loads, smart controls for electric floor heating to coordinate defrost and slab temperature needs, and automated forklift fleet charging to avoid coincident peaks while maintaining operational availability. Together, these assets will be orchestrated to shift and shed load, reduce greenhouse gas emissions by at least 20 percent relative to baseline, and assess whether the combined solution can achieve a simple payback of fewer than five years—key adoption thresholds for industrial customers.



Industrial Flex Site Layout and Refrigeration Controls

Performance targets are defined per subsystem to enable replicability: refrigeration peak load reduction of 25 percent (low target) to 50 percent (high target); floor heating peak load reduction of 15 percent to 50 percent; and electric forklift managed-charging peak load reduction of 25 percent to 50 percent.

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

EPRI serves as the prime CEC contractor and technical lead and is responsible for solution design, system integration, and multi-asset controls coordination. An independent M&V subcontractor will conduct pre-intervention baselining and 12 months of post-intervention measurement, enabling a rigorous evaluation of performance across operating modes, seasons, and grid signal conditions. Technology partners will support PCM selection and integration (e.g., commercial PCM manufacturers cited in the concept), the refrigeration controls upgrades with VEN-enabled signaling, slab/floor heating sensors and controllers, and forklift charging automation. SCE provides customer relationship, DR/Auto-DR pathway coordination, and project oversight under the EM&T portfolio.

Results/Status

During the period covered by this report, the EPRI project team advanced definition and partner alignment for the IndFlex demonstration, including site selection, articulation of system goals and performance targets, and presentation of the high-level scope of work and technology stack to SCE. The scope documents the full lifecycle from general project tasks through pre-installation M&V, design and procurement, installation and commissioning, post-installation M&V, benefits evaluation, and technology transfer activities. These preparations position the project team to begin baseline data collection and detailed design for refrigeration controls, PCM integration, floor-heat controls, and forklift managed charging in the next cycle.

The controls solution will coordinate refrigeration capacity, TES charge/discharge, floor-heat operation, and forklift charging windows against utility price signals and/or DR events delivered via the AutoDR signaling interface, targeting coincident peak reduction and carbon-aware dispatch without compromising warehouse temperature bands, defrost cycles, or fleet readiness. The design emphasizes interoperability with existing plant equipment and transparent sub-system performance indicators to support replicability for possible other types of similar sites and to isolate contributions from each asset class in measured results.

Next Steps

In the first half of 2026, the project will embark on the following activities:

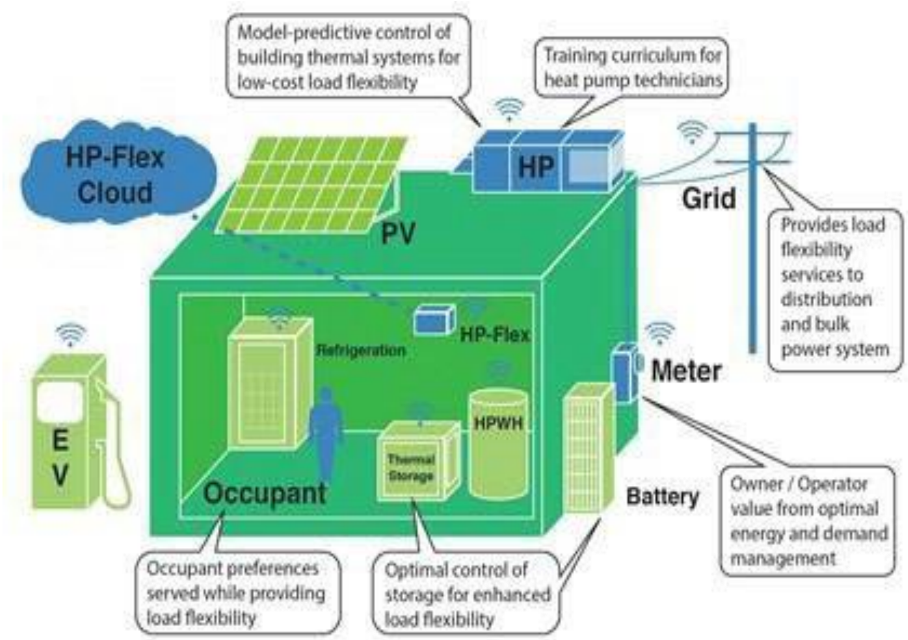
- Finalize the pre-installation M&V plan and initiate baseline monitoring, including metering points for refrigeration, slab heating, and EV charger circuits.
- Complete detailed design and procurement for refrigeration controls upgrades, PCM integration, floor-heat sensors/controllers, and forklift charging automation.
- Confirm Auto-DR enrollment and signal interfaces with SCE, and establish commissioning, post-installation M&V, and technology transfer milestones.

