Demand Response Emerging Markets and Technologies Program

Semi-Annual Report: Q3 – Q4 2017

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Southern California Edison (U-338-E)

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Contents

Abbreviations and Acronyms

AC	Air Conditioning
ACEEE	American Council for an Energy-Efficient Economy
ADR	Automated Demand Response (also seen as Auto-DR)
AHRI	Air Conditioning, Heating, and Refrigeration Institute
AMI	Advanced Metering Infrastructure
ASHRAE	American Society of Heating and Air Conditioning Engineers
AT	Advanced Technology
BAN	Building Area Network
BBI	Better Buildings Initiative
BCD	Business Customer Division
BEMS	Building Energy Management System
BESS	Battery Energy Storage System
BOD	Biochemical Oxygen Demand
C&S	Codes and Standards
CAISO	California Independent System Operator
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 Automated 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
EM&T	Emerging Markets & Technologies
EMCB	Energy Management Circuit Breaker
EMS	Energy Management System
EPA	Environmental Protection Agency

EPIC	Electric Program Investment Charge
EPRI	Electric Power Research Institute
ET	Emerging Technologies
ETCC	Emerging Technologies Coordinating Council
EVTC	Electric Vehicle Test Center
FDD	Fault Detection and Diagnostics
FERC	Federal Energy Regulatory Commission
GHG	Greenhouse Gas
HAN	Home Area Network
HEMS	Home Energy Management System
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
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
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
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
PLMA	Peak Load Management Alliance
PLS	Permanent Load Shift

PMS	Property Management System
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	Roof Top Unit (air conditioning)
SCE	Southern California Edison
SEER	Seasonal Energy Efficiency Ratio
SEPA	Smart Electric Power Alliance
SGIP	Self-Generation Incentive Program
SMUD	Sacramento Municipal Utility District
SONGS	San Onofre Nuclear Generating Station
T-24	Title 24 (California building energy efficiency code)
TES	Thermal Energy Storage
TOU	Time of Use
TTC	Technology Test Centers
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
VNEM	Virtual Net Energy Metering
VRF	Variable Refrigerant Flow
WW	Wastewater
WWTP	Wastewater Treatment Plant
ZNE	Zero Net Energy

1. Background

The Emerging Markets & Technologies (EM&T) Demand Response (DR) Projects Semi-Annual Report: Q3 – Q4 2017 is provided in compliance with Ordering Paragraph (OP) 59 of the California Public Utilities Commission (CPUC) Demand Response Decision (D.) 12-04-045[1] dated April 30, 2012.

The Decision directed Southern California Edison (SCE) to submit a semi-annual report regarding its DR Emerging Markets and Technology projects by March 31 and September 30 of each year. This report is provided for SCE's EM&T program activities in compliance with D.12-04-045.

In accordance with the CPUC direction for the reporting of the DR EM&T program, SCE completed, continued, initiated, or canceled EM&T projects identified in this report during the second half (Q3 and Q4) of 2017. This report summarizes the results and status of all of SCE's individual EM&T DR projects during the timeframes between July 1, 2017 and December 31, 2017.

2. Summary

The SCE EM&T program facilitates deployment of innovative new technologies, software, and applications that may enable cost effective customer participation and performance in SCE's DR rates, programs, and market resources. SCE has administered this program through several DR program cycles, in coordination with the changing role of DR in California. The current DR EM&T program strategy is focused on four key areas:

