Demand Response Emerging Markets and Technology Program

Semi-Annual Report: Q1 – Q2 2020

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

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SOUTHERN CALIFORNIA EDISON
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Table of Contents

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
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

1. Summary

Southern California Edison (SCE) submits this 2020 Q1-Q2 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. The subject 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 that 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 EM&T program's activities are overseen by the SCE Engineering Services group in the Customer Programs and Services organization, and the program funds its activities through a portfolio investment approach designed to provide maximum value for SCE's customers. The program focuses on advancing DR enabling technologies for SCE's programs, tariffs, and markets, consistent with the program's funding approval from CPUC D.17-12-003. The program's core investment strategies align with that guidance, and the learnings and results from each activity, study, and assessment type are shared via several communication channels with DR stakeholders and policy makers. These strategies facilitate for stakeholders 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:

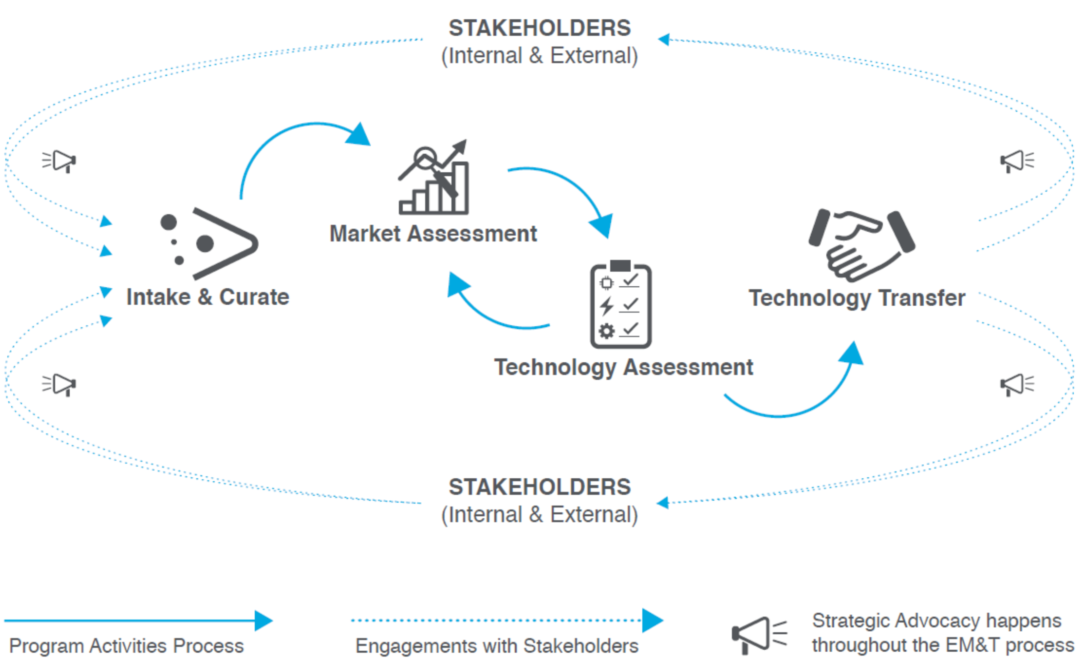
- Intake and Curation: Identifies studies, projects, or collaborations for inclusion in EM&T's portfolio and selects which ones to fund based on a well-informed understanding of the broader industry context.

- 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 of the EM&T projects and occurs throughout the stakeholder process.).



EM&T Program's Current Portfolio Investment Approach

The table below lists the EM&T projects Completed and Initiated during Q1-Q2, 2020, as well as Continuing projects included in this Semi-Annual Report. It 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
Completed Projects		
DR18.10	Automated Demand Response-Enabled Solution Development and Deployment for HVAC Distributors	Market Assessment
DR18.03	Connected Pool Pump Market Assessment	Market Assessments
DR17.18	DR Control with Variable Capacity Commercial HVAC System	Technology Assessments
In-Progress Projects		
DR19.07	Measuring Builder Installed Electrical Loads	Technology Assessments Market Assessments
DR19.03	Smart Speakers	Technology Assessments Market Assessments
DR19.02	Low Income Multi-Family Battery Storage, Solar PV and Data Collection (Pomona)	Technology Assessments, Technology Transfer
DR18.06	Willowbrook-Integration to Enable Solar as a Distribution Resource	Technology Assessments, Technology Transfer
DR18.05	Residential Energy Storage Study	Technology Assessments Technology Transfer
DR18.04	Heat Pump Water Heater Systems	Technology Assessments Technology Transfer
Initiated Projects		
DR20.02	Wedgewood Demand Flex Testing	Technology Assessments, Technology Transfer
DR19.09	Enabling Widespread ADR through use of a Virtual End-Node (VEN) at the Building Level	Technology Transfer
DR19.08	Grid Responsive Heat Pump Water Heater Study	Technology Assessments, Technology Transfer

SCE works collaboratively with the electric California Investor-Owned Utilities (IOUs), as well as 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 reviewed for their opportunities for partnership funding and technology transfer into the EM&T portfolio. The EM&T program has successfully leveraged research findings from the California Energy Commission's EPIC program, as well as the Department of Energy's Building Technology Office (BTO) research grant opportunities.

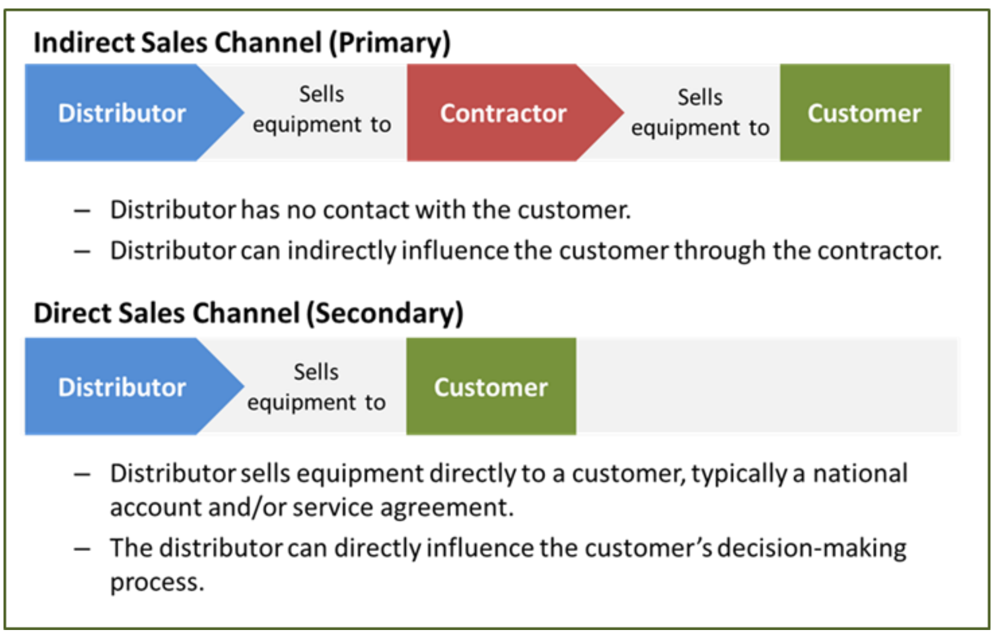
In accordance with the CPUC direction for the reporting of the DR EM&T program, this report covers SCE DR EM&T project activities during the timeframes between January 1, 2020 and June 30, 2020, for Q1 and Q2 of program year 2020.

2. Projects Completed Q1 – Q2 2020

DR18.10 Automated Demand Response-Enabled Solution Development for HVAC Distributors

Overview

The project was designed to assess effective strategies to increase the commercial availability of OpenADR certified solutions by engaging HVAC distribution sales channels. This project builds on an earlier SCE upstream IDSM pilot that examined the opportunity to combine demand responsive controls with the high-efficiency HVAC equipment upstream EE program. The IDSM pilot enrolled three HVAC distributors and two contractors who together installed three DR projects. At that time demand response OpenADR equipment was installed as an "add-on" device for HVAC systems after installation, and not part of a complete distribution sales package. OpenADR even today is considered relatively new and not considered within the perspective of the HVAC distributors.



Current HVAC Distributor Sales Channels

The addition of demand response controls adds complexity to the HVAC equipment sales cycle and business proposition. For the promotion of OpenADR, it is necessary to understand HVAC equipment sales and how the delivery processes work to understand how ADR can be integrated. HVAC distributors and manufacturers have indicated a keen interest in participating in a new pilot study. Awareness of demand response among manufacturers and distributors working in California has grown substantially in the intervening years. Sales of cloud-based smart thermostats have grown significantly, and HVAC technology has adopted integrated controls that may be amenable to OpenADR.

With the growth of smart technologies in the HVAC industry, the research team believed that there was now an opportunity to develop an "upstream" OpenADR sales channel in the HVAC industry to both educate and engage the distribution channels for including OpenADR solutions in commercial package HVAC systems, thereby facilitating more DR customer participation. This project was to examine the "smart solutions" market for HVAC distributors and manufacturers and develop a new model of program design that could provide certified OpenADR solutions "upstream" to manufacturers through the distributors.

By building on the success of the earlier pilot, continuing the education process, and renewing direct engagement with HVAC distributors and manufacturers, the project leveraged previous work conducted by the IDSM program funded by EE and DR. The long-term objective of the IDSM pilot was to deploy OpenADR-enabled HVAC control solutions through the sales channels that were developed by the EE programs, and to "integrate" OpenADR functionality as an "off-the-shelf" capability when HVAC systems are replaced. This project's objectives and activities were developed to directly address feedback from the 2013 pilot, which noted that sale and implementation of OpenADR technologies is overly complicated and requires identifying the appropriate technology and learning how to install and integrate with the HVAC system. By addressing this feedback, the project aims to remove critical barriers in order to advance ADR development and deployment for all HVAC distributors.

Project research objectives therefore consist of the following:

- Identify market-ready OpenADR-certified HVAC control solutions for each distributor and understand sales practices.
- Develop a forum to engage with HVAC distributors to inform them of Auto-DR Program requirements and opportunities to utilize incentives.

  Determine technical support needs to make selected controls solutions more ADR-capable out-of-the-box, and more easily ADR-enabled during installation.

- Propose the upstream ADR program design. Incentives, project delivery, application, and enrollment are vital ADR program elements, and need to reflect distributor business models and evolving market conditions more closely.

This project was funded under the EM&T "Market Assessments" investment category, which 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.

Collaboration

The EM&T program is funding this research completely through its contractor Energy Solutions, which is also managing the overall project to assist in training for AutoDR-enabled solutions and working with the HVAC industry in the development of case studies for OpenADR for HVAC distributors. The project team is additionally collaborating with the OpenADR Alliance, SCE DR program stakeholders, and the California Energy Commission, which provided technical oversight and in-kind (non-financial) educational support for the project. No co-funding or cost-sharing with other utilities, private industry, or other third-party groups was requested or received for this project.

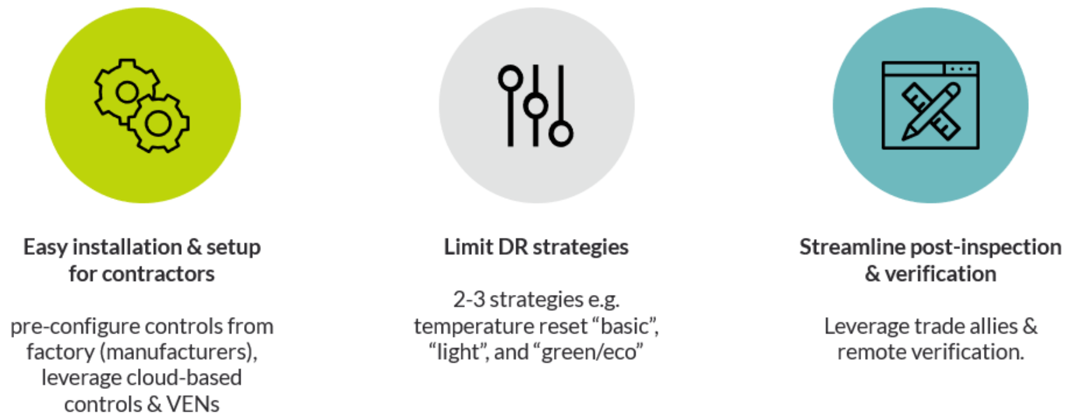
Results/Status

After reviewing lessons from the 2013 IDSM pilot and considering the distributor feedback during market engagements for this project, the Project Team concluded that distributor incentives would best facilitate the upstream adoption of OpenADR products. The remaining recommendations cover incentive design, project delivery, incentive application, and DR program enrollment.

ADR program application recommendations propose a simplified program process flow to make the program less burdensome for market actors. This includes four main steps: including the ADR Terms & Conditions form during the initial sale; collecting customer information by the contractor during installation; verifying DRAS connection and the ADR incentive application by the distributor; verifying and paying ADR incentives by the program implementer.

Project delivery recommendations center around methods to simplify the steps between and including upsell and installation. Recommendations include remote configuration and programming of controls whenever possible, use of a single DR strategy option, creation of DR Automation Server (DRAS) accounts for distributors, and designating project completion when the distributor or contractor has visually confirmed that the controls are installed and connected to the DRAS.

Other steps in the process can be simplified for easy installation and setup for the contractors, and many technical barriers can be eliminated. Contractors view the current ADR incentive process as both cumbersome and prohibitive in terms of cost and resources. Limiting the DR control strategy for the HVAC system provides a simpler programming approach. Streamlining these processes as well as the post inspection and verification approach by leveraging trade allies and remote processes can facilitate the delivery of this new program for this market sector.



OpenADR Technology Delivery Recommendations

Lastly, the Project Team recommends limiting DR program enrollment using this upstream process to just the SCE Critical Peak Pricing (CPP) program. Customers can work with their utility and an aggregator to enroll in another eligible DR program if they prefer. It is important that the distributor knows, at the point of sale, whether a customer is on CPP or eligible for a similar program.

