# Demand Response Emerging Markets and Technology Program

## Semi-Annual Report: Q1 – Q2 2023

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

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SOUTHERN CALIFORNIA EDISON
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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 |
| AMI | Advanced Metering Infrastructure |
| API | Application Program Interface |
| ASHRAE | American Society of Heating and Air Conditioning Engineers |
| AT | Advanced Technology |
| 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# | C Sharp language |
| C&S | Codes and Standards |
| CAISO | California Independent System Operator |
| CARE | California Alternate Rates for Energy |
| CALTCP | California Lighting Contractors Training Program |
| 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 |
| DOE | Department of Energy |
| 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 |
| EDF | Environmental Defense Fund |
| 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 |
| 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 |
| LIMF | Low-Income Multi-Family |
| M&V | Measurement and Verification |
| MF | Multi-Family |
| MSO | Meter Services Organization |
| MW | Megawatt |
| NDA | Non-Disclosure Agreement |
| NEEA | Northwest Energy Efficiency Alliance |
| NEM | Net Energy Metering |
| NG | Natural Gas |
| 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 |
| OpenADR | Open Automated Demand Response |
| OTE | Oxygen Transfer Efficiency |
| PC | Personal Computer |
| 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 |
| 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 |
| 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 2023 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. That Decision 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.

As described in SCE's 2018-2022 DR program application (A.17-01-012, et al), and ultimately approved in D.17-12-003, the SCE DR EM&T program facilitates the deployment of innovative new DR technologies, software, and system applications that may enable cost-effective customer participation and performance in SCE's DR rates, programs, and wholesale market resources. The program funds research demonstrations, studies, the assessment of advanced DR communications protocols, and conducts field trials and laboratory tests. These activities help enable the innovative high-tech and consumer markets to adopt DR methods and standards that advocate for continuous improvement in DR technological innovation.

The SCE Advanced Energy Solutions (AES) group within the Customer Programs and Services (CP&S) organization oversees the EM&T program's activities, which are each funded via a portfolio investment approach designed to provide maximum value for SCE's customers. The portfolio focuses on advancing DR-enabling technologies for SCE's programs, tariffs, and markets, consistent with the program's five-year approved authorization from D.17-12-003 and continued through 2023 from D.22-12-009.

The EM&T program's core investment strategies align with the guidance from D.17-12-003, and the learnings and results from each activity, study, and assessment type are shared via multiple technology transfer channels with DR stakeholders, research organizations, and policy makers. These strategies facilitate DR-enabling technology education, in-situ field testing, capture of customer perspectives, understanding of market barriers, promotion of technology transfer, and, ultimately, customer and program adoption.

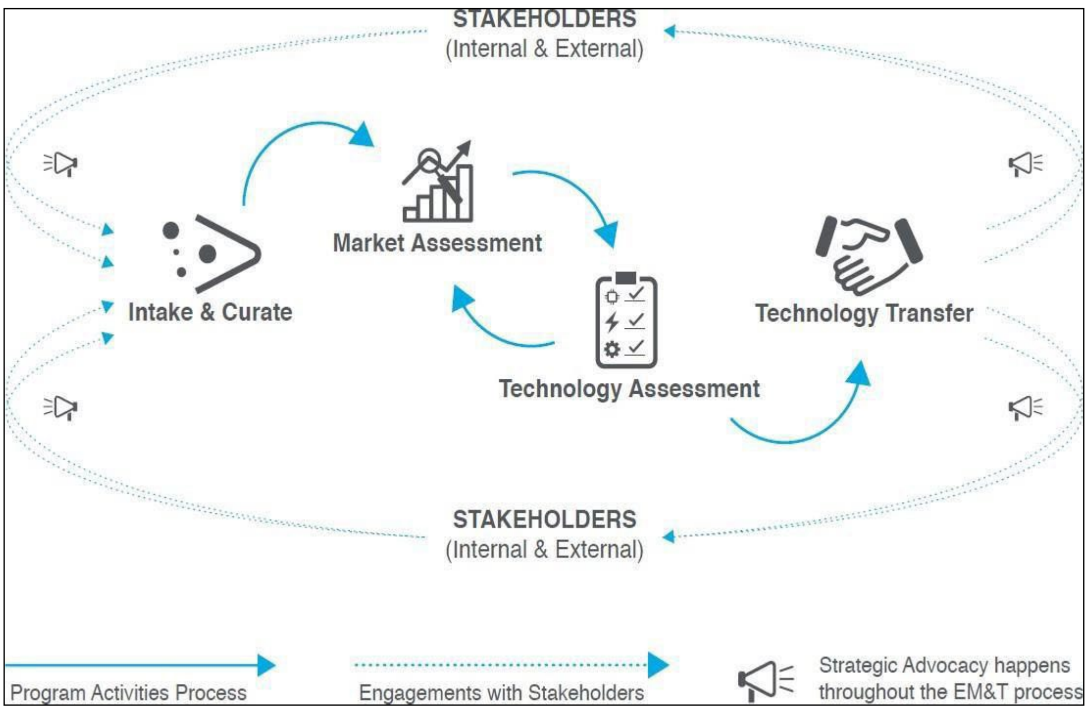
The five EM&T core investment strategies are as follows:

- 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 early 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 completed and in progress during the Q3-Q4 2022 time 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 Completed** | | |
| DR18.09 | Flexible DR Integration | Market Assessments<br>Technology Assessments |
| **In-Progress Projects** | | |
| DR19.08 | Grid Responsive Heat Pump Water Heater Study | Technology Assessments<br>Technology Transfer |
| DR19.11 | LOC-GFO-19-301-4 Optimizing Heat Pump Load Flexibility | Market Assessment<br>Technology Assessment |
| DR21.01 | DR-TTC Dynamic HVAC Test Chamber | Technology Assessments<br>Technology Transfer |
| DR21.03 | Dynamic Rate Pilot (CalFUSE) | Technology Assessments<br>Technology Transfer |
| DR22.01 | LBNL Hardware in the Loop Flexible Modeling DOE FOA-0002090 | Market Assessments<br>Technology Assessments |
| DR22.02 | HP-flex: Next Generation Heat Pump Load Flexibility DR | Market Assessments<br>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 the outcomes of their research of innovative technologies and software that could enable increased customer and stakeholder DR benefits. Many state and federally funded research studies in California are also reviewed for their opportunities for partnership funding and technology transfer into the EM&T portfolio. The EM&T program has successfully leveraged other research projects and activities funded from the California Energy Commission's (CEC) Electric Program Investment Charge (EPIC) program, as well as the Department of Energy's (DOE) Building Technology Office (BTO) and other state and federal research grant opportunities.

In accordance with the CPUC direction for the reporting of the DR EM&T program, this report covers SCE DR EM&T project activities during the timeframe between January 1, 2023, and June 30, 2023, for Q1 and Q2 of program year 2023.