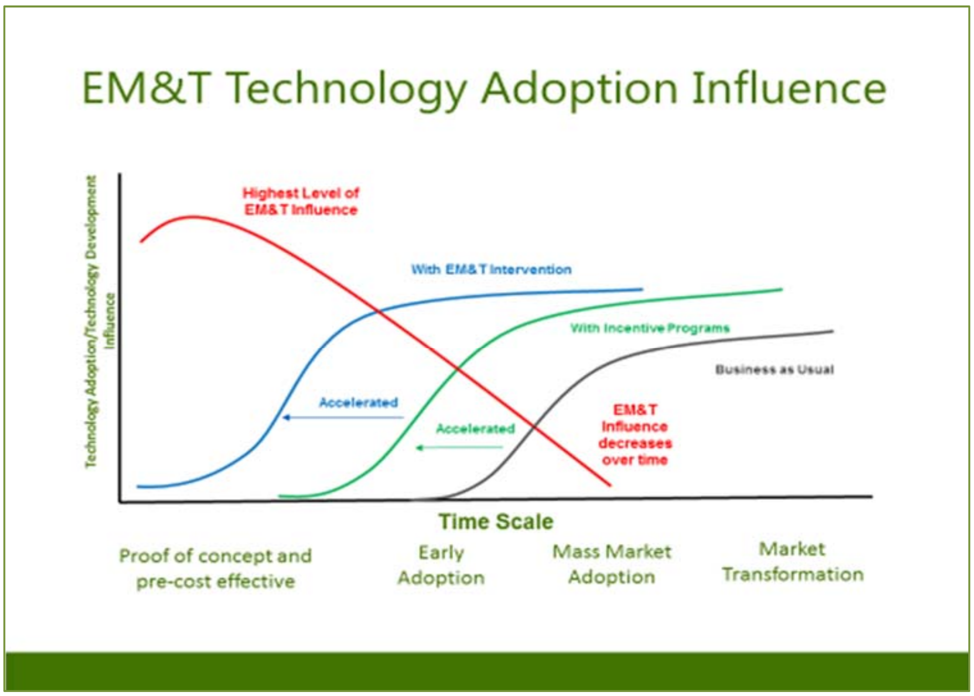
1. Enhancing the availability of cost-effective DR-enabling end-use technologies.
2. Supporting and developing DR Codes and Standards (C&S).
3. Encouraging DR technology expansion, as well as customer acceptance and enablement, through upstream market transformation.
4. Reducing technology barriers to integrating retail DR programs into the wholesale market (through Participating Load, Proxy Demand Response (PDR), and other market tariffs).

SCE works collaboratively with other California Investor-Owned Utilities (IOUs) with similar DR programs, as well as national laboratories, trade allies, and public agencies, to investigate innovative applications and software that could enable increased customer participation in SCE's DR program portfolio through the four strategies of the EM&T program.

[1] D.12-04-045, Decision Adopting Demand Response Activities and Budgets for 2012 through 2014, Ordering Paragraph 59, *available at*: http://docs.cpuc.ca.gov/PublishedDocs/PUBLISHED/GRAPHICS/165317.PDF].

The EM&T program directly funds innovative research activities by designing and implementing DR technology studies, demonstrations and assessments, as well as scaled deployments supporting DR program pilot development in support of the DR programs portfolio. The program also provides assistance and advocacy for upstream market adoption and continuous improvement of DR technological innovation by stakeholders and entrepreneurs.

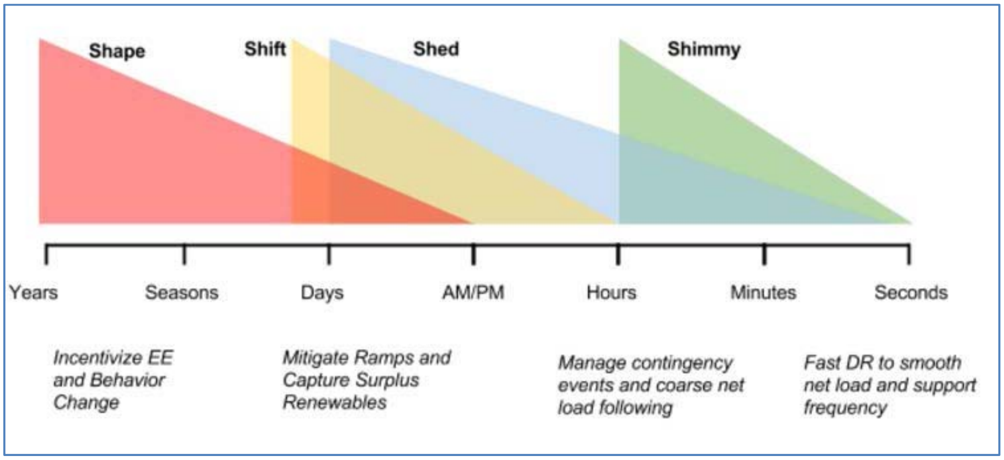
SCE's EM&T program technology adoption influence strategy includes delivering upstream industry market facilitation to bring DR awareness to the consumer industry. This includes, through technology-driven DR standards advocacy, collaborating on innovative demonstration projects and joint research studies with state agency grant awardees and research firms. These intervention efforts accelerate the deployment of DR technologies that will ultimately help facilitate the customer acceptance of cost-effective DR software and systems.