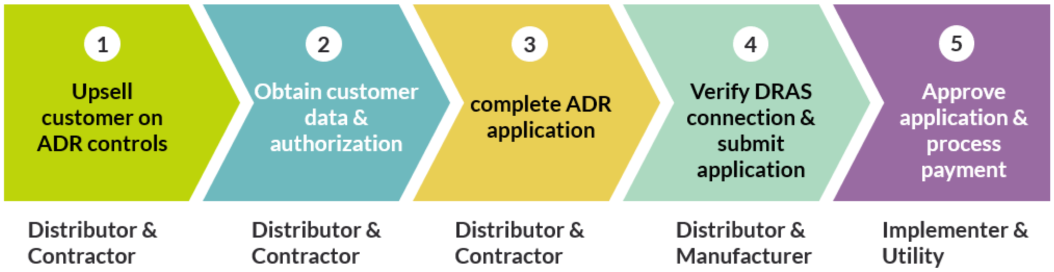
Next Steps

Several pathways could be followed to incorporate the upstream program design recommendations for ADR into DR programs. The first is layering ADR incentives onto existing upstream EE HVAC programs as part of an integrated demand side management approach. Drawbacks to this option are administrative complexity and the limited eligibility to high-efficiency HVAC equipment.

The second pathway is adding an upstream incentive option to the existing AutoDR Program at SCE, using a streamlined technology delivery process. This would engage the HVAC distributor sectors as the link between customers and SCE and would facilitate a parallel process to the AutoDR program with low overhead.

A third pathway is developing a standalone upstream ADR program similar to but separate from the EE portfolio upstream HVAC program. This option offers the most flexibility in terms of measure eligibility and is the simplest administratively.

The illustration below shows an example of a process flow for the streamlined technology delivery process and of how the distributors and contractors would facilitate the customer fulfillment, as modeled by the research team and proposed in their report.



Sample Upstream Auto-DR Program Application Flow

The final report has been completed and is available at:

https://www.etcc-ca.com/reports/.

DR18.03 Connected Pool Pump Market Assessment

Overview

The Connected Pool Pump (CPP) Market Assessment project is studying the market potential of pool pumps as a flexible distributed demand response resource. The pool pump industry has undergone technological advancements that are well aligned with new opportunities for demand response such as “shift” and “shimmy”. This project started with a literature review of previous pool pump demand response programs. It assessed current pool manufacturer technologies and characterized the supply chain. The objective was to quantify the flexible resource potential in SCE’s territory by examining how new types of pumps and motors could be made adjustable.

Modern Pool Pump Equipment Elements

The scope of this activity was to characterize the SCE residential pool pump market with information on shipments, supply chain, and influential market actors. The team reviewed distribution market channels in the SCE territory through interviews with manufacturers and select distributors, retailers, and installers as needed. The team also developed an estimate of the technical potential of connected pool pumps as flexible resources in the SCE territory.

Between 2016 and 2018, many pool pump and pool pump motor manufacturers began offering affordable connected capabilities for their variable-speed pool pumps, which are increasingly prevalent due to utility incentives and efficiency standards. These technologies allow homeowners, pool contractors, pool service companies, and/or manufacturers to change motor speed, flow, turn on/off, modify schedules, and control auxiliary loads through a Wi-Fi or other remote connection. These control technologies continue to grow in scale and capability as manufacturers see a growing market demand.

The study looked at various aspects of the SCE residential pool pump market, and the focus of this research is on the connected pool pump DR market potential in SCE territory. This market assessment explores and quantifies pool pump equipment stock and shipments, distribution channels, and other market factors unique to the Southern California pool market. Additionally, based on upcoming DOE standards and other available data, this assessment will discuss the market-ready connected DR potential, use-cases, business models for deployment, and utility intervention strategies.

The market-ready flexible demand potential for common backyard in-ground pool pumps with the SCE service territory has been estimated at over 200 MW from 2005 market studies. However, realizing this market potential is a function of appropriate market interventions and consumer protections to create a strong value proposition to customers and other market actors in the supply chain. So, while technical potential can be greater (over 500 MW), a market characterization is needed to better understand the intervention strategies and better characterize the supply chain for a more accurate market potential of connected pool pumps in SCE territory.

The key research objectives of this activity were as follows:

- Briefly characterize the SCE residential pool pump market with information on shipments, supply chain, and influential market actors
- Review market channels in SCE territory through interviews with manufacturers and select distributors; retailers, and installers as needed
- Quantify technical and market potential of connected pool pumps as a flexible demand response resource in SCE territory

This project was funded under the EM&T "Market Assessments" investment category, which 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.

Collaboration

The EM&T has contracted directly with Energy Solutions, which is leading the project research team and collaborating with the Electric Power Research Institute (EPRI). EPRI has multiple ongoing technical assessment projects on communicating pumping technologies that can support flexible demand response. SCE's EM&T group is working with EPRI and other utilities to gather data on what other research is in progress in this area. As a member of EPRI, SCE is co-funding parallel research investments with other utilities and leveraging that research to assist in this market assessment study, but no other direct cost-sharing or co-funding with any other parties was enabled.

Results/Status

The final report includes details of the literature review of previous pool pump demand response programs that have been conducted by other research agencies and utilities, and examined current "smart pool" technologies, as well as the appliance codes and standards and pool pumping systems. The study assessed current pool manufacturer communication technologies, characterizing the supply chain of installers and retail outlets, and helping to quantify the flexible resource potential. Energy Solutions compiled results of the numerous interviews held with manufacturers, pool installers, and service companies, which assessed technical developments that include new types of communications systems, APIs, and advanced pool/spa/water feature systems.

	SCE Territory 2021 Stock	Gross Demand at High Speed (MW)	Market Ready Potential (MW)
In-Ground Pool Pumps			
Small Self-Priming Pool Pumps (0.44 HHP/ 0.75 THP)	77,000	74	Not ready
Medium Self-Priming Pool Pumps (0.95 HHP/ 1.65 THP)	289,000	272	272
Large Self-Priming Pool Pumps (1.88 HHP/ 3.25 THP)	302,000	486	486
Booster Pumps (0.31 HHP/ 1.15 THP)	53,000	76	Not ready
Waterfall Pump (0.40 HHP/ 0.72 THP)	11,000	8	Not ready
Above-Ground Pool Pumps			
Non-Self-Priming pumps (0.09 HHP/ 0.16 THP)	21,000	9	Not ready
Non-Self-Priming pumps (0.52 HHP/ 0.9 THP)	179,000	195	Not ready
Total			
All Residential Pool Pumps	932,000	1,120	757

Connected Pool Pump Gross Demand and Potential

The estimated gross demand potential for pool pumps is large, at roughly 1,100 MW in SCE territory. In other words, if all the residential in-ground pool pumps, including auxiliary pumps and above-ground pool pumps as described above were turned on at once and assuming high-speed settings, where applicable, there would be nearly 1,100 MW of pool pumping demand. Note that this also assumes every pump meets DOE standards in 2021, which will not be the case until full stock turnover is achieved.

Of all the pool pumps previously described, it is self-priming filtration pool pumps in residential applications which are "market-ready" for DR and represent most of the connected load potential at roughly 750 MW. This also assumes coincidence of high-speed operation where each self-priming variable-speed pool pump operates on a generally recommended schedule of 6-10 hours at low-speed (0.2 kW) and 2 hours at high-speed (1.3 kW).

Next Steps

The assessment provides both a technology perspective and an overview of the technical potential of residential pool pumps as an enabling technology for future demand response programs. As new secure communications systems are more available in the residential sector, further field research in a scaled deployment or pilot program may assist in developing a cost-effective approach to include pool pumps as a flexible resource for both customer savings under dynamic rates and for local grid reliability. The final report has been completed and is available at:

https://www.etcc-ca.com/reports/.

DR17.18 DR Control with Variable Capacity Commercial HVAC System

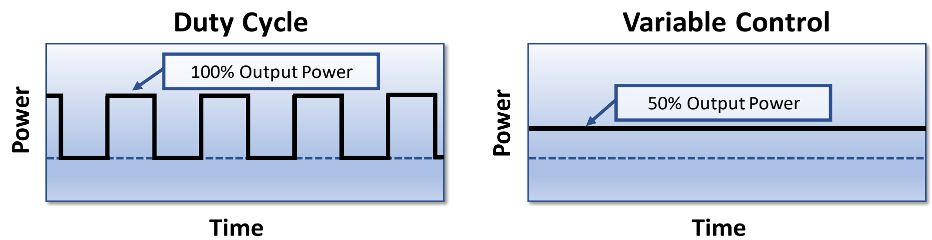
Overview

Variable-capacity HVAC equipment provides enhanced energy efficiency and customer comfort benefits over conventional, single-speed or two-speed equipment. For commercial applications, variable refrigerant flow (VRF) systems, as well as rooftop units, all leverage variable-speed compressors, electronic expansion valves and a variety of refrigerant management controls to match output of the HVAC system to the building's cooling and heating requirements. These systems have extensive on-board instrumentation which optimize system operation and enable the comfort and efficiency advantages this equipment is known for.

While the efficiency and comfort benefits of variable-capacity HVAC have been well documented, their demand response capabilities have not been fully demonstrated. With their on-board instrumentation and communications capabilities, variable-capacity systems are prime candidates for implementing both EE and DR functionality, potentially offering dual program participation. Moreover, with their superior efficiency at part-load operation, variable-capacity equipment has the potential to provide superior DR over baseline equipment, in terms of response time, occupant comfort, and operating efficiency.

VRF Rooftop Unit Under Test

The main objective of this study was to evaluate the DR potential of variable-capacity HVAC equipment in light commercial building applications through demonstration at two field sites in Southern California. This project evaluated and demonstrated new potential for otherwise unrealized demand response capability from new-to-market variable capacity commercial HVAC systems in California. SCE and its customers benefitted from this effort by unlocking a new resource for both utility-based demand response and customer-directed demand management. Variable capacity commercial HVAC systems are primarily associated with energy efficiency and superior customer comfort.



Comparison of HVAC Duty Cycle versus Variable Control

There is renewed interest across the utility industry in enabling technologies that can achieve both demand response and energy efficiency. Variable capacity systems, with their on-board instrumentation and communications capabilities, are candidates for implementing both demand response and energy efficiency at the same time. While energy efficiency measures have been in place for such equipment, demand response capabilities can push the technology further into the mainstream market. This market is dominated by rooftop units, split systems, and chiller/boiler combinations. Commercial HVAC systems are a coincident load (peak power draw occurs during the hottest days) and thus are a prime candidate for DR, while also being an efficient technology during normal operation.

The key research objectives of this activity were as follows:

- To what extent can variable capacity commercial HVAC systems provide demand response services by reducing (or increasing) power draw?
- What are the use cases for the advanced demand response capability of variable-capacity commercial HVAC systems?
- Can these candidate systems under test be integrated with open protocols like OpenADR as an application layer for secure communications?
- Will operational data from systems installed in the field that have advanced demand response capabilities provide data and analysis to fulfill the needs of SCE's possible future program implementation of advanced commercial HVAC as a demand response resource?

The project was funded under the EM&T "Technology Assessments" investment category, which 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

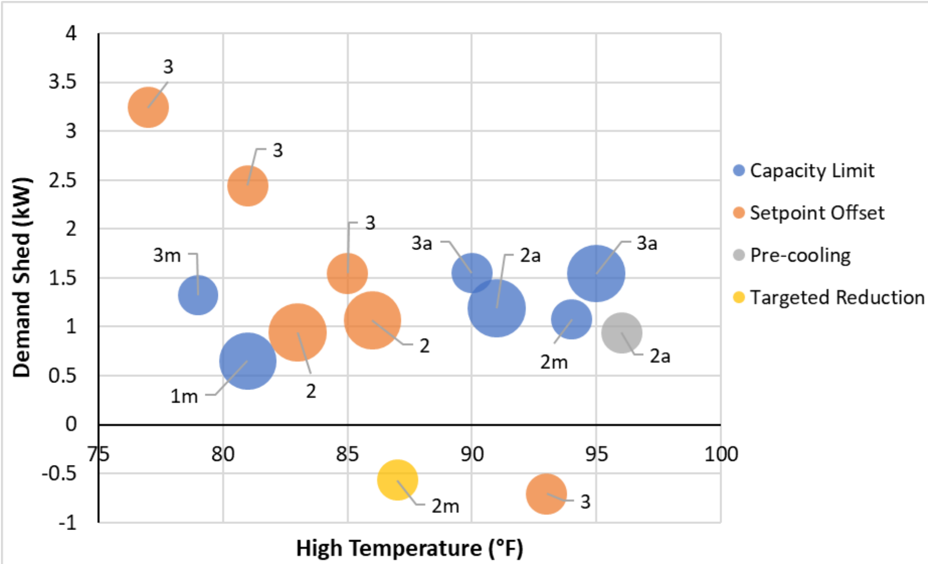
Multiple research stakeholders came together to design the project, provide technical support, and ensure project success through meaningful engagement. While SCE and EPRI collaborated on the project, the EM&T research team prepared a demand response test and analysis plan that considers demand response programs that are available today. The EPRI team facilitated data collection at two sites. The project team partnered with available DR programs with two manufacturers for acquiring hardware and technical support.

SCE shared project costs with EPRI, two HVAC industry manufacturers, and leveraged SCE's membership with EPRI for additional co-funding. As a member of EPRI, SCE is co-funding parallel research investments with other utilities and leveraging that research to assist in this market assessment study, but no other direct cost-sharing or co-funding with any other parties was enabled.

Results/Status

This project demonstrated advanced DR capabilities of variable-capacity HVAC equipment for commercial applications at two sites in Southern California. As part of this project, one manufacturer of the VRF equipment (at Site 1) developed advanced DR controls that mimicked AHRI Standard 1380, which applies to equipment with less than 5.4 tons of cooling, along with additional capabilities (load-up function, percent capacity limit based on a numerical value included in the OpenADR message, etc.), including support for OpenADR 2.0b. The other manufacturer (at Site 2) allowed testing under Temperature Setpoint Offset control only, using the manufacturer's cloud dashboard for manual initiation of DR events.

The Capacity Limit strategy was applied to the VRF at Site 1 under a variety of allowed temperature deviations, considering the average temperature deviation of all zones or the maximum deviation of any single zone, with and without a ramped recovery period, under multiple DR event and recovery durations. While the Temperature Setpoint Offset function yielded greater reductions in demand at mild outdoor temperatures, the Capacity Limit function provided more consistent reductions of about 1.0 to 1.5 kW (20 to 25%) at higher outdoor conditions for both 1-hour and 2-hour event durations. Due to the size of the VRF system and the low cooling load on the system, researchers were left with only one Capacity Limit set point (50%) that could be used to reliably reduce system demand.