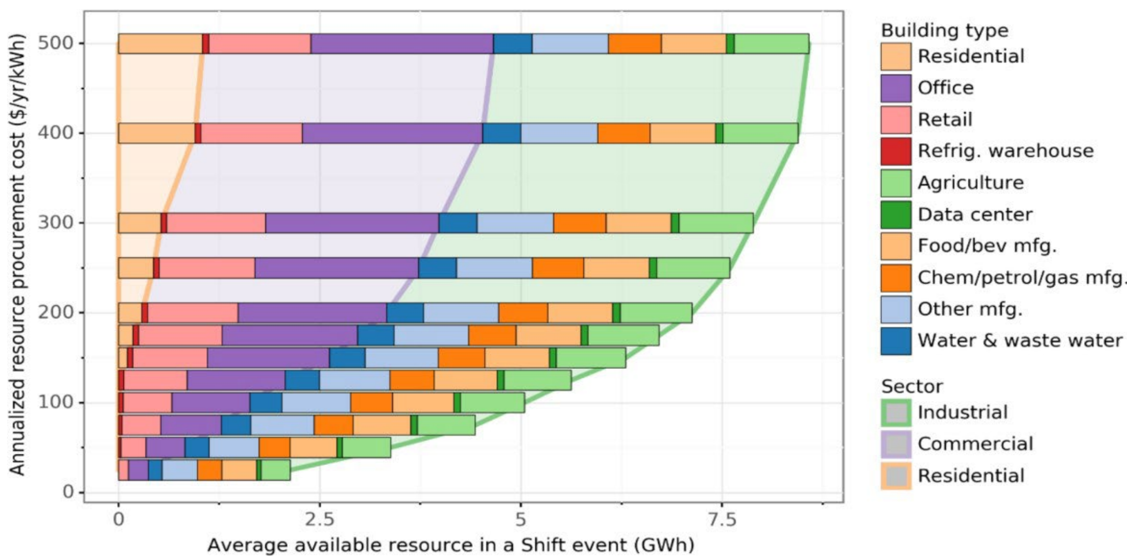
# 1. Projects Completed Q1 – Q2 2023

## DR18.09 Flexible DR Integration

### Overview

Demand response (DR) programs are important resources for keeping the electric grid reliable and efficient, deferring the need for increased peak generation capacity, reducing the impact of end use demand spikes and high loads on transmission and distribution systems, and providing societal economic and environmental benefits. SCE is committed to ensuring that customers have access to the most cost-effective demand response enabling technologies that are eligible for program incentives thereby enabling customers to manage their energy costs and time of energy use.

A series of studies performed by the LBNL Demand Response Research Center (DRRC), known as the California Demand Response Potential Studies, have forecasted the DR market and technological potential in California (Alstone et al, 2017 and Gerke et al, 2020). These studies suggest that California might be able to double the DR flexibility potential provided by customer end-use loads and innovative technologies in the next ten years.




**Opportunities for Demand Flexibility by Building Type and Sector (LBNL Study)**

The objective of this project is to explore how to develop more demand flexibility from existing and future customers and use electrical loads. End-user electrical load flexibility applications and manufacturer capabilities for integration, while not an objective of this report, is the foundation on which dynamic pricing will depend to succeed to enable that flexibility.

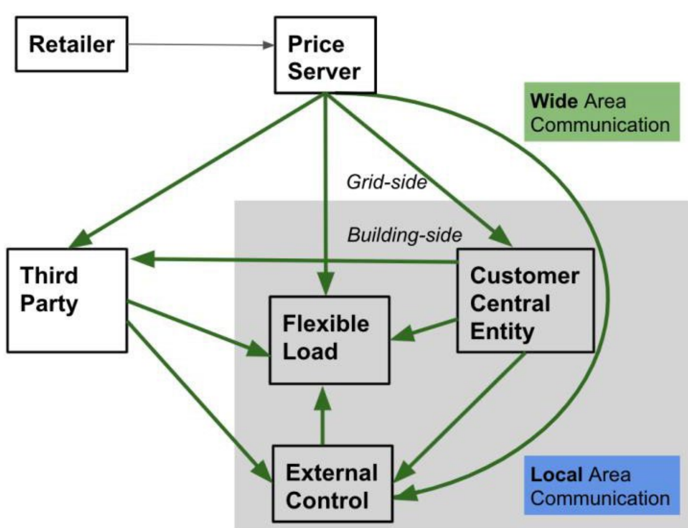
The project was funded under the EM&T Market Assessments and Technology Assessments investment categories, as there are elements of both research goals in this study. The Market Assessments category is designed to create a better understanding of the emerging innovation and developments of new consumer 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

To support development and implementation of demand flexibility opportunities in the SCE service area, the EM&T program in collaboration with EPRI enlisted the staff at the Lawrence Berkeley National Laboratory (LBNL) to investigate the barriers to customer adoption and prepare a market assessment for SCE to follow in order to encourage innovation in this area. Thus, the purpose of this report is to identify enhancements of current technology to bring widespread implementation of demand flexibility to reduce grid congestion effectively as automated demand response objective.

## Results/Status

The team at LBNL has identified the great strides California has made in developing and promoting common standards for DR automation, which are critical for enabling low-cost pathways to DR and the evolution of the internet-of-things approaches that use onboard or built-in device connectivity to support DR, a potential avenue to technology-oriented DR market transformation.




**Price-based Grid Coordination Communication Architecture**

In their report, the staff at LBNL outlined a comprehensive vision for how to achieve dramatically increased electric load flexibility from customer loads and how to enable customers' equipment and systems to receive and respond to dynamic price signals. From three core elements to success, this study's research emphasized the second and third topics in this list:

- The energy retailer sets the price.
- The price is transmitted from the retailer to each flexible load or DER.
- The load uses the price with other information to decide how to respond and operate.

This study's key findings are as follows:

- An overall communication architecture, Price-Based Grid Coordination, enables diverse communication paths and multiple locations of translating prices to functional control and offers significant opportunities for flexibility while maximizing interoperability.
- There are numerous ways for devices to receive price signals and respond. These include intelligent control algorithms in the cloud, flexible loads themselves, and central customer site control devices. All of these are now emerging.
- The new concept of a 'local price' of electricity facilitates maximum use of prices as the central mechanism for managing power distribution. Streaming prices to loads on a continuous basis to facilitate nimble use by sophisticated devices to benefit grid operators is highly practical. A standard way to represent price information (a data model) underpins the communication.
- There are several open and secure technology standards available today well-suited for price communication, but they can be improved and supplemented to make using them simpler and easier. Research and action by utilities can support implementation of each of these findings.

As summarized in the recommendations below, the path forward on developing load flexibility with dynamic pricing can be significantly enhanced through targeted research. This project identified the following items needed in the next year or two:

- Updating and harmonizing the key communication protocols and creating universal price server discovery mechanisms for local and wide area networks.
- Identifying paths to make load flexibility available to all customers, including affordable methods for moderate-income households.
- Crafting comprehensive strategies for space conditioning and water heating to enable a rapid increase in the fraction of customers having at least one

substantial device that is price responsive.
- Prioritizing research on pumping and other process loads in industry, agriculture, and municipal services that are easily shiftable as with water storage.

The project team produced the following research goals for the two-to-five-year range:

- Developing mechanisms to broadcast prices over the Internet generally, adapted to specific physical layer technologies (e.g., broadband access, 5G radio, satellite, etc.).
- Exploring ways to standardize and deploy device energy reporting to facilitate easy access to data on device energy use in response to pricing for utility customers and public policy needs.
- Developing solutions for managing capacity within customer sites and at the meter to reduce the costs for the electrification of previously non-electric loads, including EV charging.
- Using recent experience with the actual performance of price-responsive devices to inform updating quantification of load flexibility potentials.

Lastly, project outcomes distinguished the following long-term research priorities:

- Extending work on topics from the short- and mid-term that are particularly promising.
- Exploring the envelope of how much load flexibility can be obtained without notably impacting end-use load service delivery.
- Developing new and less costly thermal energy storage and related phase change materials for a wide range of applications.
- Extending price-response to other carriers of energy (e.g., district heating and cooling) and to multi-day and seasonal energy storage.

## Next Steps

The project's research work is providing a foundational road map for future demand flexibility enabling technologies enabled by dynamic pricing. The study is now complete, and the report has been posted to the DRET website in Q2 2023 at https://www.dret-ca.com/wp-content/uploads/2023/07/SCE-Flexible-DR-Integration.pdf.