EM&T Technology Adoption Influence Curve

The EM&T program also works to facilitate California clean energy and renewable integration policies by providing T-24 C&S advocacy for the current 2019 California Energy Commission (CEC) code upgrade that will include Open ADR protocols. This code upgrade is scheduled for 2019 and will include communications standards for all types of new construction. In addition, development of Zero Net Energy (ZNE) homes will assist with both California policy and SCE's grid modernization focus, by facilitating a "grid friendly" deployment of the state's new construction GHG mitigation strategy.

This upstream advocacy work in the "early adoption" phase also is designed to further enable retail and wholesale market participants to accept and utilize the Open Automated DR (OpenADR) protocols, through technology-driven DR standards leadership, innovative demonstration projects, and joint research studies to provide work papers to support the cost benefit analyses. The research is also in collaboration with the CPUC's DR Potential Study, intended to enable future DR program design, to provide long-term and short-term end-use load flexibility (also referred to as “Shape, Shift, Shed, and Shimmy”).



Future Models of Demand Response

The EM&T program actively shares its activities through DR affiliate organizations, including OpenADR Alliance (OADR), Peak Load Management Alliance (PLMA), Association of Energy Services Professionals (AESP), Smart Electric Power Alliance (SEPA), and Association of Energy Engineering (AEE).

These are examples of a few of the SCE-implemented EM&T partnership affiliations and strategic communication approaches:

- Partnership with the Electric Power Research Institute (EPRI), to test and execute DR projects through participation in the core Power Delivery and Utilization program, as well as supplemental projects focused on specific DR technology assessments.
- Publication of full reports on EM&T projects on the Emerging Technologies Coordinating Council (ETCC) website,[2] for public access. The ETCC coordinates among its members, which include the California IOUs, Sacramento Municipal Utility District (SMUD), and the California Energy Commission (CEC.
- Assistance in organizing DR-related conferences to promote and support DR technologies, markets, and programs and services. This includes hosting events held in California, to encourage customers and stakeholders to attend trainings and presentations.

This engagement strategy will assist with educating and influencing industry stakeholders and non-participating customers to better understand DR technology opportunities. They also encourage consumer technology firms and other innovation market actors to adopt emerging DR technologies and strategies, which will ultimately assist with the beneficial customer participation of future DR program models.

[2] Emerging Technologies Coordination Council (ETCC) website [*available at*: www.etcc-ca.com].

3. Projects Completed Q3 – Q4 2017

In Q3-Q4 of 2017, several SCE EM&T projects were nearly finished, Field and laboratory tasks were completed, data analysis was finalized, and project summary reports were in either the peer review or final draft stages. The EM&T DR Semi-Annual Report for Q1-Q2 2017, filed in September of 2017, indicated that six project reports were to be completed by the end of Q4 2017. This section describes those reports, which are posted on the ETCC website.

DR12.17 Field Testing of Climate-Appropriate Air Conditioning Systems

This field test was part of an ET study and evaluated the current and potential DR capabilities of climate-appropriate Air Conditioning (AC) systems, such as evaporative cooling and Variable-Capacity Heat Pumps (VCHPs). SCE analyzed how automated, optimized DR technology, with an understanding of Heating, Ventilation, and Air Conditioning (HVAC) capacity and thermal characteristics, enables accurate relationships between DR lead time and duration, customer incentives, external environment conditions, and building occupancy.

By mapping efficiency, capacity, power draw, and air flow rates (in every operating mode and across a range of climate conditions) SCE was able to better understand the technical potential for demand response impacts under a load shed strategy. The study also presented a specific performance assessment of the observed installation, to help understand the system's advantages in a challenging application.

Findings

The ET results of this field test demonstrated that the VC-RTU systems achieve superior high-energy efficacy at full- and part-load conditions. Additional observations support a 30% load shed potential in energy usage at peak load during a DR curtailment scenario. As more VC-RTU systems are deployed in the SCE system, manufacturers should work with SCE and others to develop the added capability to respond to DR signals while optimizing EE performance, which would provide a good fit for a future integrated EE/DR integrated measure offering.

Next Steps

SCE is currently engaging HVAC manufacturers in discussions about DR capabilities as part of their overall EE/DR upstream market transformation activities, will share these findings with them, and will continue to pursue DR technology enablement in future HVAC research and pilot programs.