Test Site 1 Demand Shed Test Results

Findings from testing with the VRF system at Site 1 indicate that the Capacity Limit strategy could reduce system demand with minimal impact on indoor temperatures. Yet with only one manufacturer offering this functionality for commercial systems, its market potential is limited. A technical standard that specifies intended behavior and communications approach that could be adopted by multiple manufacturers, could significantly increase the potential of this approach.

With positive results from VRF testing at Site 1, it is recommended that this technology be considered for a larger pilot to understand the impacts of its adoption on a larger scale. For example, the sizing, loading, and network connectivity of VRF systems in the field could impact their performance in a utility DR program. Additional data on the performance of these systems under more restrictive limits and on hotter days would give insight into their full capabilities when most impactful to DR programs. It would be beneficial to confirm that the new controller and its control algorithm produce the same (or better) DR response by their VRF equipment.

Next Steps

The research demonstrated that a VRF-specific HVAC industry standard is needed for DR control algorithms that properly leverage variable-capacity equipment for these functions to be broadly available on the market. Such a standard would build upon AHRI Standard 1380, which applies to systems that are sized at 5.4 cooling tons and below, including residential and very small commercial systems, and could extend or expand this standard for the next class of variable-capacity equipment, including RTU and VRF systems. It is recommended that AHRI be engaged to develop a new DR control standard for variable-speed RTU and VRF systems that apply to light commercial buildings. Alternatively, AHRI may decide it is easier to modify Standard 1380 to expand applicability to this equipment segment.

The final report has been completed and is available at:

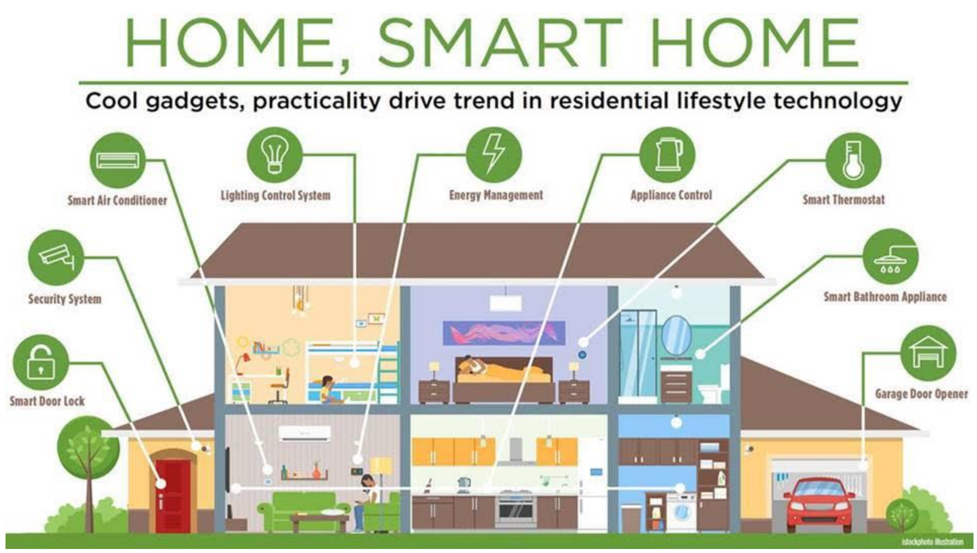
https://www.etcc-ca.com/reports/.

3. Projects Continued Q3 – Q4 2019

DR19.07 Measuring Builder Installed Electrical Loads

Overview

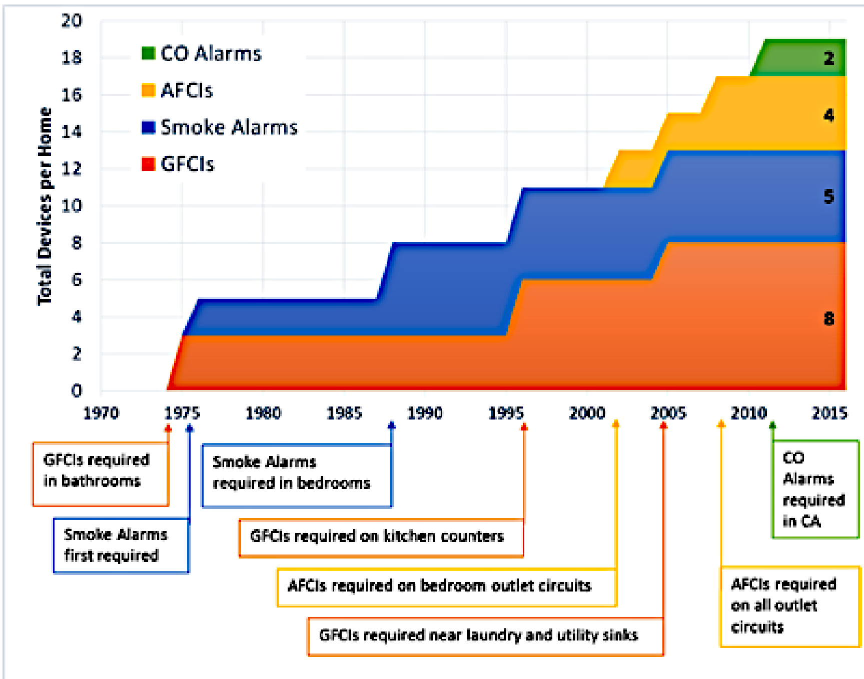
The home builder/contractor mostly selects and installs the permanent (or "hard-wired) electrical appliances and components in new homes. The minimum energy efficiencies for the common appliances—air conditioners, heat pumps, heat pump water heaters, pool pumps, refrigerators, etc. are determined by standards—so the homebuilder's impact on energy consumption is likely to be modest. At the same time, new homes—and especially new, "smart" homes— are outfitted with a second group of devices. This group includes EV chargers, communications infrastructure, batteries, and security equipment. These devices communicate through various protocols to both in-home hubs and via the cloud. The figure below illustrates just a few of the devices appearing in new homes.



Smart Home Technologies Illustration

These devices provide diverse services, but they are connected in the sense that the builder is responsible for their selection, installation, and commissioning. Builders and clients are uniquely challenged to make rational trade-offs because little consistent information is available on costs, features of energy and power consumption, and demand. In contrast, SCE has close connections with developers and builders; which gives SCE a unique opportunity to influence decisions regarding equipment selection in future smart homes, either through information or incentives. The first step, however, is to understand the "builder-installed" loads.

Anecdotal data from an ongoing CEC EPIC project suggests that builder-installed electrical loads are contributing as much as 1,300 kWh/year in total power usage in new homes, even before occupants have moved in. No information is currently available to assess how this impacts load shape. This first phase of research is needed because this aspect of residential energy use has not yet been carefully studied. Also, as new homes receive PV, smart inverters, energy storage, and smart car charging systems, the impacts of these loads could increase.



Growth in Code-Required Systems in New Homes

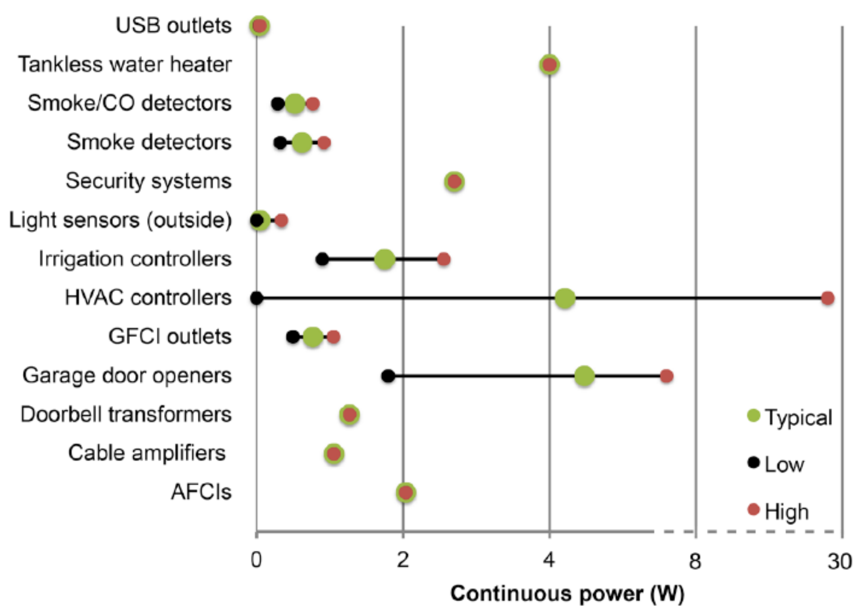
The research objectives of this project are to:

- Examine opportunities for load management (shift and/or shed) of new construction hard-wired loads that could possibly be managed to reduce their small but growing impact on future overall residential energy load shapes and ultimately GHG emissions.
- Develop anticipated new load shapes and energy use of new, "smart homes" and new all electric homes, with a focus on builder-installed equipment. such as EV chargers, smart inverters, and battery storage systems
- Develop a comprehensive assessment to provide a technical forecast for the demand response potential of such smart homes.

- Help SCE identify opportunities for load shifting, demand response, and energy savings with the new home technologies.

The first step in the study is to collect data on electricity consumed by equipment in newly constructed homes. Short-term, whole-house power measurements will be taken from new homes during a relatively short time period between the completion of construction and move-in of the homeowner. The research team will identify builder-installed electrical devices found in new, smart homes in California and other relevant locations. The team will collect bills of materials and information about actual construction practices in new homes. Focus would be on non-standard appliances and devices (that is, not air conditioners, refrigerators, lights, etc.) and all-electric homes. The team will prepare a list of devices and their technical characteristics. This includes estimating the power draw, load shapes, and energy consumption based on nameplate, laboratory measurements, and literature surveys.

The information will be assembled in the form of typical homes, with estimates of types of builder-installed devices, their power, load shape, and energy use. The focus will be less on conventional appliances and equipment (e.g., air conditioners, water heaters, etc.) and more on products associated with "smart" homes. Thus, the main product will be a portfolio of typical homes, along with their energy characteristics, for the devices typically installed by the builder before the occupants move in. The focus will be on early-adopter configurations; however, some homes with a more modest collection of smart devices will also be included.



Summary of Typical Builder Installed Loads

In the next phase of the project, the research team will create a model of prototype home data that can hold builder-installed device data and perform simple calculations. This will include home information such as floor area, and device characteristics such as load shape and demand shifting opportunities. The team will create five "smart home" prototypes with builder-installed devices based on the bill of materials. The team will then calculate the contribution of the builder-installed devices to the home's power draw, energy consumption, and load shape.

For a specific assessment of the demand response potential, the team will investigate the gross load impact of builder-installed devices, calculate the whole-house load shape for each prototype, and evaluate the load shifting potential of individual builder-installed devices, with an emphasis on dispatchable devices and possible interaction with either EV smart inverters or installed energy storage.

The project was funded under the EM&T "Market Assessments" and "Technology Assessments" investment categories, as there are elements of both of those 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

This project includes collaboration with internal SCE groups, including Emerging Technologies and the Business Customer Division. Stakeholders have an interest in finding demand responsive solutions for builders that will make the homes they construct less energy intensive while managing loads to minimize grid impacts. The study will be conducted with researchers located at the advanced buildings section of the LBNL facility, EPRI, and coordination with builders through SCE field services. The project is being co-funded by the SCE Emerging Technologies program and as a member of EPRI, SCE is also co-funding parallel research investments with other utilities and leveraging that research to assist in this study, but no other direct cost-sharing or co-funding with any other parties was enabled.

Results/Status

This project was initiated in late 2019, the overall research work approach and test plan was finalized at that time, and the contract was executed in early 2020. However, COVID-19 restrictions that were implemented in March of 2020 have significantly delayed progress in identifying project resources, as field and lab installations were expected to begin in the second quarter of 2020 once customer recruitment was completed. At the current time, the team is conducting technology research that can be facilitated remotely and is examining non-field lab access for testing based on current COVID-19 limitations.

Next Steps

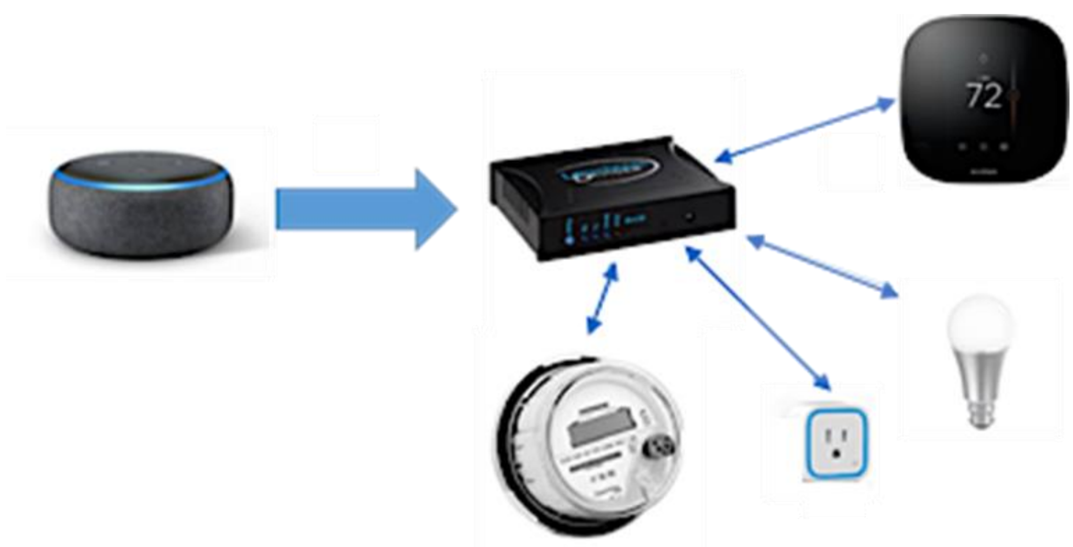
With the delays in the project due to COVID-19 limitations for on-site work and laboratory access (as well as the slowdown in construction), the team is examining non-field testing using the LBNL Flex Lab as a proxy for field testing. As of the date of this report, the team has not yet identified a new schedule or test plan for this project but expects to examine alternative research strategies for this work.

DR19.03 Smart Speakers

Overview

Virtual voice assistant devices such as Amazon's Alexa are increasingly popular with residential electricity customers for use in entertainment, shopping, education, and communications. In the last four years since 2015, Amazon has sold over 100 million Alexa-enabled devices across the world. Smart Speakers are becoming exceptionally popular, and according to public market research reports, as of 2019, an estimated 35% of U.S. households were equipped with at least one smart speaker and by 2025 the penetration rate in expected to increase to 75%.