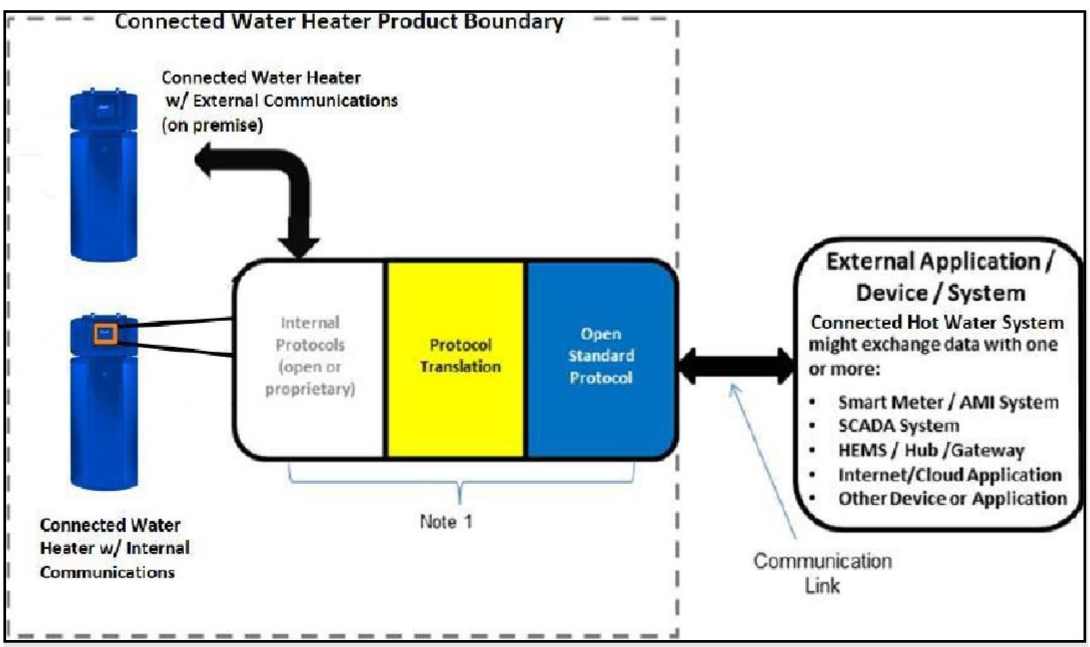
# 2. Projects Continued Q1 – Q2 2023

## DR19.08 Grid Responsive Heat Pump Water Heater Study

### Overview

SCE's Emerging Technologies Program (ETP) and Emerging Markets and Technology (EM&T) Program have been conducting joint technology assessment studies of heat pump water heaters (HPWHs), and this study is a continuation of those efforts. The research team has been examining innovative emerging data management technologies that are applied and implemented for the deployment of the HPWH controls and their associated communication equipment, and for the test instrumentation and data collection of field studies when installed in customer homes.

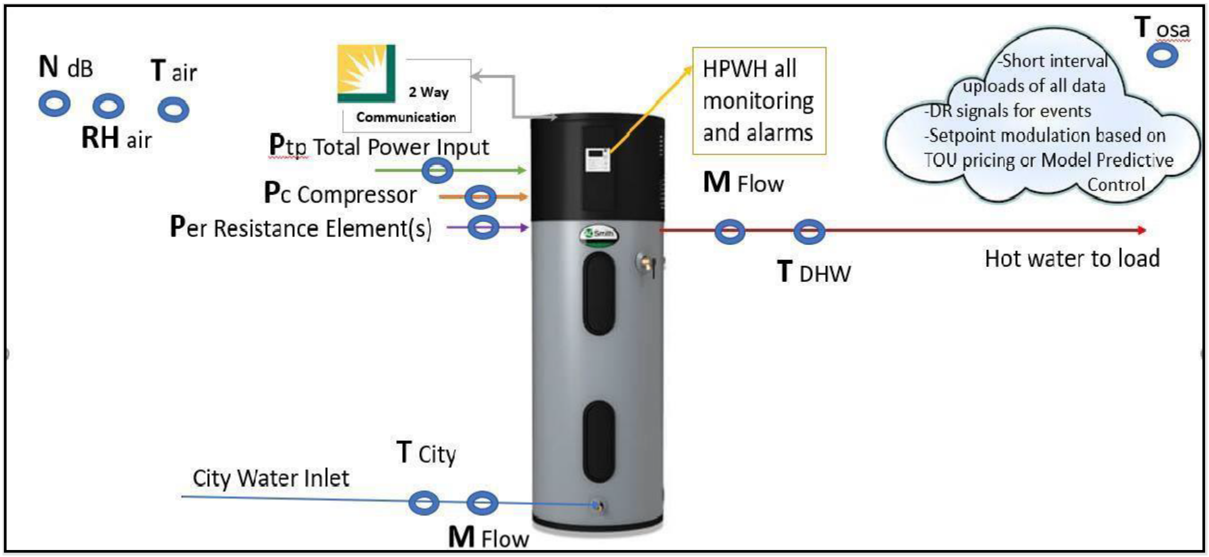
The study is in response to CPUC orders which stipulated: "Target installing local preset controls and/or digital communications technologies on 150 heat pump water heaters in each of PG&E and SCE's service territories." In response, SCE proposed the "SCE San Joaquin Valley Disadvantaged Communities Electric Pilot Implementation Plan" (SJV Pilot PIP), which was submitted to the CPUC through Advice Letter 3971-E filed on March 19, 2019.




**Connected Water Heater Communications Architecture**

As part of San Joaquin Valley (SJV) Disadvantaged Communities Pilot Projects, SCE will deploy electric HPWHs equipped with smart-grid communication technology that will allow the water heater to be used as a grid-responsive technology element of the pilot to electrify homes and reduce emissions within the SJV and California City.

The EM&T project will provide twelve (12) HPWHs with hardware and software to allow grid-responsive communication between the HPWH and the grid to control tank temperature and HPWH operation. The same 12 HPWHs will have instrumentation to monitor, at a minimum, the performance of the water heater, signals between the grid and HPWH, operation of the HPWH, water flow and temperatures, local grid conditions, and ambient conditions.




**Metering Diagram for HPWH Performance Testing**

The EM&T study is designed to address the following research issues:

- Assist SCE in understanding integration of renewables and load dispatch as well as helping inform SCE if and how effectively a grid responsive HPWH can provide flexible load control and hot water storage over various time frames. SCE hopes to gain insight into how heat pump water heaters acting as aggregated distributed resources can be used to benefit the grid and simultaneously offer residents the ability to manage energy consumption through time-of-use (TOU) management of their energy consumption.
- Inform how hot water storage over various time frames can be used to add load or shed load. The demonstration research will provide anecdotal results that should enhance SCE and other stakeholders' understanding of utilizing heat pumps for assisting in the integration of renewables and offering a resource for load dispatch. This will be achieved through detailed monitoring and analysis of the technical performance of HPWHs, including the technical capability of providing local grid impacts from grid responsive HPWHs as well as their performance in supplying hot water for the customers.
- In addition, SCE will gather information on customer experience, technical performance, grid benefits, and impacts of actual performance of the grid-responsive HPWHs as electric appliances in underserved communities.

All 12 homes selected have a garage for the HPWH and no recirculation system. The 12 homes are part of a larger SCE pilot to electrify 150 homes and reduce emissions within the SJV. The prime General Contractor (GC) and Community Energy Navigator (CEN) of the larger project will be responsible for the customer selection and the selection and installation of the grid controlled HPWH and a proposed communication package to be used by SCE for the grid responsive signals. In order to minimize the risk of any failures of the technology that might occur at the customer's home, the HPWH controls and the grid-responsive communications technology will first be functionally tested in a laboratory environment prior to deployment in the homes.