2. Projects Continued Q3 – Q4 2025

DR22.02 HP-Flex: Next Generation Heat Pump Load Flexibility DR (GFO-19-301)

Overview

Lawrence Berkeley National Laboratory (LBNL) submitted a proposal to the CEC in response to EPIC solicitation GFO-19-301, Group 4. The proposal was awarded a contract agreement (EPC-19-013) by the CEC 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. SCE provided a Letter of Commitment in support of LBNL's proposal, and is a partner in the research.



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.

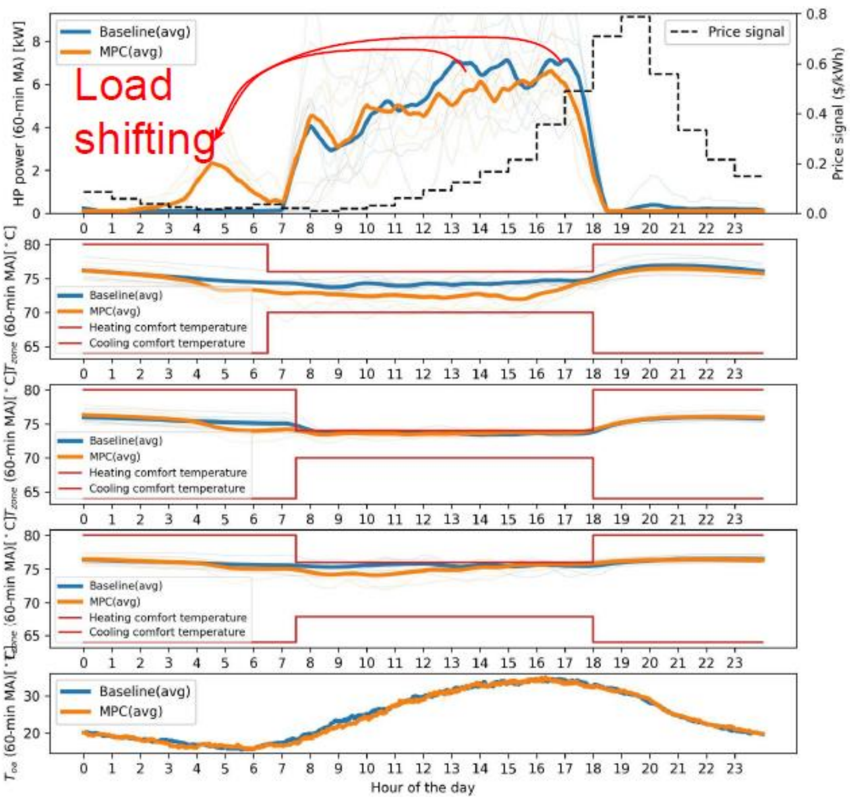
Collaboration

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

Two project coordination meetings were held through Q3 – Q4 2025, with preliminary results shared to SCE stakeholders. The LBNL team was granted a no cost contract extension from the CEC, extending the overall project end date to June 30, 2026.

The LBNL research team successfully demonstrated model-predictive controls (MPC) for heat-pump systems at five field sites, achieving an average 21 percent reduction in peak load and up to 12% percent electricity-cost savings while improving occupant comfort. Locations of the field sites included Davis, Los Angeles County, Bakersfield, San Bernardino, and San Leandro.



Example Site 1: Load Shifting Plots

The project developed open-source MPC software that can be used in existing small commercial buildings with heat pumps. The non-proprietary software is designed to be scalable and does not require a central building automation system. The project team also developed educational resources and documented lessons learned from deploying the software. These resources cover topics such as MPC technology, commissioning protocols, measurement and verification, management of user overrides, and mitigating communication errors.

These educational materials are being incorporated into training programs for technicians through the Building Efficiency for a Sustainable Tomorrow (BEST) Center and into college courses at the University of California, Davis. HP-Flex demonstrates that intelligent, cost-effective controls can transform common building equipment into grid-responsive assets that increase affordability while maximizing occupant comfort. Open challenges persist due to the limited interoperability between devices and systems from various vendors that need to be integrated by the platform, such as thermostats and heat pump (HP) controls, which causes systems to be brittle and results in increased integration and maintenance/upgrade costs.