With smart speaker technology already integrated into more than 100,000 different smart home products from over 9,500 brands in thousands of SCE homes, these devices may offer a creative way for SCE to both connect with customers (such as making a payment or receiving energy-saving tips) and enable smart home devices for effectively managing their energy through demand response programs and dynamic tariffs.



In Home Smart Speaker and Control Equipment

As customers are changing their digital interactions with utilities—especially within the connected home arena—SCE wanted to explore the possibility of a voice-enabled smart home service as a "gateway" for customer interaction. This could allow customers to engage with the SCE's demand response rates and programs without having to use a computer, phone, or laptop. The primary goals of this project were to:

- Better understand how connected smart thermostats and other "smart" household end-uses can optimize their energy usage via "smart speaker" voice commands subject to SCE's TOU rates and customer comfort and savings preferences.

- Evaluate how voice interactions related to energy – usage, estimated bill, best times to use appliances – can be improved to identify optimal voice command "skills" and "smart speaker" interactions.

- Develop optimization algorithms and voice interaction vocabulary specific for the new SCE time-of-use rates and demand response programs.

The secondary objectives of the EM&T Smart Speaker demonstration project are to:

- Better understand how customers can effectively interact with and use the smart speaker and other connected technologies in the home, for their preferences for energy management.

- Determine how customer satisfaction is impacted by the customers' experience with smart speakers and connected technologies for managing energy, and if the interaction persists or is just a novelty.

- Estimate the change in customer energy use that can be attributed to the enabling technology of a smart energy management hub with Smart Speaker and associated Alexa skills as an "integrated energy management package".

Customers in the study will receive training on how to ask energy related questions and set their home energy optimization preferences using the smart speaker. A "smart hub" provides algorithms to use various information such as the customer TOU rate, energy use, and preferences, to optimize connected devices. Device settings are adjusted to run less during peak times. This project will demonstrate the smart speaker's interactive capabilities with household occupants and will assess whether the smart speaker can enable customers to manage their energy use and cost by optimizing connected devices.

The project will use a meter-based assessment that is individualized for each home to assess impacts of energy savings and shifting, and load reduction. The goal will be to understand energy usage impacts and to potentially develop a deemed IDSM measure for both residential energy efficiency and demand response programs, using real time meter data to assess incremental changes in usage.

The project was funded under the EM&T "Technology Assessments" and "Technology Transfer" investment categories, as there are elements of both these 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, including raising awareness, developing capabilities, and informing stakeholders during the early stages of emerging technology development for potential DR program and product offerings.

Collaboration

This work leverages the previous "smart speaker" work funded by the CEC and supported by SCE under the CEC EPIC GFO 15-311 RATES transactive energy project ($3.1M CEC grant). This was a transactive energy pilot that developed certain software and smart speaker skills that are foundational to this current project. This new work is a collaboration among multiple groups within SCE — EM&T, SCE Product Development — other technology stakeholders, and the CEC grant awardees such as Universal Devices. The technology transfer from this effort leverages over $3M of funding. The M&V study to assess the load impacts or price elasticity effects will be conducted by Nexant under contract to SCE. No other direct cost-sharing or co-funding with any other parties was enabled.

Results/Status

The project team worked with the Amazon software development team to create a new set of Alexa voice "skills" for proactive notifications of energy-related activities. These categories did not previously exist. The Alexa Skill for this study is named the "SCE Energy Expert" and can be invoked by saying "Alexa, open Energy Expert" to Alexa. In addition, the team has established a test lab with ecobee, WiFi light bulbs, Philips Hue, and a couple of Z-Wave devices in which the system is being tested.

The team also developed and successfully tested the Alexa Skills commands, described below, within the lab and launched the SCE Energy Expert skill on Amazon. The SCE Energy Expert skill enables customers to optimize their connected equipment (thermostat, smart plugs, lights, etc.) for energy and bill savings and to receive helpful proactive energy notifications from Alexa. Participants can query Alexa about their electricity costs, inquire about the best time to run an appliance, establish preferences to optimize (for savings) connected equipment (thermostats, lights, etc.) through automation, and can take other actions. Last, but not least, customers can opt out of any equipment automation by either prompting Alexa (e.g., Alexa, Stop Optimizing My Devices) or by changing their user preferences in the pilot's user portal.

At the end of Q2, the team surveyed participants in the study, who indicated they were having a positive experience and that the Alexa Smart speaker was easy to use, accurate, and convenient. Participants also indicated that they intended to continue using the smart speaker after the conclusion of the pilot. Moving forward, the team will educate customers on how to use the SCE Energy Expert skill, including how to optimize their connected devices to save energy through automation.

The COVID-19 restrictions in March caused installations at the customer sites to end prematurely. At that time, the field contractors were placed on customer hold for site visits, but the software vendor is still communicating with the systems installed to ensure that connected equipment stays online and operational. Approximately 40 of the 69 installed smart thermostats are currently active, and the software vendor is continuing to troubleshoot to ensure that more units are online and operational. The updated Amazon Alexa Skill was submitted for certification by Amazon and was approved.

Next Steps

The project was delayed in the first half of 2020 due to restrictions from the COVID-19 customer-interaction protocols. In May, SCE provided guidance to its service providers to resume customer visits and site installations, with specific direction for adhering to all COVID-19 safety protocols. The research team will re-assess how the program can proceed under safe work practices as well as follow the most restrictive state, county, or local orders. When site inspections can be re-instated, the research team will determine the next steps for data collection and extension of the project schedule.

DR19.02 Low-Income Multi-Family Battery Storage, Solar PV, and Data Collection

Overview

Battery Energy Storage Systems (BESS) and solar PV systems are being integrated into Multi-Family, owner-managed residential building portfolios at a growing number of sites across California. This project is designed to assess how BESS can provide demand response benefits, along with the potential impact on local distribution transformers, the distribution infrastructure, and customer electric bills. These interactive effects need to be better understood so SCE can provide better customer support for future Distributed Energy Resource (DER) installations, improve the models for grid infrastructure design and planning, and gain experiential data from these customer assets for new models of DR.

Zero Net Energy Multifamily Low-Income Facility

This project is designed to provide research related to the interconnection, commissioning, system performance, customer objectives and grid impacts of the installed energy storage system and PV array installed at Pomona Mosaic Gardens, and provide knowledge transfer for similar energy storage projects. The multi-family housing complex at Pomona Mosaic Gardens has been identified by SCE's

Emerging Markets and Technology (EM&T) research program as a key venue to test and validate function, operation and value of battery energy storage in the context of PV solar and customer loads. The proposed project endeavors to characterize the changes in the building's load shape and grid impact qualities associated with behind-the-meter (BTM) customer-sited energy storage.

The project will give SCE a better understanding of how the various BESS, PV, smart inverters, and related components work as a system in the context of Low-Income or other Multi-Family housing, and how they can act as a DER to provide grid-responsive services, "shift" for dynamic pricing response, or backup energy. The focus will be primarily on storage acting as a DR resource.

Battery Energy Storage System in Multi-Family Building

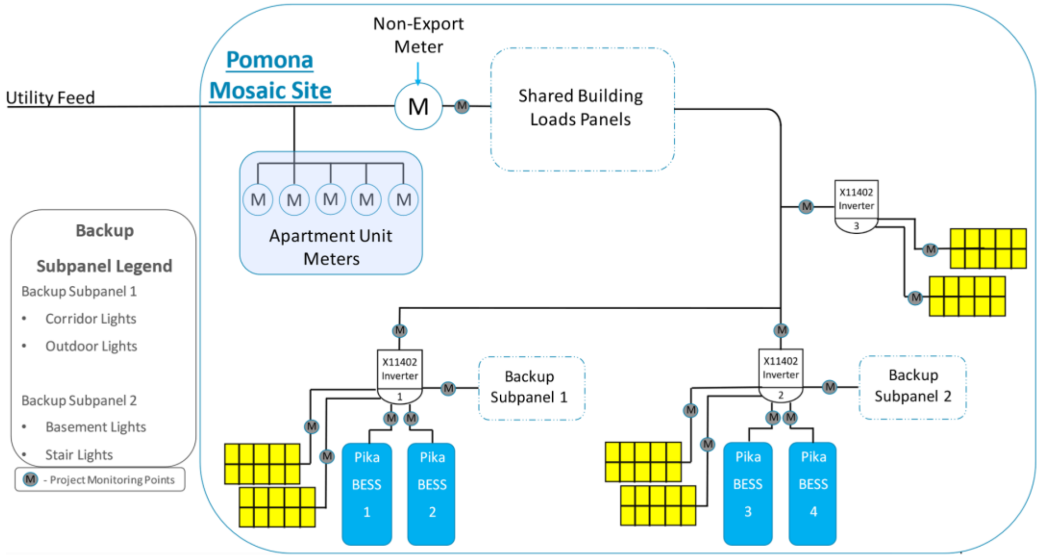
To enable the DR operation of the battery storage system, the project will leverage previous BESS research to gain a comprehensive understanding of the system's performance and its benefits/impacts for the customer and grid operator as a possible new DER resource. The planned study will provide in-field case studies for SCE and its technical stakeholders for the continued adoption of customer energy storage as it impacts tariff compliance, customer and grid economics, and technical grid services that might be achieved through independent and coordinated operation of these potentially flexible assets.

Performance testing of the paired solar and energy storage solution can provide SCE with valuable information on the characteristics of the building energy storage system with islanding inverters, as well as its impacts on the customer building performance and the local grid equipment. SCE's research interests in customer-owned storage are emerging and broad, and as customers increase their adoption of solar plus storage systems at the multi-family level, SCE seeks to understand how these systems can:

- Create incremental grid value in locations with demonstrated needs (e.g., areas with reliability related service interruptions, distribution circuits experiencing high loads, etc.)
- Create incremental customer value above the typical use case for PV-paired battery systems. Efforts may help to unlock additional customer value streams (e.g., satisfaction, incremental customer revenue streams from grid deferral, etc.)
- Assess Product Design and Cost Assessment: What are the features of various products and total cost of ownership? How do storage products installed in the field perform in comparison to manufacturer specifications and owner expectations?
- Achieve Technology Readiness: Are products able to be safely and reliably deployed with robust operations? What are actual deployment experiences, as well as standards and requirements that apply for installation, safety, operation, monitoring, and integration?
- Document Real-World Operating Conditions: How do storage products operate and what is the resource availability outside of standard lab conditions in real-world environments, including weather extremes and conditions exceeding manufacturers specifications?

Performance assessment of electric storage at a high-efficiency "zero net" building to better understand the issues posed will be accomplished by first developing a detailed test plan which will characterize the energy storage system itself, as well as grid service-based operations and customer service-based operations. Several dispatch strategies will be examined, as well as assessing which secure communications approach and set of protocols are applicable.

The specific assessment of the energy storage system as both backup and as a distributed energy resource (DER) will include characterization of round-trip efficiency, battery module degradation, depth of discharge and power capacity at variable states of charge. Grid service characterization will cover non-export constraints, and recommendations for potential modifications to the control and operation of this and similar energy storage systems. Retail energy time-shifting and solar self-consumption services are often considered customer services but can provide as much or more benefit to the utility as well.



Solar/Storage Electrical Overview with Smart Inverters

The primary objectives of this project are to demonstrate how customer storage can be leveraged and to quantify impacts to both customer and grid stakeholders. The research focus will cover the following areas:

- Interconnection for non-export systems: providing lessons learned and best practices that developed during the initial phase of the project
- Characterization of battery modules under operation in accordance with the dynamic pricing schedules and opportunities for demand response impacts
- Grid Control Strategy: understanding the objective of the parties involved, grid services, customer applications, and how certain control modes are focused on achieving one or the other, or both simultaneously for load balancing
- System Performance: evaluation of efficacy of energy storage systems and software regarding:
    - Control and communication, both local and remote
    - Grid services and tariff compliance, and customer uses and applications

- Economic Analysis: characterization of customer economics and grid benefits associated with this system, and similar optimized systems, based on specific control strategies and values such as deferred costs and loss of load

This project will be executed in several phases. It begins with the completion of the battery and solar interconnection and proceeds to design validation to ensure interconnection was completed as intended. Any issues found are reported and repaired, issues can be used to guide SCE's future work with customer-sited energy storage, and measurement & verification can be achieved accurately. The research team will also advise on appropriate installation techniques, including appropriate metering to achieve project objective and the appropriate choice of backup loads chosen to ensure appropriate results to achieve test objectives, while providing the customer facility with resiliency during power outages.

The project was funded under the EM&T "Technology Assessments" and "Technology Transfer" investment categories, as there are elements of both these 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, including raising awareness, developing capabilities, and informing stakeholders during the early stages of emerging technology development for potential DR program and product offerings.

Collaboration

This work is a collaboration between two SCE groups – the EM&T program and a team of technical experts from SCE's Transmission and Distribution Strategy group, with support from Kliewer and Associates for field work and oversight. The building owner is LINC Housing which has a 36-year history developing multi-family housing for elderly and low-income residents and is an active and supportive participant in the work. The Electric Power Research Institute (EPRI) is supporting this project through the collection and analysis of monitoring data and the development of a test plan to examine demand response communications, interconnection (non-export) and value characterization of the BESS installed by SCE.

While the research and storage systems are funded by the EM&T program, SCE is leveraging its membership in EPRI with learning and best practices from the parallel research by other EPRI utility members as a cost-sharing strategy. Also, as a corporate funding member of EPRI, SCE is co-funding parallel research investments with other utilities and leveraging that research to assist in this market assessment study, but no other direct cost-sharing or co-funding with any other parties was enabled.

Results/Status

Inspection and review of the installed BESS – batteries, inverters, and PV solar optimizers has been completed and Permission to Operate (PTO) issued as of early Q1 this year. Approval of BESS interconnection by SCE inspectors has been an issue (due to the novel system design), and the delay in PTO has not allowed the project schedule to reach its planned objectives as originally planned. The installation contractor (Promise Energy) needed modifications to the system to add engineering labor to receive PTO and to also apply advanced control monitoring to facilitate the testing criteria established by EPRI. The COVID-19 restrictions delayed the installation of additional equipment and slowed progress through the end of Q2. The BESS and solar system are currently operational at the site, but further site work and field assessments have been delayed. Travel and access by all team members is limited until California COVID-19 restrictions allow for more detailed site visits for all personnel.