The project was 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 during the early stages of emerging technology development for potential DR program and product offerings.

## Collaboration

The research team consists of SCE's Engineering Services group under the direction of the ETP and EM&T program managers and will be assisted by SCE's technology consultants. The SCE Income Qualified Program group will oversee the SJV DAC and will work with the research team to select the customers for the study.

Community leaders from the San Joaquin Valley and the communities of California City, Ducor, and West Goshen will also be involved. The project is jointly funded by the EE, DR, and the Energy Savings Assistance (ESA) and California Alternate Rates for Energy (CARE) programs.

## Results/Status

The field work for the study is still ongoing. Data collection and analysis/baseline characterization was conducted on an ongoing basis from Q1 - Q2 of 2023.

Preliminary findings across all 12 sites for ~ 6 months (January through June 2023) indicate the following metrics:

- Avg Daily Energy Usage = 3.8 kWh/day
- Avg Daily Peak Demand = 4.2 kW
  - Avg % time above 1 kW = 1.3% (minimal usage time of heating elements)
- Avg Energy Factor = 2.6 (Rated UEFs were 3.75 and 3.61)
- Avg Delivered Temperatures of 125.2 F
- Avg Daily Hot Water Use = 69.4 gal/day

Avg Daily Hot Water Events = 64 events/day

*Note = One of the field test sites was discovered to have had its power shut off in June. It is unclear if the HPWH will be reconnected, and the project team will conduct outreach/investigation.

Previous preliminary findings across all 12 sites for ~ 4 months (September through December 2022) indicated the following metrics:

Avg Daily Energy Usage = 2.6 kWh/day
Avg Daily Peak Demand = 3.4 kW
Avg % time above 1 kW = 0.6% (minimal usage time of heating elements)
Avg Energy Factor = 2.8 (Rated UEFs were ~~3.88 and 3.45~~, 3.75 and 3.61)
Avg Delivered Temperatures of 125.6 F Avg
Daily Hot Water Use = ~~358 gal/day~~ (error)
Avg Daily Hot Water Events = 66 events/day

## Next Steps

The project team will continue to collect and analyze data at each of the remote customer sites. Comprehensive investigation/outreach shall be conducted for the singular test site with disconnected power. The project team will finalize the design of the demand response field tests and subsequently implement them in the latter months of 2023. Testing and validation of demand response communication is planned for later in 2023. The project is targeted for completion in Q1 - Q2 2024.

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

## Overview

This CEC EPIC project 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), with the goal of providing 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).

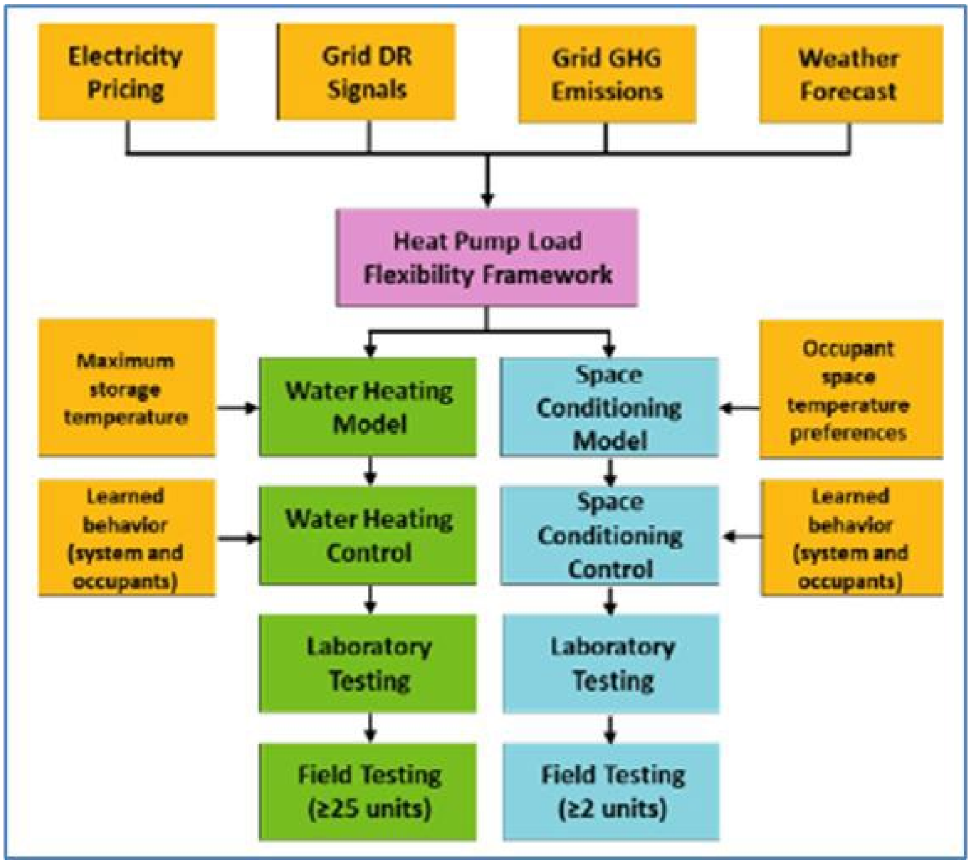
Tackling both space conditioning and water heating controls from a common framework is useful and efficient, as most of the data needed for a heat pump load controller (e.g., electricity pricing, grid DR signals, grid emissions, weather) are not specific to the heat pump end-use type (Figure 1). By applying 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 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.

Heat pumps for space conditioning and water heating are currently controlled using rule-based logic to maintain a programmed water temperature or an indoor air temperature setpoint. While this approach is proven and robust for maintaining a user-defined setpoint, this type of control does not provide any flexibility for the timing of heat pump operation. For example, whenever the water or air setpoint is not satisfied, the rule-based control will run the heat pump until the setpoint is satisfied, regardless of the cost of electricity or the electrical grid GHG emissions rate.

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.

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.



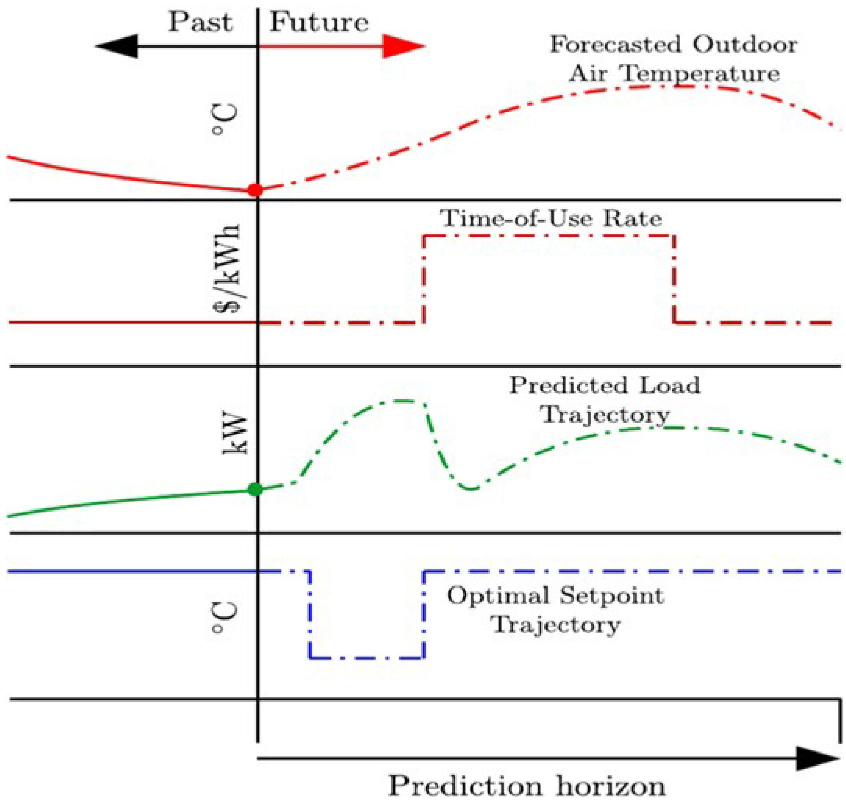

**Overview of Project Design and Modeling**

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.