Next Steps

LBNL and SCE will continue to coordinate on final reporting and project closeout, and the project is expected to be completed by Q2 2026 at which time the final report will be shared with the appropriate stakeholders.

DR23.01 DR-TTC Dynamic HVAC Test Chamber

Overview

SCE Technology Test Center (TTC)

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 Q3-Q4 of 2025, the Technology Test Center team successfully onboarded its contractor, began equipment selection finalization and will continue with equipment procurement, installation and commissioning activities in 2026. The TTC team continued activities with its facilities group to execute planning for upgrading site electrical infrastructure and verifying roof structural requirements.

Next Steps

The team will continue activities through Q1-Q2 2026 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 2027.

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

Overview

The late 2024, the SCE DR team idneitfied the need for a forward-thinking study to cost-effectively revolutionize SCE's future DR customer programs and engage behind the meter electric systems for future DR opportunities. The DR team subsequently 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 is investigating 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 is also designing and testing 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 DR program 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, evaluation, and go-to-market strategy. The first phase of the study conducted 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.

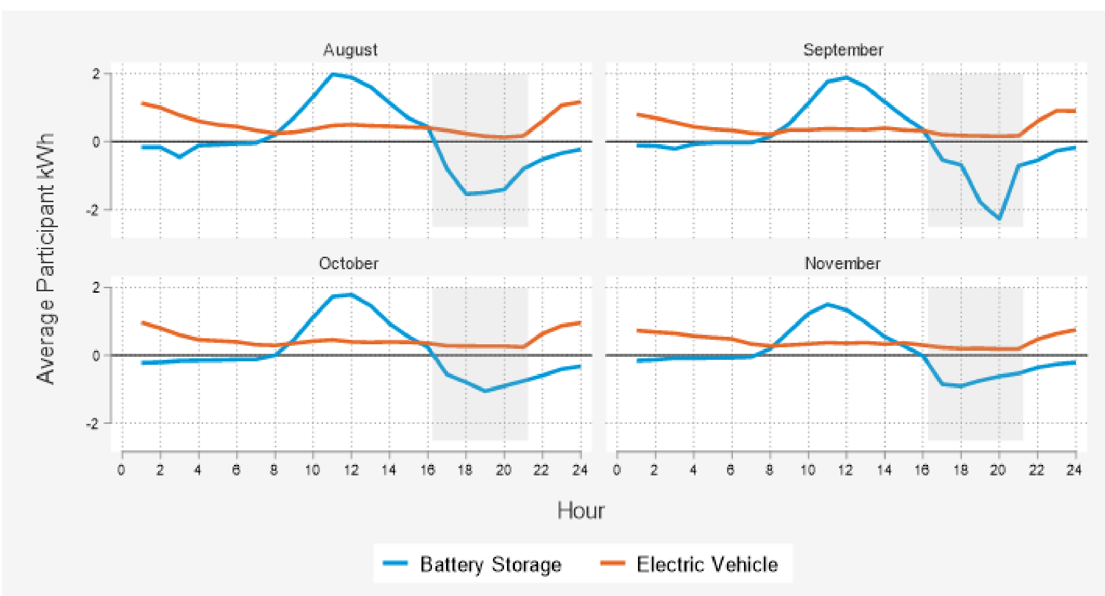
In addition, SCE is working with other technology and software providers who already manage groups of SCE customers for demand management services and other value streams. These providers and other automation service providers (ASPs) will be engaged to collaborate with SCE in assessing the technologies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

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

During Q3 – Q4 2025, the BOLT study made substantive progress toward a scalable multi-end use demand flexibility framework centered on daily load shaping, incremental event-based dispatch, and a simplified customer experience across batteries, EVs, and smart thermostats. Demonstrated portfolio growth at the end of the year, dispatch analytics, and operational buildout collectively reinforced the study's "battery-first" renewed design approach while continuing to test the complementary roles of EVs and thermostats.

Enrollment expanded meaningfully across all three device categories, led by residential batteries, with vendor-reported totals reaching 826 batteries, 625 EVs, and 130 thermostats by the end of the Q4 period. This growth translated to nearly a 10× increase in dispatch-eligible devices from the first to the last event window (rising from 173 to 1,581 devices), with battery enrollments notable scaling by roughly 20× before the final two dispatch events. These gains were supported by OEM-oriented outreach and incremental improvements to onboarding and cross-marketing pathways.