Next Steps

SCE and EPRI are planning to complete the installation and commissioning of the auxiliary BESS optimization equipment in collaboration with the BESS vendor, the installing contractor, SCE's interconnection group, and the building owner LINC under the current COVID-19 safe work practices. While the project was delayed in the first half of 2020 due to restrictions from the COVID-19 customer-interaction protocols, in May, SCE provided guidance to its service providers to proceed with customer visits and site installations, with specific direction to adhere to all COVID-19 safety protocols. When the restrictions are relaxed and safety guidelines can be maintained, the research team will then reassess how the program can proceed under safe work practices and at the same time follow the most restrictive state, county, or local orders.

The EPRI team will be developing the BESS test plan based on the facility capabilities and interests of the SCE EM&T and T&D engineering staff and will work with LINC to facilitate BESS operational changes. Implementation and testing of the system were expected to be completed in late 2020; however, a new adjusted schedule is being developed and testing will commence possibly in Q4 2020. A draft interim report may be available Q1 2021 and the final report deliverables are now expected to be completed in mid to late 2021.

DR18.06 Willowbrook Low-Income Multi-Family DER: Energy Storage with PV

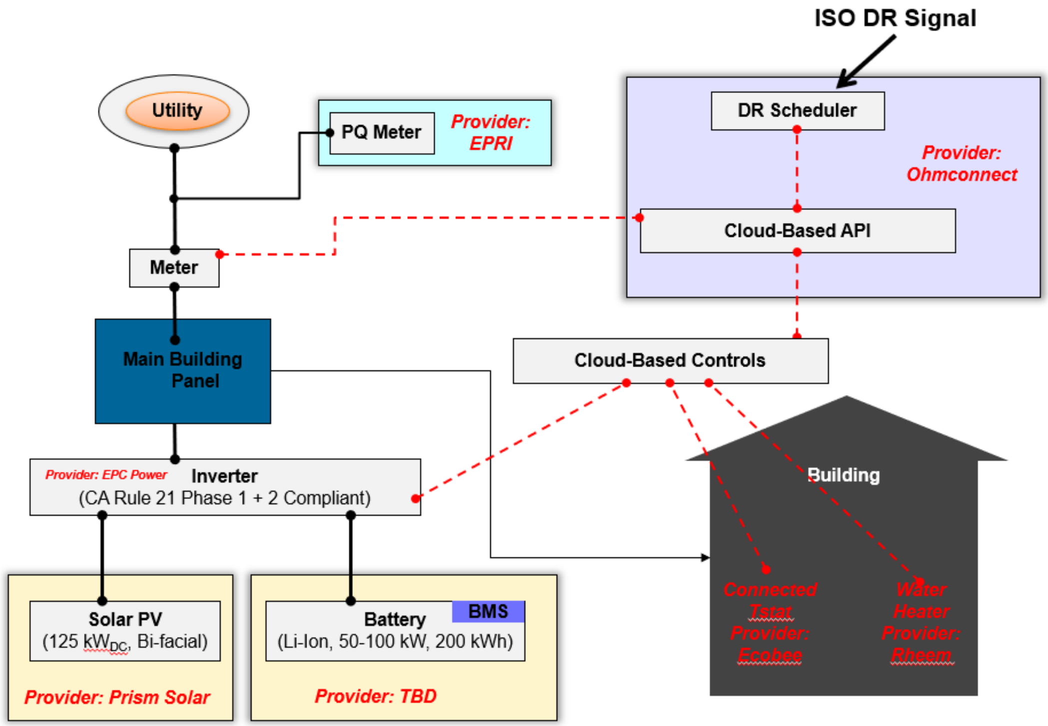
Overview

This in-situ DER demonstration project is an innovative research demonstration study located at a residential community called Mosaic Gardens. This housing was developed by LINC Housing in the Willowbrook neighborhood of Compton, California. The building consists of 61 apartments with 1, 2, and 3 bedrooms, of which half are family housing, and the other half are reserved for formerly homeless and regular users of county services. This project showcases a host of DER technology advances that collectively can contribute substantially to the understanding of how DERs can meet the state's clean energy goals.

Architectural Rendering of the Willowbrook LIMF Project

There are many market barriers to the adoption of DER innovation in retrofitting multi-family buildings with solar and storage technologies, and this study, funded by the CEC, will address cost, efficiency tradeoffs, and space constraints. These are all potential barriers to meeting the Zero Net Energy goals in both residential and commercial buildings. Advanced bifacial PV are being installed at this site with a target efficiency of about 23%. The project is studying use of a DER integration platform that is communications agnostic. The multi-port storage arrangement with smart inverter configurations enables a "shared savings" model. Relevant M&V efforts will include a comparison of pre- versus post-treatment energy utilization, disaggregated by end-use as well as feedback on the customer experience. Many customers will be trained and provided a smart phone app for energy management.

The project, according to the CEC EPIC grant funding opportunity that was awarded to EPRI, is also looking at developing and implementing innovative testing techniques to evaluate new configurations for solar and optimization, and how DR dispatch strategies with the storage can be investigated for overgeneration mitigation.



Willowbrook DER Architecture Overview

An overview of the technologies being demonstrated include:

1. Bifacial solar with target efficiency around 23% that can substantially assist commercial and multi-family buildings with roof area constraints to meet Zero Net Energy goals. Commercial buildings commonly have a lack of roof space for solar, which is necessary for meeting ZNE performance.

2. Demonstration platform that can manage both loads and storage to manage diurnal solar production, evening peaks, and increase overall efficiency of solar utilization in multi-family communities. This will be achieved using customer-responsive as well as automated demand-side resources (i.e., thermostats, lighting, hot water heaters, and HVAC).

3. Integration of DC mini-grids that will eliminate conversion losses for solar PV to feed loads and further enhance overall system efficiency, and evaluation of direct DC-powered air conditioners and lighting systems.

4. Evaluation of multi-family code readiness for 2020 and future code cycles, analyzing performance at the community and individual level to current code,

including meeting criteria for JA5, JA12 and JA13 using DC-integrated solar and storage.

5. Integration of solar and storage on the DC side using smart inverters to enable customers with segmentation of storage for meeting various needs, such as peak demand management, utility-controlled distribution grid flexibility, etc.

As part of the CEC EPIC work, EPRI will be examining the following overarching research objectives:

- What are the combined economics (real and net present value) of a community-level solar plus storage solution?
- What is the feasibility of community scale solar plus storage to attain California's ZNE goals or meet the needs of T-24?
- What are pre or early commercial technologies that can help overcome economic and field implementation barriers for solar plus storage?
- What are ratepayer and broader societal benefits for community-scale solar plus storage systems given renewable goals?
- What are some alternate business models or arrangements to engage IOUs more effectively in community-scale, customer-sited DERs for both end-customer and grid-support benefits?

The use of DR strategies with storage is a new concept that will be investigated in this project, as part of the overall DER design in the building. Specifically, EPRI will be examining how the bifacial PV and DC microgrid can be optimized with the DER integration platform that will receive CAISO dispatches. The goal of that effort is to design, build, and test the overall community solar, storage, and load control system, which is connected to each DER asset (PV, battery, advanced inverter, smart thermostat, water heater, etc.), receive price/control signals from the utility, market, and/or a DSO, and optimize the aggregated system's dispatch and control for stacked value at the customer and grid level.

The project team also plans to investigate innovative business strategies – such as those informing community solar programs and value-of-solar tariffs – to maximize the value of DER to both end-users and the utility. Another overarching objective of the project is to demonstrate a cost-effective solution for achieving Zero Net Energy (ZNE) within an affordable housing community, and thereby realize California's 2020 goal for new sustainable and scalable ZNE communities.

The project was funded under the EM&T "Technology Assessments" and "Technology Transfer" investment categories, as there are elements of both these 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 EM&T program is funding the DR portion of the project through an EPRI Supplemental Program Agreement (SPA) as a co-funding commitment to a larger CEC grant. The overall project is being designed and operated by EPRI under a contract with the California Energy Commission's EPIC program. Other partners include LINC Housing, Canadian Solar, E-Gear, GridScape, EPC Power, Staten, Kliewer and Associates, and OhmConnect (some of these are partners to the EPRI grant). While the EM&T program is funding the project through a contract with EPRI, SCE is also leveraging its membership in EPRI with learnings and best practices from the parallel research by other EPRI utility members as a cost-sharing strategy. Also, as a corporate funding member of EPRI, SCE is co-funding parallel research investments with other utilities and leveraging that research to assist in this market assessment study, but no other direct cost-sharing or co-funding with any other parties was enabled.

Results/Status

The project was placed on hold by the CEC in late 2019 due to construction delays, and EPRI was asked to suspend project activities until the contracts were resolved. The overall scope of work for this project was driven by the milestones to complete the installation of the solar PV and battery energy storage systems which are being stored on site, ready for construction to begin. The project is still on-hold now due to a temporary "stop work" order from the CEC, so the work at the site has ceased.

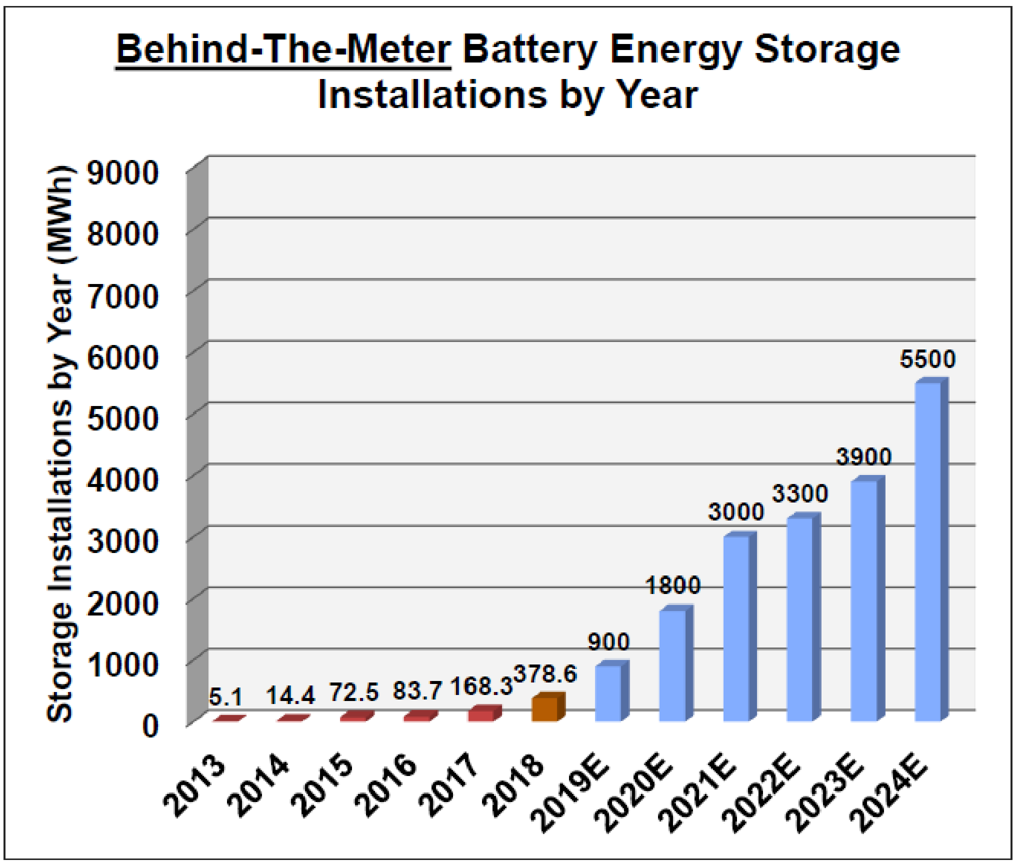
Next Steps

The construction and retrofitting of the DERs for the project are significantly behind schedule, as the EPRI SPA final deliverable between SCE and EPRI was scheduled for Q1 2020. EPRI has completed the test plans for the research and taken delivery of some of the DER hardware. EPRI is now awaiting approval from the CEC to restart the project. The future schedule for construction, testing, and commissioning is forthcoming once CEC approval to restart the work is received, and then EPRI will submit a new SPA to SCE.

DR18.05 Residential Energy Storage Study

Overview

Customer-sited battery energy storage products are emerging quickly, due to cost and performance improvements in lithium-ion battery technology, and government and utility programs that support grid resilience and improved integration of renewable energy. Storage may be adopted by customers for electric bill savings, backup power, or increased use of local renewable energy. As a result, electric utilities are increasingly faced with the opportunity to interface with customer-sited storage systems, either as interconnected devices or potentially as shared resources with multiple uses.



Source: GTM Energy Storage Monitor data

Distributed energy storage is regarded as one important solution to support increased distributed solar in California while minimizing operations stress on the distribution grid. SCE and other IOUs, the California Independent System Operator (CAISO), and the CPUC are exploring various approaches to dispatching and compensating behind-the-meter customers. In-home batteries with PV are growing in popularity and installations are accelerating rapidly, especially in California.

The flexibility of the battery to either charge or discharge on short notice has a huge advantage as it can store energy for later discharge and thus accommodate more variable solar generation. It is important for utilities to understand the systems being interconnected to the grid from functional, safety, and power quality perspectives. The EM&T program developed a project to examine the application of retail tariffs with highly dynamic prices for energy storage and explore the automated dispatch of storage to address customer economics and grid operational issues, with an emphasis on demand response capabilities for shift and shed.

The Residential Energy Storage (RES) project has been identified as a venue for testing and validating behind-the-meter energy storage system functions such as load shifting and demand response load reduction. LG Chem batteries with SolarEdge inverters have been installed at three homes, and an additional unit has been installed in an SCE Smart Home. The proposed project allows for the extension of concurrent and previously established research to gain a comprehensive understanding of the technical performance of the system as well as the benefits and impacts for both the customer and grid operator.