The project vision is to develop AHWC and ASCC that are 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.



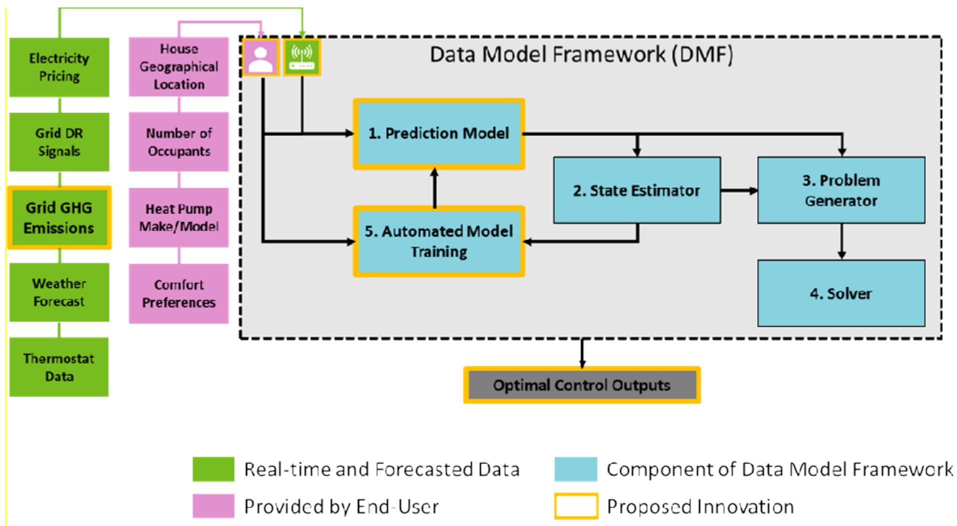

**Modelling Predictive Control Optimization**

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) in Figure 3 will replace the MPC subject matter expert and simplify the configuration, setup, and maintenance process.

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.

The project will 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 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 project 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.




**Project Data Model Framework**

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 overall project that is led by the UC Davis's Western Cooling Efficiency Center (WCEC). The project is being designed and operated by UC Davis under a contract with the CEC's EPIC program 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 EPIC research activities Also, as a founding member of WCEC, SCE has insights to ongoing research and leveraging that research to assist in this study.

## Results/Status

The market characterization study has been completed. It reviewed available literature and interviewed 14 subject matter experts. This study found:

1. Based on the residential appliance saturation survey,
   a. Space conditioning heat pumps comprise 4% of CA market, up from 2% in 2009.
   b. Heat pump water heaters comprise 0.6% of CA market, up from 0.3% in 2009.
2. Many heat pumps have basic load flexibility capabilities (receive only) but are underutilized.
3. Penetration of advanced load flexibility (two-way communication) is very low.

Development of the AWHC is in continuation. The cloud environment has been built, with lab testing over a range of air and water temperatures expected in Q3 / Q4 2023. The validation testing of laboratory HPWH set-up is complete. The project team has investigated different approaches to using electricity costs and GHG emissions in the optimization. Simulation testing on AWHC approach is ongoing and initial results have shown that the MPC can shift HPWH operation to times when the electricity generation is cleaner, while still minimizing operating costs and maintaining occupant comfort[1].

The ASCC laboratory benchtop test setup has been completed. The setup is made up of the Ecobee smart thermostat, Ecobee remote temperature sensor, a small temperature control box, and building and equipment models simulated in EnergyPlus. In the remaining months of 2023, representative models for the field site buildings and equipment will be developed for EnergyPlus and integrated into the test setup.

M&V data collection is on-going at the twenty-six households who have been recruited for project field demonstrations. Baseline surveys for water heating and space conditioning have been completed and more will be administered once the AWHC and ASCC have been deployed.

The project received CEC approval to continue work after the critical project meeting in July 2022. It has received a no-cost extension from CEC and the new project end date will be Q2 2025.

## Next Steps

The project will continue hot water use forecast model development with data from the field demonstrations. Testing the AWHC on HPWH will begin in Q3 2023. The study will continue to focus on the following tasks:

- Testing MPC performance in simulation and on HPWH in lab.
- Expand the Data Model Framework for space conditioning system & building models.
- Develop representative EnergyPlus models for the field site buildings and equipment.
- Prepare retrofit of AWHC & ASCC and monitor control performance for 9-12 months.

[1] Loren dela Rosa, Caton Mande, Henry Richardson, Matthew J. Ellis. Integrating Greenhouse Gas Emissions into Model Predictive Control of Heat Pump Water Heaters. ACC 2023.

# DR21.01 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.

The current ratings for residential/small commercial HVAC systems are based on traditional steady state lab test methods that are not sufficiently representative of field performance. Dynamic testing or load-based testing is necessary to better characterize the performance of the actual advanced controls of these heat pump systems. TTC seeks to build an environmental test chamber capable of advanced dynamic HVAC testing at the facility in Irwindale, CA.

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 operation of native controls. It is important to find out if various test methods in the lab 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 projects HIL and HP-Flex (A framework to characterize the performance of building components in providing flexible loads and building services using a hardware-in-the-loop approach, Next Generation Heat Pump Load Flexibility), F-Gas Reduction Incentive Program.

The project was 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 during the early 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.

## Results/Status

Overall renovation of the facility layout was completed in Q4 2022. National supply chain issues are expected to continue to delay forecasted equipment procurement timelines beyond the planned construction schedule. The project team is actively exploring feasible test chamber build options using alternate pathways to build upon existing equipment and retrofit chamber controls. Completion of test chamber planning and vendor selection is targeted for Q4 2023.

## Next Steps

Dynamic test chamber planning will be finalized Q4 2023. The project targets dynamic test chamber completion by Q4 2024.