BOLTS Hourly Responsiveness Between Batteries and EVs

Dispatch analysis underscores batteries as the primary driver of measurable load reduction, with the majority of observed drop occurring in the first event hour—

consistent with standard battery dispatch practices. By contrast, EVs and thermostats exhibited near-zero attributable reductions during the 4–9 PM event window, reinforcing earlier findings that their peak-period DR potential during a TOU period is limited. Load shape data further show that EV charging remains largely non-coincident with peak demand and that non-event battery dispatch was less pronounced in October–November when summer peak pricing signals subsided. These observations validate the study's emphasis on overnight EV load management and battery-anchored shaping, with thermostats and EVs contributing through targeted daily micro-adjustments rather than heavy reliance on peak-hour event reductions.

Operationally, SCE and its vendors advanced key foundations for scale: re-contracting with existing ASPs, progressing OEM battery agreements, and standing up unified multi-DER data pipelines, forecasting, clustering, and dispatch automation. In parallel, the team matured orchestration algorithms (including battery-solar alignment and thermostat micro-adjustment strategies), executed communications and device-response testing, and expanded cross-marketing to convert battery participants into multi-device households. These efforts collectively position the study for broader pilot operationalization and full-system beta testing as it transitions into the next phase.

The period's results reaffirm several lessons from the 2025 study period that will continue to shape future research: the limited DR potential of EVs in the 4–9 PM window, the importance of layering daily shaping with event-based dispatch to quantify incremental value, and the need to tailor customer outreach and quality assurance to vendor capability differences.

Next Steps

In early 2026, the BOLT team will finalize orchestration algorithms, complete automation of event dispatch instructions across vendors, and finish communications and device-response testing ahead of full-system beta operations. The team will continue targeted battery recruitment, scale cross-marketing to deepen multi-device participation and engage OEMs to reach device-native audiences. Outputs from these activities will be translated into program design recommendations, including eligibility and incentive structures, enrollment and onboarding improvements, and longer-term grid-integration strategies for coordinated multi-DER operations.

DR25.07 EPRI 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 residence, with the added feature 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 houses with retrofits of all-electric appliances by actively managing end use loads, and for managing on-site 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 continued to identify both the availability of smart panel technologies and customer applicants through the end of 2025. The project tasks include reviewing candidate sites and technology eligibility, selecting and specifying smart panel models with breaker and circuit mapping, and supporting permitting authority acceptance. At the end of 2025, eight sites were in the final stages of installation.

Analyses once the installs are completed will quantify customer engagement reactions, assess 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. The project team is continuing their review of the customer eligibility for each site (wiring, load capabilities, and permitting processed) and are continuing their discussions with the OEMs and equipment installers as new product features are released.

Next Steps

In Q1 and Q2 of 2026, EPRI and SCE will continue ongoing host site recruitment and customer application reviews and oversee the installations and customer training. The project team will finalize designs for the remainder of the enrolled customer sites to move ahead into permitting and installation. The implementation team is aiming to have preliminary data by the end of Q2 2026 of the first phase of the project and will review the plan for summer end use optimization.

3. Projects Completed Q3 – Q4 2025

DR23.03 Achieving Integrated and Equitable Decarbonized Loads with the CalFlexHub (GFO-19-309)