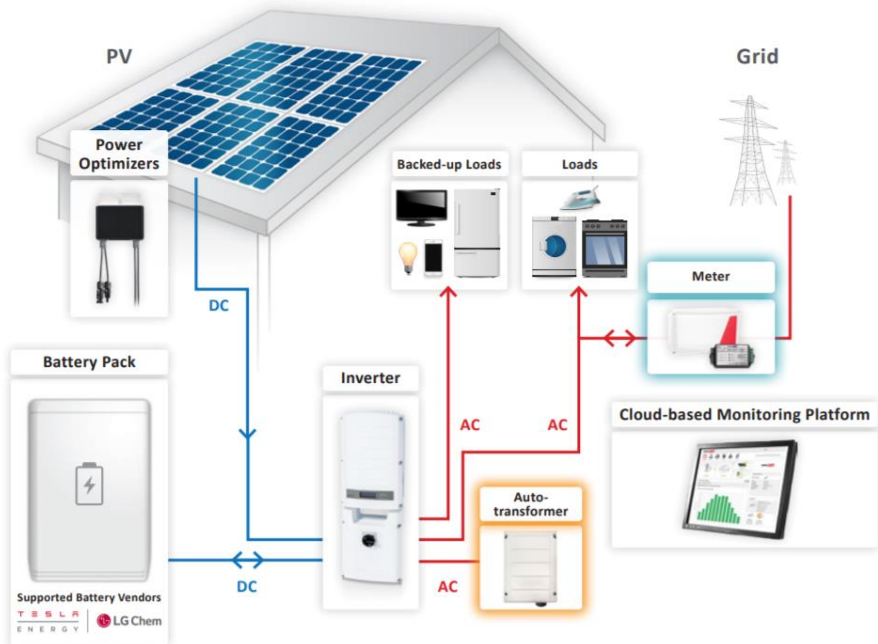
Residential Battery Storage System Under Assessment

Another goal of the project is to better understand how smart inverter APIs can demonstrate the monitoring and automated control of behind-the-meter residential batteries for grid support, demand response, and price elasticity to dynamic tariffs. This project will assess the performance of three residential lithium-ion batteries with SolarEdge smart inverters that have been installed and commissioned in the Moorpark area. The research will also address some important overarching issues around how SCE can include behind-the-meter battery systems to meet the local needs for grid-interactive communities to ensure distribution upgrade affordability, reliability and resilience, and environmental performance. These include the following:

- Dynamic Management: Building end-uses can be designed to help meet grid needs and minimize electricity system costs, while meeting occupants' comfort and maintain lifestyle productivity.
- Resource Co-Optimization: Device design prioritization with buildings to provide greater value and resilience to both utility customers and the grid.
- Integrated Value: Energy efficiency, demand response, and other services provided by facility resources.

StorEdge™ Features:

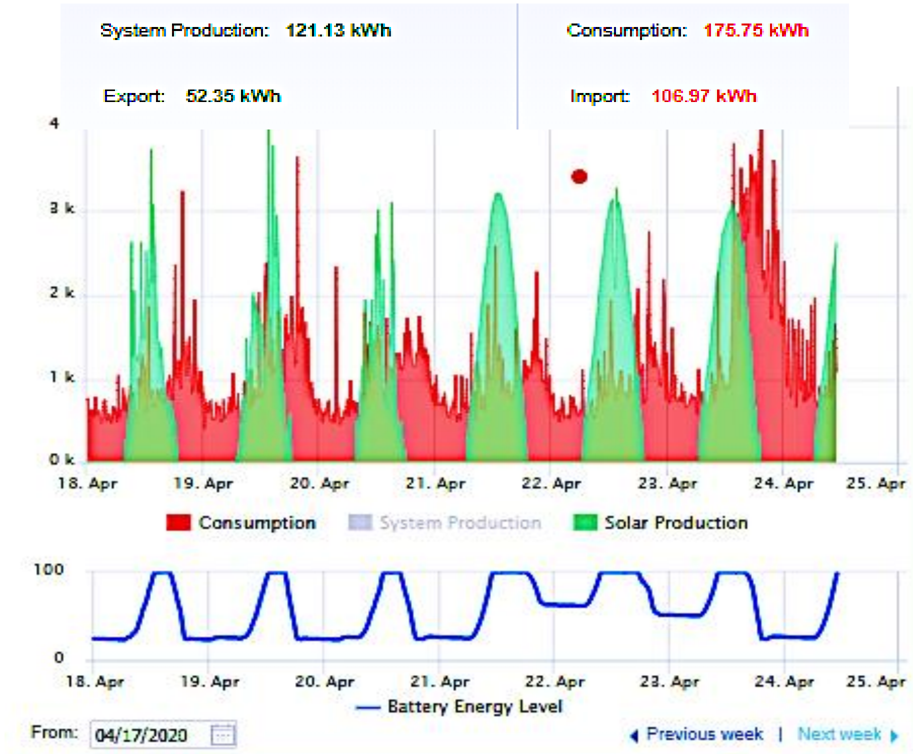
- Smart Energy Management - export control, time-of-use shifting, maximized self-consumption, demand response and peak shaving capabilities
- Backup power - automatically provides power to backed-up loads in the event of grid interruption
- All-in-one solution uses a single DC optimized phase inverter to manage and monitor both PV generation and energy storage
- Compatible with Tesla Powerwall Home Battery and the LG Chem RESU



SolarEdge StorEdge™ Solutions for North America - Product Selector			
	Grid-tied solar, backup power and smart energy management	Grid-tied solar and backup power	Grid-tied solar and smart energy management
Single Phase StorEdge™ Inverter	✓	✓	✓
Auto-transformer	✓	✓	
SolarEdge Electricity Meter	✓		✓
Battery	✓	✓	✓

Solar PV and Battery Components and Features

The research outcomes from this project will prepare SCE and its technical stakeholders for the adoption of customer energy storage as it impacts tariff compliance, customer and grid economics, and technical grid services that might be achieved through independent and coordinated operation of these potentially flexible assets.



Residential Battery Storage System Charge/Discharge Profile -. Alignment with SCE Tariff TOU-D-Prime

The research team will develop a test plan that will examine the following:

- Charge and Discharge Setpoints - The ability to accurately schedule commands for the battery system to charge and discharge are paramount for end users, utilities, and permitting jurisdictions to rely on the further installation of energy storage systems in this and other behind-the-meter contexts for the future.

- Retail Energy Time Shift - Battery energy storage systems can be used to reduce electric bills by using stored energy during times when the retail rate for energy is highest. Given that the utility prices the tariff based on marginal costs for providing power to a facility, this use case and application has potential benefits to both the customer and distribution system. The test plan, however, will examine how to maximize customer benefits in accordance with the TOU-D PRIME rate from SCE.

- Retail Demand Charge Management - These RES systems may be capable of providing retail demand charge management. This mode of operation would allow for flattening of retail loads throughout the day.

The project was funded under the EM&T "Technology Assessments" and "Technology Transfer" investment categories, as there are elements of both these 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

SCE is leveraging three residential participants from a previous CEC EPIC grant project, who have allowed the battery energy storage system (BESS) to be installed by a third-party systems integrator. The BESS includes a SolarEdge smart inverter system and the LG Chem RESU battery panel. Kliewer & Associates has facilitated the system commissioning and inspection of each home and is currently developing a training module for the grid interactive API that will enable SCE engineering staff to schedule the systems for grid-responsive flexibility testing. The project is wholly funded by the EM&T program and no co-funding or cost-sharing with other utilities, private industry, or other third-party groups was requested or received for this project.

Results/Status

The project field testing work during the first quarter of 2020 was placed on hold due to COVID-19 restrictions that prohibited on-site customer engagement. The SCE project team subsequently secured licensing for an enhanced version of the BESS control APIs designed for aggregators (SolarEdge Grid Services) in the meantime and is examining how the software can be managed for both remote scheduled BESS operation and customer real-time management. This functionality required establishing an NDA between the contractor performing the work and the battery manufacturer. The project team secured safe work practice recommendations at the end of May and subsequently performed final commissioning at all three sites, aligned BESS scheduling to the Prime-D tariff, and successfully demonstrated transactive load control response via remote scheduling.

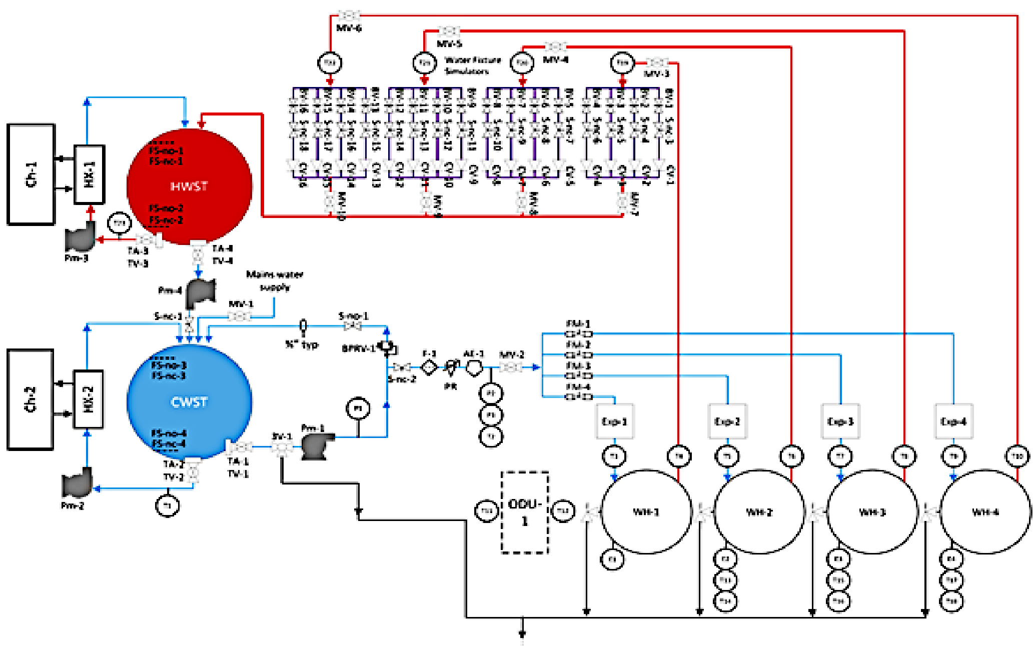
Next Steps

The project was delayed in the first half of 2020 due to site visit restrictions from the COVID-19 pandemic. In May, SCE provided guidance to its service providers to resume customer visits and site installations and included specific direction to adhere to all COVID-19 safety protocols. The research team is reviewing how the program can proceed under safe work practices and at the same time follow the most restrictive state, county, or local orders. Implementation of the software upgrades and testing are expected to be conducted in late 2020, and SCE will use data developed via remote execution of the test plans to complete a final report detailing design validation, selection of use cases, test plan development and test plan execution. The development of a final report that includes test plan results will depend on the data available, and a draft report may be available in Q2. The research outcomes from this project will prepare SCE and its technical stakeholders for the continued adoption of customer energy storage as it impacts tariff compliance, customer and grid economics, and technical grid services that might be achieved through independent and coordinated operation of these potentially flexible assets.

DR18.04 Heat Pump Water Heater Systems

Overview

The project has been developed to facilitate a test environment to assess how electric Heat Pump Water Heater (HPWH) systems can securely communicate and provide time-based operational flexibility under various laboratory conditions. To support that research, SCE is designing and constructing a Flexible DR Secure Communications Demonstration Lab for Water Heating Systems at the SCE Energy Education Center. The project will create a lab-demonstration for HPWH Open AutoDR testing using various transport media, and study communication capabilities and integration with the OpenADR 2.0a and 2.0b VEN architecture and CTA-2045 physical layer[1].



HPWH EEC Lab Design Schematic (LDS-1A)

Much like an air conditioner, HPWHs use electricity to transfer (or "pump") via a vapor compression cycle the ambient heat from the local environment. In the case of the HVAC system, the air is cooled by removing the heat from the internal space. For a HPWH, the water within the storage tank is heated by transferring the heat from the local environment, instead of heating the water directly (as through

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[1] CTA is the Consumer Technology Association's standard on modular communications interface for energy management.

resistance coils in an electric water heater). Through this compression cycle heating mode, HPWHs are two to three times more energy efficient than conventional electric resistance water heaters. However, these systems are also equipped with resistance elements (coils) as backup, which can be activated during periods of high hot water demand or if the ambient temperature is low. The units can also be deployed in a "negative" demand response mode, meaning if the electricity rate is very low (due to excess renewables at the market level), the HPWH can act as a "take" to heat the water, and thus acts as a "grid responsive" end-use load. This type of operation has not been well demonstrated, and so SCE initiated this project. The test plans include case studies for customer-to-grid integration scenarios to examine how HPWHs can react to dispatch and shift signals and the effect on temperature from water draw during times of high- and low-water usage.

Typical Residential HPWH Installation

The HPWHs in the SCE Lab will be modified if needed to be converted to a grid-responsive device by either adding a two-way communication device or accessing the existing communications module within the system. This will allow the HPWH to be controlled remotely by SCE. The communication device can signal the HPWH to increase the thermostat temperature control during low-electric consumption times and will lower the water heater thermostat control during high-energy consumption periods throughout the day. During peak energy consumption times, customers will use water that is already hot. The HPWH's electricity usage is reduced during this peak consumption period, which leads to a decrease in the amount of energy drawn from the grid.

The key research items to be examined in this project are:

- Load shape and energy demand case studies for HPWHs, based on a wide range of water usage and temperature set point profiles.
- Demand response value propositions for developing flexible load shifting strategies and their effect on water supply, water temperature, and energy usage and demand.
- Test realistic hot water draw events for demonstration purposes and study 24-hour profiles for performance evaluation.
- Provide a test bed to serve as both a showcase for emerging DR enabling technology for HPWHs, and a highly capable working laboratory for long-term performance studies.

The project was funded under the EM&T "Technology Assessments" and "Technology Transfer" investment categories, as there are elements of both these 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 demonstration lab is being installed in SCE's Irwindale Energy Education Center (EEC) and funded by the EM&T program and the EEC. It will serve as both a fully functioning working lab and an opportunity to engage customers, vendors, and others to assess and review HPWH technologies. While the EM&T program is funding the project directly and through a supplemental contract with EPRI, SCE is also leveraging its membership in EPRI with learnings and best practices from the parallel research by other EPRI utility members as a cost-sharing strategy. Also, as a corporate funding member of EPRI, SCE is co-funding parallel research investments with other utilities and leveraging that research to assist in this study, but no other direct cost-sharing or co-funding with any other parties was enabled.