# DR21.03 Dynamic Rate Pilot

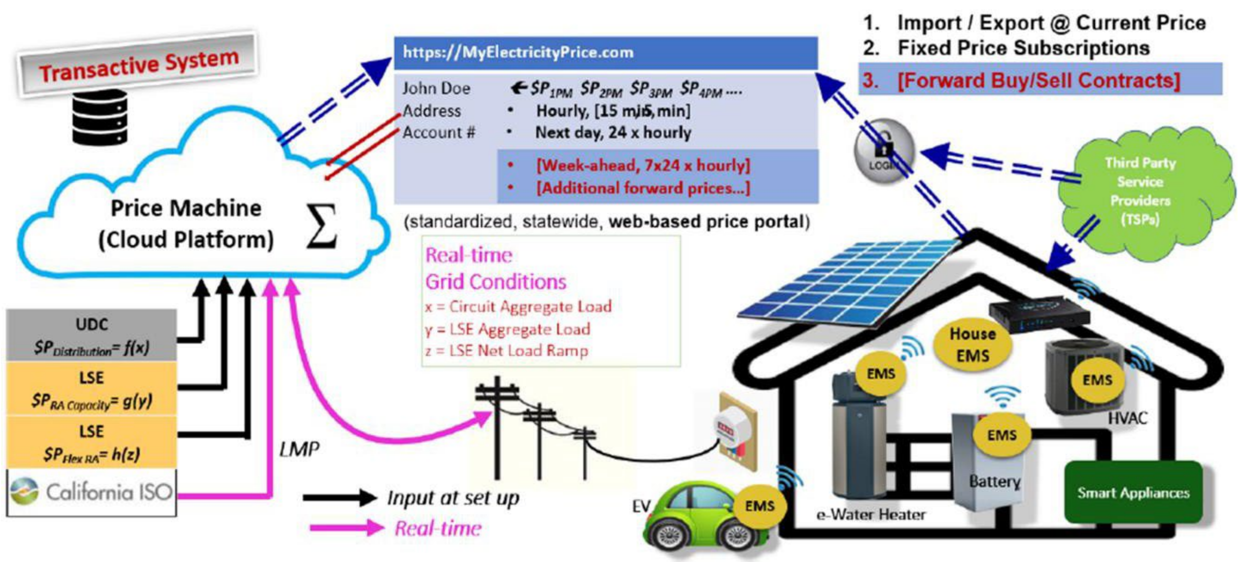
## Overview

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 will combine real time pricing design and transactional subscription elements from both the RATES and UNIDE tariff concepts. The Pilot will also investigate 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.

The key operational tasks of the Pilot will be 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.

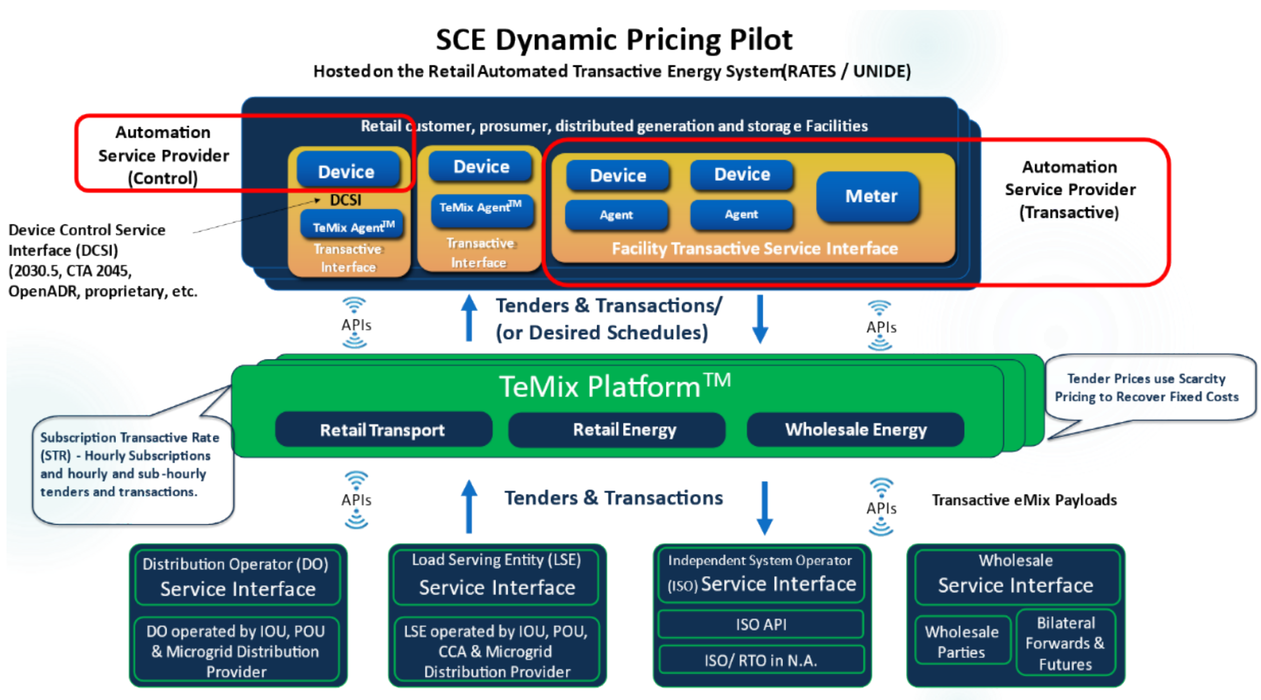
SCE was encouraged to enroll residential, commercial, and industrial customers in this exciting demonstration. SCE will work through reputable Automation Service Providers (ASPs) with existing relationships with these customer types and previously installed automation software or hardware at these customers' 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 will be provided with a tailored subscription for their monthly electricity use based on an analysis of their historical usage. During the pilot the customer will receive 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.




**CalFUSE Concept for Dynamic Rate Design**

The Pilot will combine real time pricing design and transactional subscription elements from the CalFUSE tariff architecture. For the CalFUSE hypothesis to be fully examined, the Pilot metrics will be 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, automated service providers (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 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 during the early 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 machine provider to use the TeMix platform software service as directed in the CPUC decision. TeMix proposes for the Pilot to provide this software services platform for a period of three years or longer, with the option for extended services as needed.

The platform will transmit dynamic tariff prices securely to participating SCE retail customers during the Pilot and will also record these dynamic pricing tender transactions for settlement purposes via a "shadow bill" approach.

SCE is working with other stakeholders such as ASPs, 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).

Electric Power Research Institute (EPRI) is a partner and provides technology support, having previously worked with both the CEC and TeMix on research projects to facilitate flexibility and responsiveness to dynamic test signals. The customer sectors in prior research included industrial (refrigerated warehouses and water/wastewater facilities) and large commercial office parks and institutional customers (hospitals, state facilities, etc.). SCE will coordinate with EPRI and examine opportunities to engage these and other customer groups to receive TeMix signals like what EPRI has done through OpenADR.

SCE also intends to collaborate with Lawrence Berkeley National Laboratory (LBNL) to leverage LBNL's research with the CalFlexHub. This collaboration will allow SCE to coordinate price messaging protocols and develop an expeditious pathway for alternative messaging transport services that may result in additional customer eligibility for the Pilot (e.g., underserved rural areas and disadvantaged communities lacking Wi-Fi access).

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 will be engaged to collaborate with SCE and TeMix and will be included in the project team as providers and advisors. SCE has also 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.

Additionally, SCE will work to engage other innovative partners who have expressed interest 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 Pilot has been operational during this reporting period, focused on growing engagement of the service providers and with internal SCE teams to establish new processes such as dynamic price design and development, billing meter data transfers, grid forecasts, and data verification, which make up the foundation for implementation of the dynamic rate tenders and transactive tariff.

The SCE marketing team completed the creation of customer and vendor-facing informational materials to communicate the Pilot purpose and foster interests. Five automated service providers (ASPs) have been enrolled to engage with the price machine provider, solicit customer sites for the pilot, and identify end uses and protocols for response to the price signals. Multiple new internal processes have been developed and the price telemetry systems are actively being tested, which require ASP validation of the customer eligibility, including identification and circuit mapping to p-nodes and utility API interfaces.

SCE rate design teams have established subscriptions for the first customer batch and completed validation assessments on the accuracy of their Utility API data. TeMix has successfully completed one month transmission of non-quantity tenders in a customer testing period that enabled telemetry to be correctly validated. These price signal transactions are now ongoing, with TeMix providing SCE consistent visibility to their tenders and subscriptions platform for continued validation. TeMix has also provided SCE with bill calculations & methodology accompanied with system reports for validation.

SCE billing teams have been addressing the "Shadow Bill" processes for customer payments with verification review of shadow bill components for both a residential and nonresidential account. With this informed evaluation, SCE is updating shadow bill templates to reflect greater transparency of bill components minus taxes. SCE's law department has assisted in this effort and is coordinating more streamlined contracting of customer data to improve Utility API and TeMix customer approval process.