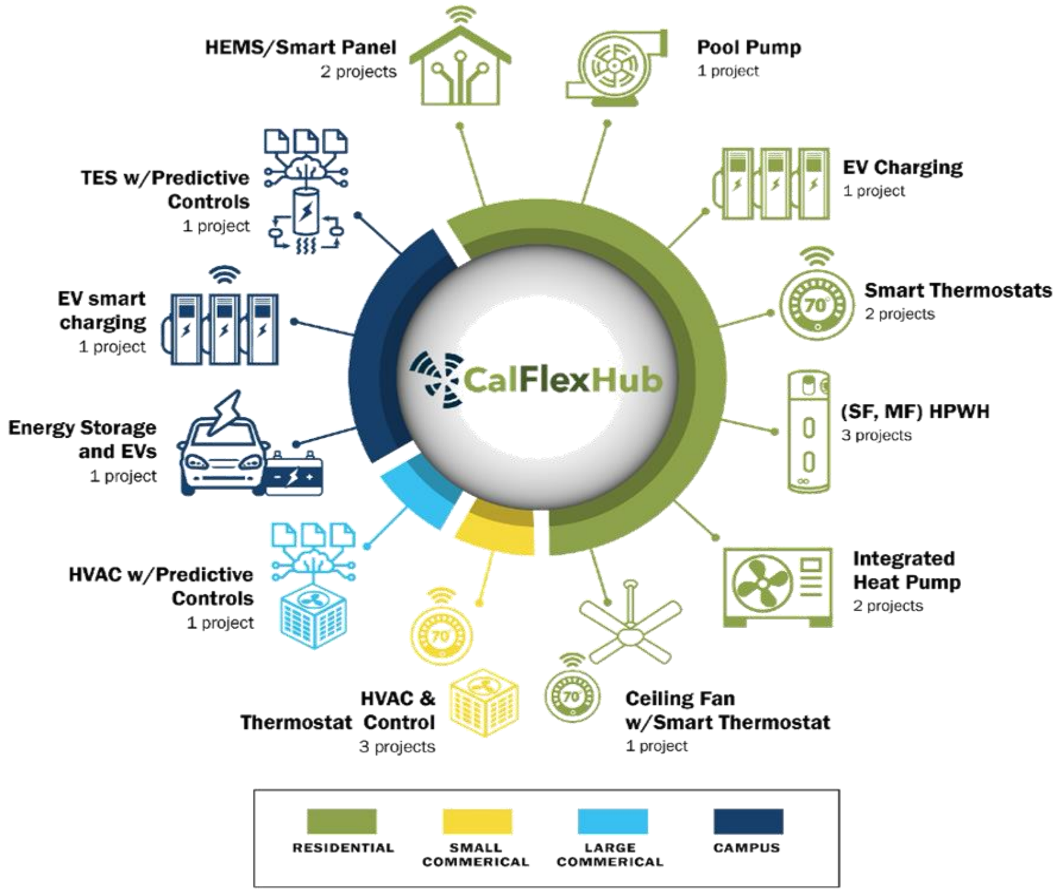
Overview

LBNL submitted a proposal to the CEC in response to EPIC solicitation GFO-19-309. The proposal was awarded a contract agreement (EPC-19-309) to fund the California Load Flexibility and Deployment Hub (CalFlexHub). The overarching goal of the CalFlexHub is to accelerate the understanding of how customer electrical end-use loads could provide dynamic load flexibility and to advance the capability of smart building technologies to provide flexible energy load. 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 technical support for SCE- specific projects.

In addition, 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. One aspect of the participation will be to develop training curriculum for customer-based training of new electric consumer goods.

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 test and demonstrate innovative technologies compatible with the LMS platform to enable affordable flexible loads. Once technologies are tested and usability research is complete, CalFlexHub will support the 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, providing 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 with financial and health burdens that disadvantaged and vulnerable communities will need to overcome, 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, 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 on 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 at an engineering or 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 operational system and qualified through demonstration, wherein the technology has been proven to work in its final form and under expected conditions. SCE engineering staff has supervised 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 reviews and assesses 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 CalFlexHub TAC establishing directions 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 as well as access to the reports and deliverables produced for the CEC contract advisors.

Results/Status

Throughout Q3 and Q4 of 2025, LBNL continued regular CalFlexHub–SCE coordination, including monthly check-ins, review cycles, and delivery of required work products per the SCE-LBNL Master Agreement task order. Key deliverables provided to SCE included:

- Updated Key Findings Presentations that summarized the overall CalFlexHub program progress, interim insights, and cross-project recommendations.
- LBNL Project Final Report Memorandum, providing consolidated progress updates for all SCE-supported subprojects.
- Finalized outputs for five matched-share projects, all of which reached completion by late 2025 or early 2026, including documentation, datasets, training materials, simulation results, and technology demonstrations.

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.

LBNL and Elexity completed multi-season testing to demonstrate Elexity's EMS receiving day-ahead hourly dynamic prices (via MIDAS) and executing paired precooling and setback actions to shift HVAC load during the highest price-differential windows, while maintaining customer-defined comfort bands. Control and treatment testing was completed across two dealership sites in spring and summer 2025, confirming repeatable load shedding and quantifiable customer cost savings attributable to price-responsive control. In the spring testing window, the two sites shed 6.0 kW and 20.9 kW (59% and 77% of baseline) during 5–7 PM, and in the summer testing window shed 7.7 kW and 29.6 kW (68% and 54% of baseline) during 6–8 PM; normalized load reduction intensity ranged from 0.23 to 0.59 W/sf.