This project will coordinate its research findings with SCE's research partner EPRI and will also inform the grid responsive HPWH investigations underway in the San Joaquin Valley (SJV) Electric Pilot and the Demand Response Pilot for Disadvantaged Communities (DR DAC). Future collaboration with the CEC's EPIC program with participation in their research and possible coordination with the OpenADR Alliance in the development of the CTA-2045 certification testing protocol is planned for 2021.

Results/Status

Construction was implemented in the third quarter of 2019 after the lab design and materials procurement were completed. The facilities team at the EEC and EPRI's engineering staff (who designed and built their testing facility in Knoxville, TN) provided construction management and consulting services as the electrical and mechanical systems were installed and tested.

HPWH Test Lab at the SCE Energy Education Center (in construction)

While the overall build-out of the test pad, overhead frame, and water reuse holding tanks were installed and substantially completed during the first quarter of 2020, the heat pump systems themselves were procured, shipped, and installed during that time as well, but COVID-19 restrictions delayed activities during the second quarter of 2020. Travel restrictions also limited EPRI site visits to the EEC during this time.

In addition, the final installation of laboratory supervisory controls and data acquisition (SCADA) systems were not completed in the second quarter of 2020 as planned also due to the COVID-19 cessation of activities at the EEC; however, the

SCE contractors have been notified to continue work in accordance with the “safe work practice” guidance, and the research team is reviewing how the program can proceed following the most restrictive state, county, or local orders.

Next Steps

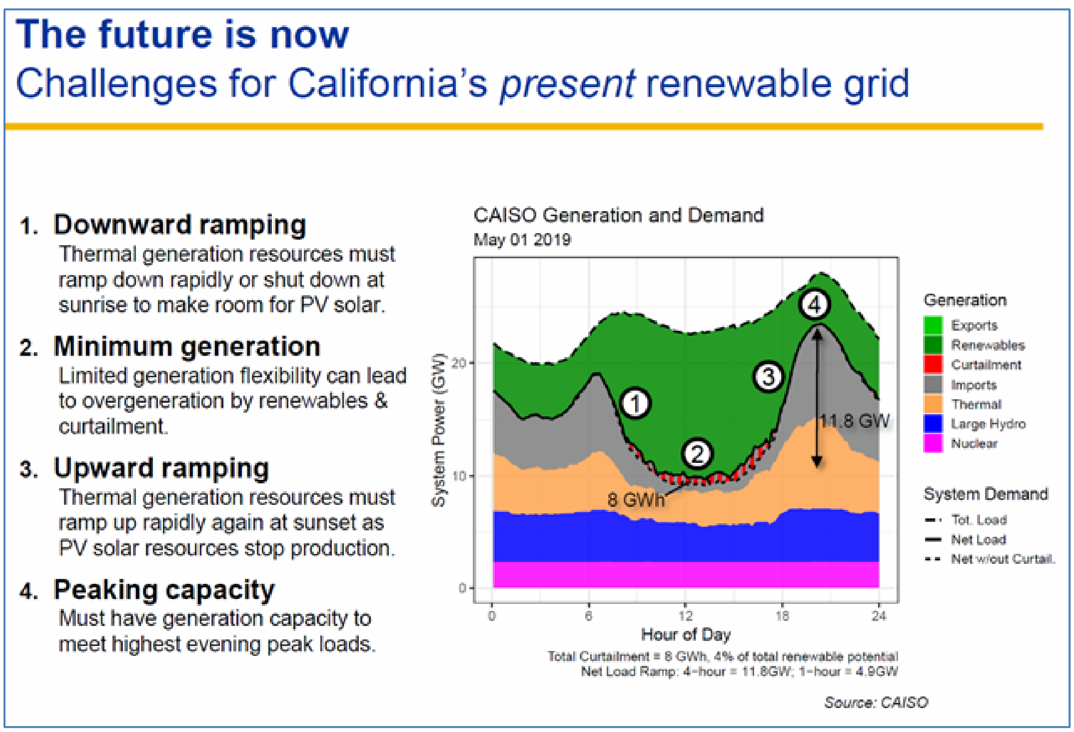
SCE has proposed a study to deploy HPWHs equipped with communication technology that will allow the water heater to be used as a grid-responsive heating technology for the San Joaquin Valley (SJV) Disadvantaged Communities pilot. This study will only be conducted in the residential single-family dwellings of customers participating in the SJV Pilots. SCE plans to minimize the risk of any failures of the technology that might occur at the customer home; therefore, the HPWH controls and the grid-responsive communications technology will first be functionally tested in the HPWH laboratory environment prior to deployment in the homes. Currently the deployment of the SJV HPWH pilot (as well as the work at the HPWH lab) is delayed by the ongoing COVID-19 travel and customer access restrictions at the EEC, but remote work is still ongoing.

4. Projects Initiated Q3 – Q4 2019

DR20.02 Wedgewood Demand Flex Testing

Overview

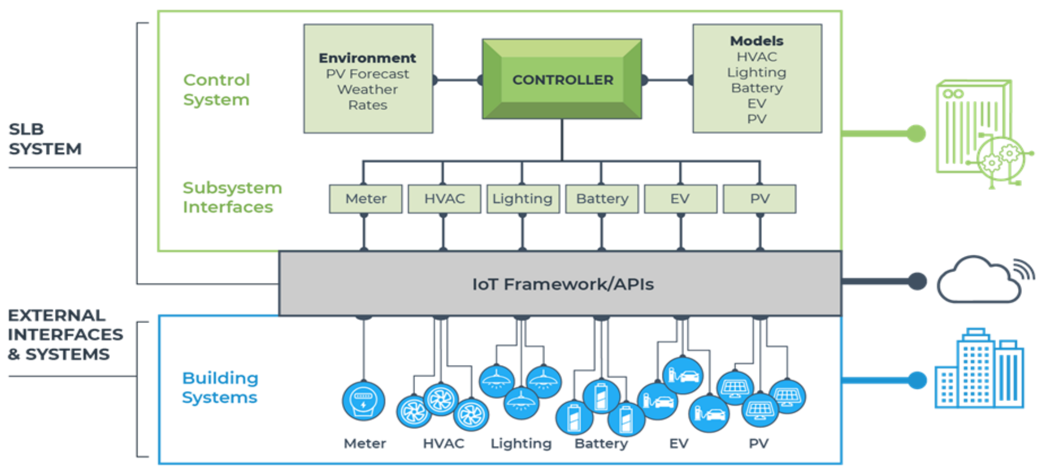
The ability to shift loads without significantly impacting tenant comfort is key to California's ability to address California grid challenges. The grid obstacles include power intermittency, demand peaks, and localized capacity resulting, in part, from rapid growth and scaling of customer self-generation, behind-the-meter storage, and intermittent loads such as new electrification loads and EV chargers. Smart buildings are needed to compensate for differences between forecasts and actual loads. Recent work by LBNL in its DR Potential Study confirms that the load-resource balance is already increasingly difficult to maintain on sunny spring days.



California's Future Energy Challenges

While the issues of ramping, "duck curve," and curtailment of renewables have been discussed for years by planners and operators throughout California, progress has been slow in developing technologies and programs that directly address these issues. In the meantime, solar deployments have continued at a rapid pace. More and more customers are adding both solar and storage "behind-the-meter", in efforts to manager their energy costs and ensure reliability in an uncertain energy future.

At the same time, the combination of behind-the-meter distributed energy resources and advanced system controls have shown to be intelligently controlled to better manage customer loads in order to participate in traditional load shed programs, or to conform to emerging time-of-use rates and other emerging energy pricing signals. For example, there are current software systems designed to use predictive algorithms to optimize loads based on predicted and actual weather and solar generation. These systems are thus able to manage customer loads in concert with the needs of both the grid and the customer's operations.



Intelligent Load Balancing Software Illustration

The Wedgewood Demand Flex Testing Project will evaluate the energy and non-energy impacts and benefits of using an innovative load management software platform. This software will optimize the commercial building's HVAC operations in coordination with the building's onsite generation system of solar power. The study will be conducted at an 83,000 square feet commercial office building located in Redondo Beach, California. The facility has two floors with over 500 employees working across nine different businesses. The site has a 625-kW solar PV system installed on its rooftop and on top of carport canopies in the parking lot. The Solar PV system serves most of the facility's electric needs and supplies power back to the grid when Solar PV production exceeds the facility demand. Major end-use energy consumers at the facility are heating ventilation and air conditioning (HVAC) equipment, Electric Vehicle (EV) charging stations, lighting systems, and other miscellaneous loads.

The Wedgewood campus has a combination of factors that are favorable for electric load optimization techniques and Demand Response capability:

- Solar PV production accounts for a sizeable portion of the facilities' total energy usage due to the size of the system.
- The facility is on TOU rate structure TOU-GS-3 Option E (previously TOU-GS-3 Option R) allowing for shift opportunities.
- Fixed operating schedules provide an opportunity for time-based optimization, reducing variably in the machine learning algorithm.
- System Demand Response capability is fast and flexible and can increase or decrease power many times each day relatively quickly.

Wedgewood Building Demonstration Site

In a phased approach, the Wedgewood Demand Flex study has developed a set of research hypotheses which will evaluate the ability of the software to modify the Wedgewood HVAC operations in two ways to support current and future California and SCE DR programs and load management initiatives.

1. Load Shift Hypothesis: First, can the software effectively reduce the customer's HVAC-related demand charges by between 10% and 25%, without negatively impacting building tenant comfort, by shifting operations and increasing loads during SCE's non-peak TOU periods, and reducing loads during peak periods?
2. Load Shed Hypothesis: Secondly, by driving a deeper level of HVAC setback than under normal operating conditions, can the software enable two to four hours of load shift of at least 20% of whole-building load in response to simulated day-ahead, hour-ahead, and 15 minutes-ahead load curtailment signals from SCE?

The intelligent software system was designed to reduce a customer's peak demand use by shifting energy use from more costly demand periods to periods when the building's solar PV panels are generating power, using its algorithm based on forecasted and actual weather conditions. Under this scenario, and the customer's current rate schedule (TOU-GS-3-E), the software is expected to reduce customer demand costs between 10% to 25%, while minimally impacting tenant comfort. The team will examine the M&V results of the reduced customer demand and costs by shifting energy use from more costly demand periods to periods where the building's solar is predicted to be generating power, based on predicted and actual weather conditions. Full data analysis of the load as well as the efficacy of the load management system will be examined and reported.

The project was funded under the EM&T "Technology Assessments" and "Technology Transfer" investment categories, as there are elements of both these 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 EM&T program team has engaged Alternative Energy Systems Consulting (AESC), Incorporated as the lead contractor, and Extensible Solutions is providing the software platform, working with the Wedgewood facility team for system integration. SCE is also sharing the scope of this work with its partners within the ETCC and other research organizations to provide advisory services and technical review. While the building owner at Wedgewood is conducting an equipment upgrade at this facility and leveraging energy efficiency funding, no DR co-funding or cost-sharing with other utilities, private industry, or other third-party groups for this project was requested or received for this project.

Results/Status

Due to COVID-19 pandemic restrictions during Q1 and Q2 of 2020, access to the facility was prohibited, and the field software installation and M&V tasks have been delayed. At this time, the estimated schedule for the project has been extended by five months. The final report was expected to be completed in the first quarter of 2021, but the completion date will be reassessed on a month-to-month basis as delays persist for building occupancy access and facility management upgrades at the site.

Next Steps

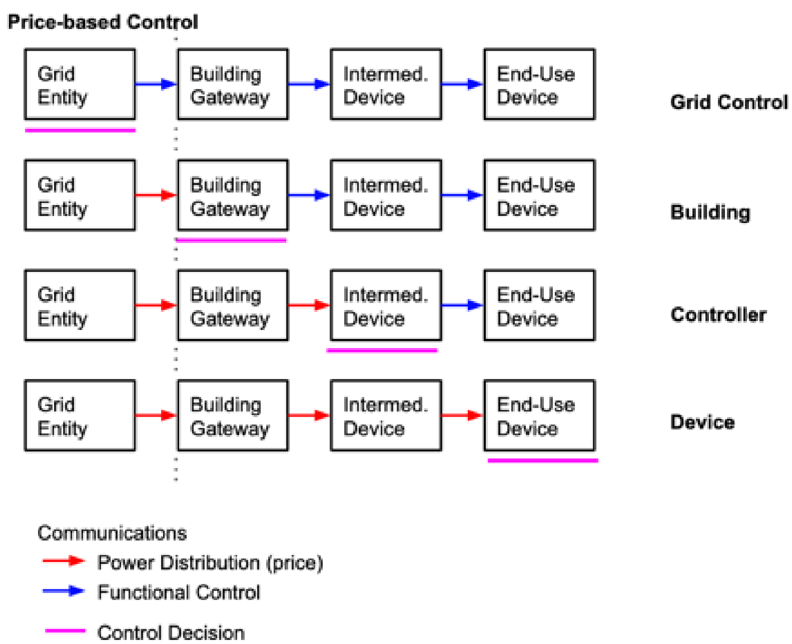
Data gathering and field work will be the next scope to be implemented once the COVID-19 access restrictions to the building are relaxed and allow for this research study to continue with its planned activities.

DR19.09 Enabling Widespread ADR through use of a Virtual End-Node (VEN) at the Building Level

Overview

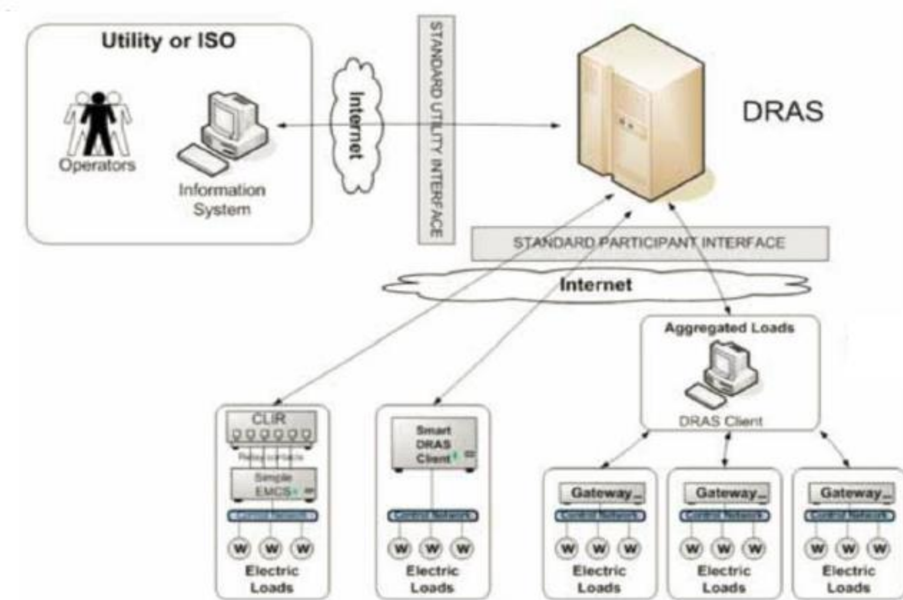
Grid-interactive efficient buildings (GEBs) with automated demand response will play an integral role in improving and modernizing the electric grid of the future. Strategic load management via shifting and shedding has the potential for widespread demand mitigation, if implemented at scale. However, most devices and buildings today are not grid responsive. In general, electric utilities express their preferences to customers through 'grid signals', which can be either prices or events. Ultimately, individual end-use devices provide flexibility by changing their functional behavior. Nonetheless, some entity needs to translate the grid signal to the device's functional control.