The ASPs have enrolled eligible customers to support demonstration of the real time pricing design and transactional subscription elements for the CalFUSE price design, incorporating elements from both the RATES and UNIDE tariff concepts identified in the Pilot's initial phase. Customers have been successfully engaged by the ASPs from a variety of sectors including residential, industrial, commercial, and more. The SCE Pilot team is further engaging with OEMs, EVSP, EVSEs, similar EV assets and their communication capabilities to assess their technical and market feasibility to participate in the pilot as an ASP.

## Next Steps

Project teams will continue to work with SCE teams and the CalFUSE service providers to operationalize the dynamic prices based on the data requirements from the CalFUSE architecture. Collaboration is ongoing between SCE supply chain management, audits, finance, and IT to ensure compliance with customer data and dynamic grid information access, shadow billing processes, transactive subscription rate design, incentive payments, etc. Accomplishing a full round of customer testing, initial customers are now primed and well positioned to "Go Live" with the incoming slate of updated subscriptions.

All pilot teams are continuing outreach & education to ASPs to assess TeMix API compatibility, the process for better identification of the grid location of customers, examining additional customer end-use opportunities, and verifying shadow bill data and validation processes. Full dynamic price development and communication to the ASPs and their customers with the transmission of the CalFUSE transactive energy tenders for dynamic management is expected in Q3 2023 as more customers continue to be enrolled and validated for participation.

# DR22.01 LBNL Hardware in the Loop Flexible Modeling DOE FOA-0002090

## Overview

Lawrence Berkeley National Laboratory (LBNL) submitted a proposal to the Department of Energy (DOE) Office of Energy Efficiency and Renewable Energy (EERE) Building Technologies Office (BTO) in response to the DOE's Energy Efficiency and Renewable Energy (EERE) funding opportunity exchange DE-FOA 0002090, "BUILDINGS ENERGY EFFICIENCY FRONTIERS & INNOVATION TECHNOLOGIES (BENEFIT) – 2019". The BTO's overall goal is to improve the energy productivity of buildings without sacrificing occupant comfort or product performance. The goal is to use energy more productively and efficiently, not simply to use less energy. Progress towards achieving this goal will make building energy costs more affordable to the benefit of American families and businesses. Achieving BTO's priorities across the building technology landscape requires sustained, multifaceted innovation.

**LBNL FLEXLAB Test Site**

The proposal submitted by LBNL was titled "A framework to characterize the performance of building components in providing flexible loads and building services using a hardware-in-the-loop approach" and was awarded a contract agreement by the DOE for $1.6M to fund the development of a framework to characterize the performance of building components in providing flexible loads and building services using a hardware in-the-loop approach. The overall project objectives are to measure demand flexibility for different grid services and system/building types (commercial) and generate data for researchers/policy makers.

SCE provided a Letter of Commitment (LOC) in support of LBNL's proposal titled "A framework to characterize the performance of building components in providing flexible loads and building services using a hardware-in-the-loop approach" in response to the DOE's BENEFIT FOA 0002090 solicitation, intending to cost share $300,000. This DOE project will generate high fidelity measurements of building system energy use and their ability and performance to provide grid services and demand flexibility while maintaining acceptable levels of service to building occupants. It will measure demand flexibility for different grid services and system/building types (commercial) and generate data for researchers/policymakers.

Research questions include:

- How much demand can be actually "shifted" by a light commercial building?
- What are the controllable end-uses and equipment types that provide the highest impact?
- How do mass and insulation affect the amount of shiftable load?

The project objectives are:

1. Generation of high-resolution data (i.e., 1 min sampling or less) measuring the performance (building and grid service) of at least 3 systems (e.g., HVAC, lighting, plugs) while operating under all four flexibility modes (i.e., efficiency, shed, shift, modulate) in at least 5 different scenarios (e.g., a mix of weather, occupancy, building characteristics)
2. Development of test procedures to measure building flexibility
3. Generation of a component-level and system-level Modelica model of FLEXLAB to be used in future simulation research (e.g., to test advanced controls)
4. Setup of a hardware-in-the-loop infrastructure at FLEXLAB to support new lab experiments

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 supplementary to work funded by the DOE's Energy Efficiency and Renewable Energy (EERE) funding opportunity exchange DE-FOA 0002090, "BUILDINGS ENERGY EFFICIENCY FRONTIERS & INNOVATION TECHNOLOGIES (BENEFIT) – 2019". SCE is working with LBNL as a funding partner and active reviewer of the work in progress.

## Results/Status

SCE-LBNL check-in meeting was conducted in Q2 of 2023. SCE was provided with several deliverables:

- Summary of FLEXLAB Modeling activities (Modeling Plan, List of End Uses, building components, FLEXLAB configurations & other modeling variables)
- Existing calibration datasets
- FLEXLAB experimental results

Calibration Summary Findings

- Successes
    - Calibration of parameters and schedules allowed for good agreement between model and tests, most importantly for parameters such as VAV terminals, fan power and cooling load
    - VAV control sequences works well for both model and test (e.g., Dual Maximum VAV Box Control Logic)
    - Calibration allowed 12/14 components to pass ASHRAE G14 tests (most importantly chilled water-cooling load)
- Shortcomings
    - Mismatch between controls in FLEXLAB and idealized case in modeling (economizing sequence, coil valve control, scheduling)
    - Values reporting from test components are not idealized and must be taken into account (damper positions)
    - Limited base case testing period for model calibration

FLEXLAB Test Results

Test 1: Three controls tested (Baseline, Ideal Model Predictive Control-MPC, Hybrid MPC)

- Total building power measurements show MPC's clear benefit in reducing peak demand in peak price window.
    - 30% reduction compared to that of the baseline scenario.
    - Approximately 20% HVAC energy cost
- Achieved by providing higher price differential in peak period
- Hybrid MPC (estimated values for internal gains) performed equally as well, providing promise for more scalable MPC option using less sensing.

Test 2: Two controls tested (Baseline-Heuristic, price responsive control. Blackbox-price responsive MPC)

- MPC successfully shift load by using thermal energy storage (TES).
- Despite Baseline already avoiding the peak time, MPC gets 19% of cost reduction by increasing load shifting.
- There is an 8% HVAC load discrepancy between the two cells.

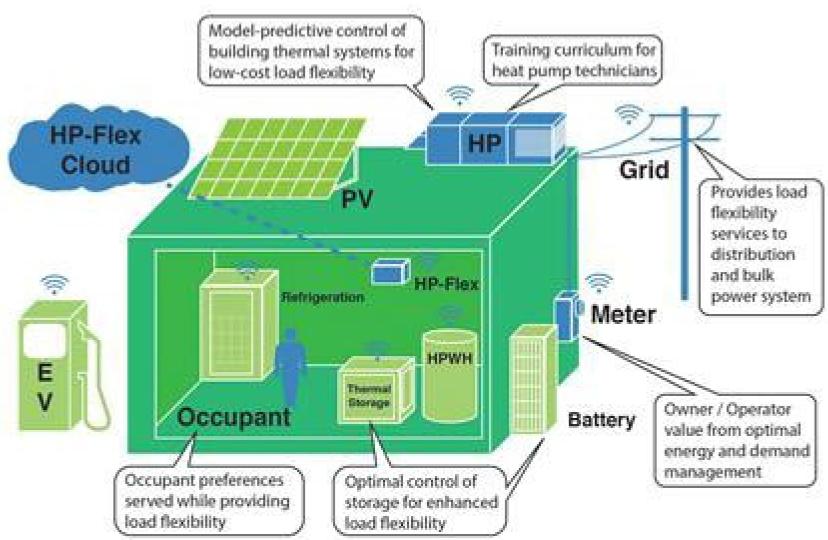
## Next Steps

LBNL and SCE will continue their coordination and transfer of key findings and outcomes as the project progresses. Receipt of remaining deliverables, including project check-in/completion meetings and final reporting, is expected in Q3 - Q4 2023.