The project also quantified customer bill impacts during the precooling/setback windows, documenting savings of $6.0 and $24.1 per day during spring (3–7 PM) and $9.3 and $36.4 per day during summer (4–8 PM), with normalized savings of $0.22 to $0.72 per day per 1,000 sf. A successful functional demonstration of EV charging modulation was also completed (limiting charging rate to ~50% during high-price hours), establishing feasibility for expanding beyond HVAC to additional flexible loads in future work.

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.

LBNL completed a suite of training materials designed for integration into SCE Energy Education Center offerings, including finalized installer-focused handouts/posters and a professionally recorded training video (webinar format) targeting engineers, architects, Title 24 consultants, contractors, and related industry participants. The content covers HPWH fundamentals, selection and sizing, installation best practices (including ventilation and recirculation considerations), commissioning guidance, and practical pathways for participating in utility load shifting programs.

LBNL also completed supporting analysis to contextualize customer value, including comparisons showing HPWHs as a low operating-cost option across major California utility territories and additional savings potential when paired with load shifting. In parallel, the team developed and validated a proof-of-concept Python-based CTA-2045 communications toolchain using low-cost hardware, demonstrating successful dispatch of basic load shifting signals (e.g., Load Up, Normal, Shed, Grid Emergency) and publishing documentation/installation guidance to enable replication—creating a pathway toward more open, utility-program-relevant communications without proprietary middleware dependencies.

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.

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 Ecobee 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 (TES)

Objectives:

- Determine the potential opportunities and obstacles associated with using commercial TES systems in SCE territory for responding to prices and other demand flexibility events.
- Develop and test simulation models representing TES systems to better understand how to drive CA market adoption and identify buildings in SCE territory best suited for TES adoption.

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, a 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 energy efficiency. Other new application areas identified that could drive future growth for TES are greenhouses, district energy networks, data centers, and cold storage facilities.

LBNL finished a modeling study using project-developed simulation models that evaluated the performance of thermal storage in commercial buildings within a variety of climate zones. LBNL developed and validated a simulation toolchain to evaluate two TES configurations—ice storage integrated with chiller plants for larger buildings and PCM-based approaches for RTU systems serving smaller buildings and retail stores—then used the toolchain to assess performance and payback under SCE TOU rate structures across climate zones.

Results show TES can deliver attractive economics, with payback periods generally in the 2 – 5 year range depending on system type, climate zone, and building application, and with particularly strong demand charge reduction potential where TES can reduce or eliminate peak-period chiller operation.

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.

LBNL completed a multi-phase assessment of how California's transition to dynamic pricing is shaping (and being constrained by) the business models of OEMs, automation service providers, aggregators, platforms, and other market actors, drawing on CalFlexHub stakeholder needs assessments, structured review of CPUC R.22-07-005 docket and Track B working group materials, and semi-structured interviews conducted in 2025.

Across these data sources, findings consistently show that policy uncertainty, high integration costs, uneven device-control access, fragmented customer-data authorization pathways, and overlapping program/tariff requirements create friction that slows investment and scaling. Stakeholders widely agreed that automation and standardization are prerequisites—not optional enhancements—for scalable flexibility, emphasizing the need for consistent price-signal delivery (including MIDAS-aligned access), uniform APIs and device-control interfaces, and streamlined customer authorization and settlement processes.

Although technology developments are challenging, stakeholders indicated that "the hardest part is figuring out how to align everybody's interests" through the market construct that California's policy process is developing.

- Policy uncertainty translates to business uncertainty about the rate and direction of technological change and the need to adapt.
- Many stakeholders said that to justify taking on the costs of developing load flexible technologies, they need to be able to see that there will be sufficient demand for their products and services.

Next Steps

This overall CalFlexHub Project contract with SCE at Lawrence Berkeley National Lab along with SCE advisory and project management participation was completed in 2025. Final reports and presentations of the results of the work are being delivered to EM&T stakeholders in Q1 of 2026.

4. Budget

The following table represents the total expenditures for SCE's 2023 - 2027 EM&T authorized budget as of December 31, 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 February 2, 2026.

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	$12,881,940

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.