As shown below, this translation function can be implemented by some grid entity (e.g. the utility, or aggregator), a building gateway device, an intermediate device (e.g. a thermostat, external controller, or CTA-2045 module), or the end-use device itself. In an ideal future, all end-use devices will be directly price responsive.



High-level Methods for Grid-Responsive Control

The purpose of this project is to identify technology paths to enable easy automation of demand response in small commercial buildings, with a focus on flexible loads. The scope will initially consider time-of-use (TOU) rates and may extend to residential devices in certain cases. This study is designed to develop an implementation of a virtual end-node (VEN) as defined in the OpenADR Alliance's OpenADR 2.0 Profile B Specification (HTTP pull), updated on July 1, 2013. OpenADR defines a machine-to-machine interface and includes the information model, transport and security mechanisms, and the way data is exchanged between two end points. OpenADR 2.0 defines what and how information is communicated between an electricity service provider and customers, but it does not define how either endpoint uses the information. This open source application is written in the C# language and includes a graphical user interface. Developed to interact with an OpenADR 2.0 Virtual Top Node (VTN), its information model, XML payloads, and interactions with the VTN, can provide secure messaging.



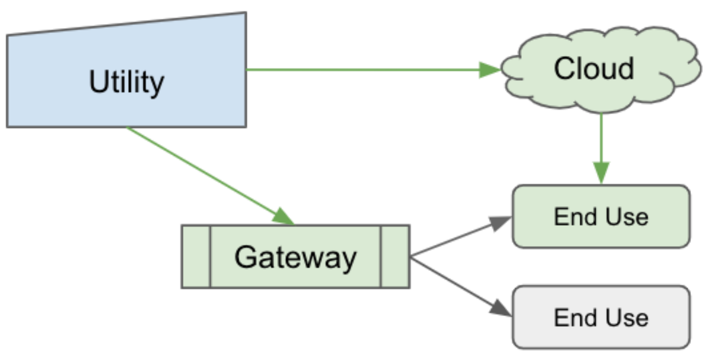
Open ADR System Architecture

VEN is underutilized within the general population, mainly due to customers not knowing that VEN is currently available for individual customers, and that aggregators are employing a form of VEN. The goal of the project is to gain widespread acceptance and implementation of a "virtual" VEN at individual buildings by educating utility customers and using other means of increasing market penetration. With a more accessible VEN application, the advancement of demand response operational understanding and adoption within the mass market sectors can move customers to a more beneficial dynamic rate or utility program.

The relevant end-use categories will be examined for demand response potential. Load shifting capability is rated based on the ease of shifting without disruption to the occupants. Shedding priority is scaled from low to critical, where low-priority loads are shed first, and critical loads must always be powered. Loads may also have a discrete on/off state-based operation or can operate at any point on a continuous curve of output versus power consumption. Continuous curves are more amenable to price-based control. It is also assumed that all large motor loads in the future will use variable-speed drives with near-continuous (but variable) operation.

The research team does expect the laboratory demonstration to include intermediate devices that can facilitate virtual VEN-VTN engagement. Examples of these "middleware" systems include:

- A communicating power outlet to power or de-power a device in control of the gateway. A pool pump is an example, as it needs to be powered a certain amount of time per day but have the actual start time(s) be flexible.
- A CTA-2045 module that can act as a "physical layer" for the VEN system. The team will examine two devices that support this module: a water heater simulator and an electric vehicle charger.
- A "smart hub" home device like the Samsung SmartThings.



Options for VEN Gateway Communications

Ultimately, the VEN gateway developed will not require any intermediate devices, but the team predicts that the consumer market will need this hardware flexibility for a (long) transition time. An end-use device can have zero, one, or more intermediates, with one likely being the most common in the near term. This architecture for grid coordination also applies to central electricity storage (a battery), or to dispatchable generation, but flexible end-use loads are the core focus for this project, and it is not likely to include stand-alone storage or generation.

Devices for the demonstration will be selected based on end-use category and protocol. No single gateway implements every relevant protocol, and sub-gateways or hubs will likely be required. Protocols such as Z-Wave and Insteon are only relevant to a small handful of end-use categories. Most of the larger smart appliances communicate via Wi-Fi, and frequently require intermediate controllers for connectivity. Criteria were developed to help the research team select devices and models to include in the demonstration.

Devices should:

- Be able to be integrated with the proposed gateway device by the gateway manufacturer, device manufacturer, or another secure entity
- Be able to accept prices directly from a remote server, in real time
- Contribute to a wide range of end-uses for the project demonstration
- Have a significant amount of shiftable load for small commercial customers
- Use innovative control mechanisms that do not need customer intervention

Other criteria for devices may be applied as the project progresses.

The project was funded under the EM&T "Technology Transfer" investment category, which 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 principal investigators of this project will be LBNL through a contract with EPRI. The project is directly funded by the EM&T program, and all materials will be shared with DR stakeholders via public access and in collaboration with the ETCC. While the EM&T program is funding the project directly and through a supplemental contract with EPRI, SCE is also leveraging its membership in EPRI with learnings and best practices from the parallel research by other EPRI utility members as a cost-sharing strategy. Also, as a corporate funding member of EPRI, SCE is co-funding parallel research investments with other utilities and leveraging that research to assist in this study. No other direct cost-sharing or co-funding with any other parties was enabled.

Results/Status

The contracts have just been released to LBNL by EPRI and the research team has held a kickoff meeting to assess research personnel availability and specific technology opportunities to assess and review. Development of the VENs were planned to be executed in the third quarter of this year; however, COVID-19 restrictions at the LBNL facility have delayed laboratory activities until further notice. While technology reviews and software reviews can proceed virtually, any field testing or laboratory work at LBNL is restricted due to COVID-19 access guidelines set by the management at LBNL in accordance with federal, state, and local rules.

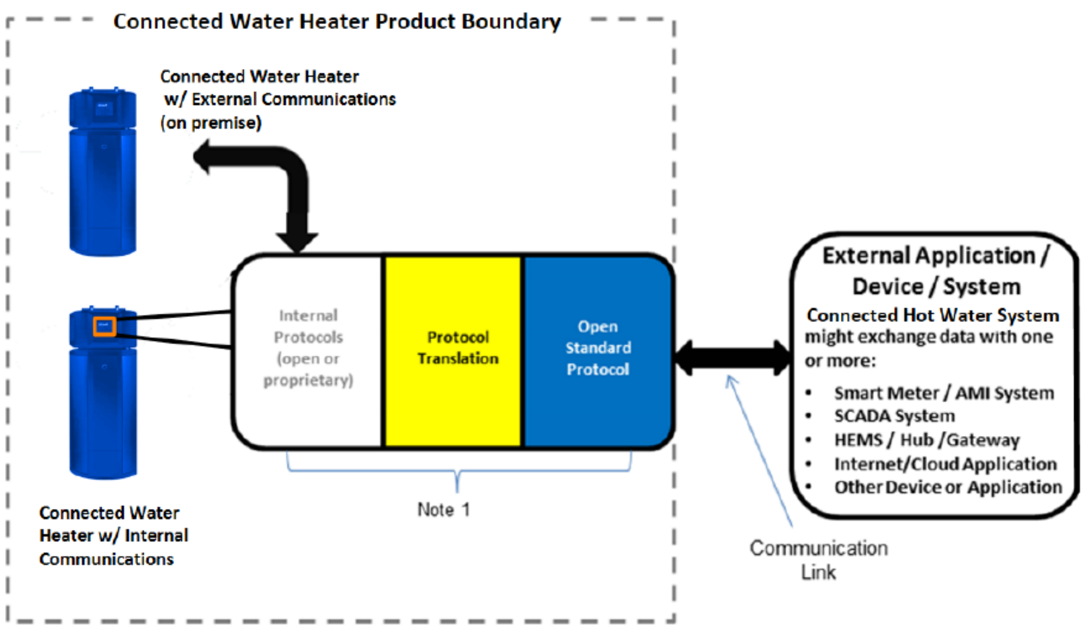
Next Steps

The next steps are to finalize a gateway design and select end-use devices for the demonstration by the lab research team. The gateway selection will be influenced by the desired DR strategy behaviors, and the end-use device selection will be motivated by the selected gateway specifications. Once the necessary modifications are finalized, the project team will deliver an interim memo describing the design of the gateway software and messaging architecture. The final report is scheduled to be available in late 2021; however, the team is now rescheduling project activities due to COVID-19 restrictions at the LBNL facility, which is causing both office access and testing schedule delays.

DR19.08 Grid Responsive Heat Pump Water Heater Study

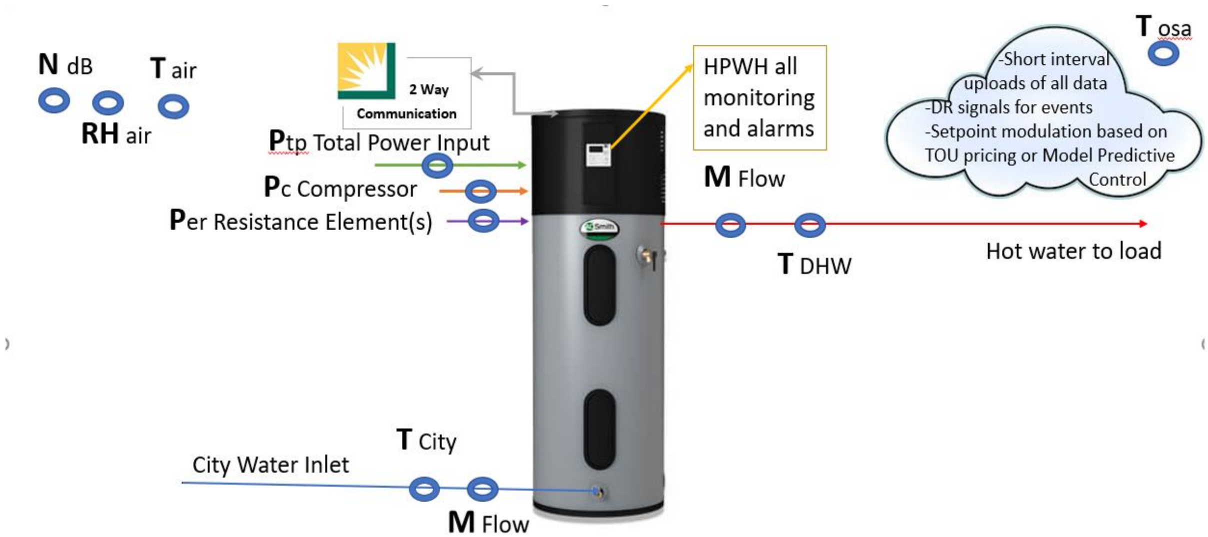
Overview

SCE's Emerging Technologies Program (ETP) and Emerging Markets and Technology (EM&T) Program have been conducting technology assessment studies of heat pump water heaters (HPWHs), and this study is a continuation of those efforts. The research team will be examining innovative technologies that will be applied and implemented for the deployment of the HPWH controls and communication equipment, and for the test instrumentation and data collection. 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 "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 heat pump water heaters (HPWH)s equipped with smart-grid communication technology that will allow the water heater to be used as a grid-responsive heating technology element of the pilot to electrify homes and reduce emissions within the SJV and California City. The SCE pilot will provide 150 qualified single-family homeowners in three SCE communities opportunities to replace their propane water heaters with HPWHs to reduce overall energy costs and improve the health, safety, and air quality of the residents in those communities. Twelve (12) of the 150 HPWHs will have 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 be instrumented 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 study is designed to address the following research issues:

- Assist SCE in understanding integration of renewables and load dispatch as well as help 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 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.

- Help inform how hot water storage over various time frames can be used to add load or shed load. The research will provide results that should enhance SCE and other stakeholders' understanding of integration of renewables and load dispatch. This will include detailed monitoring and analysis of the technical performance of HPWHs, including grid benefits and grid impacts of 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 will have a garage for the HPWH and no recirculation system. The 12 homes are part of a larger pilot of 150 electrified homes deployed with the pilot to electrify 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. SCE plans to minimize the risk of any failures of the technology that might occur at the customer home; therefore, 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 these 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 consist 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. The EM&T program is only funding a portion of this 12-home study for the development of the specific demand response research outcomes.

Results/Status

The SJV DAC project schedule has been significantly affected by the COVID-19 restrictions currently in place in California as of Q2 2020. While the overall pilot project is still in the homeowner recruitment stage, contracts are being developed for future SCE field work by the research team in anticipation of future customer sign ups.

Next Steps

The original San Joaquin Valley Project Timeline plan developed in 2019 had indicated that the HPWH installations would be conducted in 2020. The Engineering Services research team will assess its project rescheduling options for this study if the SJV DAC activities in Q3 and Q4 of 2020 are still significantly impacted by COVID-19 restrictions.

5. Budget

The following table represents the total expenditures for SCE's 2018-2022 EM&T authorized budget. 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 I2, SCE Demand Response Programs and Activities Expenditures and Funding, January 20, 2020. Values do not reflect commitments for projects, including those described in this report, which have been scoped and contracted, but not yet executed or monies that have not been spent.

Southern California Edison's Emerging Markets and Technology Program (D.17-12-003)	
Approved 2018-2022 Budget	$14,610,000
Budget Spent to date	$ 9,608,055
2018-2022 Budget Remaining	$ 5,001,945