# 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 solution (called HP-Flex) for optimal demand management of high-efficiency heat pumps in small and medium commercial buildings. The goal of the CEC Agreement 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 (HP) installations in small to medium-sized commercial buildings, to increase benefits to both individual building owners and the distribution grid compared to standard HP installations.




**HP-Flex: Next Generation Heat Pump Load Flexibility**

Southern California Edison (SCE) provided a Letter of Commitment in support of LBNL's proposal for the EPIC GFO 19-301 Group 4 EPIC solicitation, intending to cost share $300,000 ($150k / $150k from EE & DR funds). The project will develop and demonstrate an open-source energy and load management system designed to control advanced heat pumps on small/medium commercial buildings. This system will minimize energy use and bills while allowing buildings to effectively participate in load shed, shift, shimmy and shape 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 (SMC).
- Verify that HP-Flex integrated in SMC buildings can meet the following criteria:
    1) Achieve a 20% reduction in site peak energy costs compared to an SMC 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 SMC 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 payback time of 2 years.
- Integrate and control a thermal energy storage system with a SMC heat pump.
- Develop educational curricula to train engineers and technicians on the design, installation, and maintenance of load-flexible HP 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.

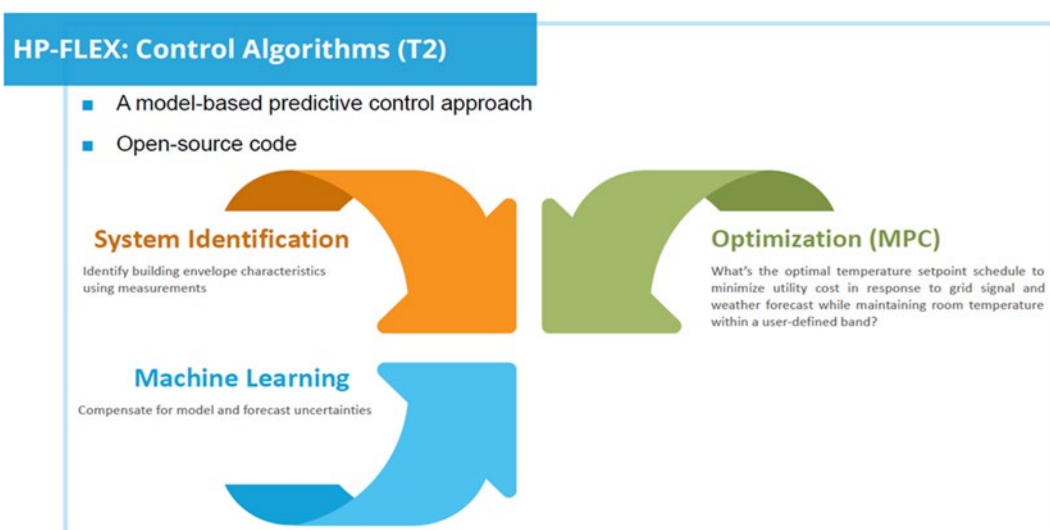
The Technology Assessments category assesses and reviews the performance of DR-enabling technologies through lab and field tests and demonstrations designed to verify or enable DR technical capabilities.

## 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).

## Results/Status

SCE-LBNL check-in meeting conducted in Q2. Below is a model of the HP-FLEX Algorithms:




An initial version of HP-FLEX software has been developed.

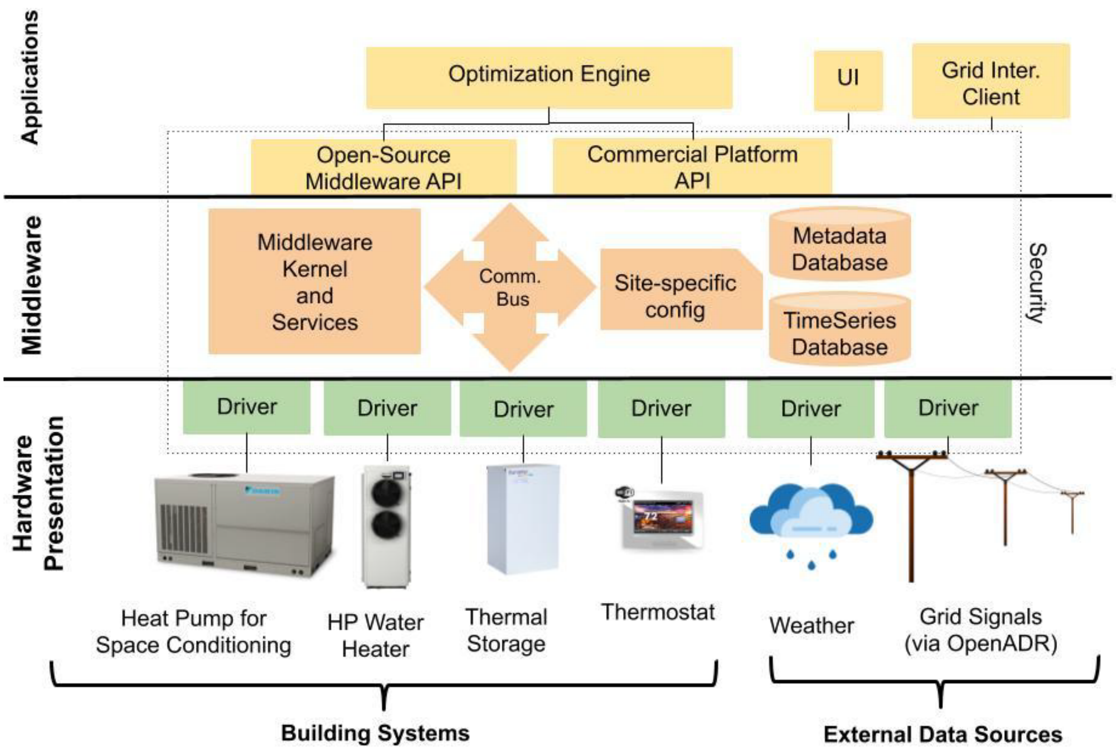
- Project has extended the previously developed MPC algorithms for HP applications for both space heating and cooling applications.
- Includes a free, open source but more powerful optimization-solver
- The project team has developed a hybrid MPC that uses machine learning to compensate for uncertainties.

The HP-FLEX software has been tested in FLEXLAB.

- The preliminary performance assessment was conducted.
- Tests of integration with open-source middleware platform have been performed.

HP-FLEX Middleware Software

- The same platform and setup are used for:
  - DOE BTO HIL
  - NYSERDA OPENBOS-NY
  - CEC CFH
- Status: Software has been tested in FLEXLAB and in two field installations.




**HP-Flex: Hardware, Middleware, and Applications**

## Next Steps

LBNL and SCE will continue ongoing coordination on the project activities and deliverables, including further test scenario assessments, technical reviews, testing of Model Predictive Control algorithms, presentations/sync-ups, associated memos, and M&V plans.

# 3. Budget

The following table represents the total expenditures for SCE's 2023 EM&T authorized budget as of June 30, 2023. 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 July 26, 2023.

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<br>Emerging Markets and Technology Program<br>(D.21-12-015 and D.22-12-009)** | |
|---|---|
| Authorized Budget | $7,000,000 |
| Budget Spent to date | $3,240,896 |

*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.*