For more information on the data analyses and detailed results, the final report is available at:

https://www.etcc-ca.com/reports/field-testing-climate-appropriate-air-conditioning-systems

DR12.21 Field Testing of DR-Ready End-Use Devices

Manufacturers are continually developing DR-ready end-use control devices for household appliances into the market. The project was co-funded by SCE's ET program as part of an EE/DR research study with EPRI, which included a description of advances in DR-ready devices and programs for mass-market customers, to assess the market and technical potential of these new devices, and to conduct field tests as applicable.

This project (part of EPRI Subproject G) selected a "smart plug" modlet technology to assess for its ability to meet demand-reduction objectives. It was field tested to control existing customers' AC units, then lab tested with a connective window AC. The field trial identified the impacts achieved when the technology controlled the ACs, including:

- Full impact (ACs cycled off throughout DR events).
- Reduced duty cycles.
- Delayed cycling.
- Partial impact.
- No impact (due to user override or not using the AC during the DR event).

Findings

In a lab test, the modlet achieved 49-55% reduction in average power consumption, with setbacks of 75°F to 78°F, compared to baseline window AC operation at 72°F target temperature and no modlet. By communicating the benefits of participating in DR programs based on product capabilities that also address lifestyle needs, utilities can increase customer engagement and expand deployment of DR-ready devices such as with these devices. Smart plug technologies can be installed and commissioned by customers. Overall the products that were field and lab tested performed as manufacturers described in their marketing literature.

Next Steps

SCE recommends that further examination of the DR opportunities may be explored via a pilot program, to evaluate demand savings in real-world situations with enough customers to establish statistically-meaningful results. Integrating control devices with house fans (such as whole-house fans) could augment the pilot investigation.

For more information on the data analyses and detailed results, the final report is available at:

https://www.etcc-ca.com/reports/evaluation-residential-room-air-conditioner-control-smart-plugs-peak-load-reduction

DR12.40 Field Testing of Occupancy-Based Guest Room Controls

Occupancy-based guestroom Energy Management Systems (EMS) sense when hotel rooms are occupied, and adjust energy systems (such as HVAC, lighting, and outlets) to save energy. The control capabilities of these products could be used for DR. However, implementation requires additional investment in software and communications. In addition, hotels and motels have been reluctant to implement DR measures in guestrooms due to concerns about inconveniencing guests.

To address this challenge, SCE conducted a technical evaluation and field test of an innovative solution that could have the potential for facilitating DR responsiveness without sacrificing guest comfort. Engineers conducted a study at two hotels in the Southern California service area utilizing two brands of occupancy controlled guest room thermostat products. The primary objective of this assessment was to compare the energy use and demand response capability of the emerging technology with the existing technology.

Findings

The study found that centralized guestroom controls in the form of Property Management Systems (PMS) integrated with the facilities EMS may be an effective DR technical approach for hotels. Proper outreach and education would be needed to drive a shift to better understanding of the benefits of DR in the hospitality market. Combining this technology offering with an educational outreach program may result in proven energy savings benefits and compel the hospitality industry to invest in centralized guestroom controls. This project demonstrated however that for a hotel having a high occupancy rate, the technology costs are significant and may not warrant investment in centralized guestroom controls.

Next Steps

Based upon the results of this assessment, it appears that the contribution of the centralized guest room controls integrated with the PMS/EMCS offers energy efficiency potential but not as significant as expected unless rooms go unsold longer than seventy-two hours. Future studies are recommended to study methods to improve equipment capabilities on network reliability and security to enhance acceptance of hotel owners to employ technology. The technology studied in this report is promising and deserves a more detailed study with a chance of developing more thorough strategies for DR in guest rooms.

For more information on the data analyses and detailed results, the final report is available at:

https://www.etcc-ca.com/reports/centralized-guest-room-controls

DR13.06 EPRI EB III A – Variable-Capacity Space Conditioning Systems for Residential

Because residential Variable-Capacity Air Conditioning (VCAC) for residential markets may someday be a utility program measure enhancement or added resource, this study investigated VCAC for both EE and DR residential space conditioning DSM program participation. SCE conducted a technical survey of available equipment, ran a laboratory assessment of three VCACs of varying Seasonal Energy Efficiency Ratio (SEER), and did a field study of the systems during a California cooling season. The investigation included a technical survey of available equipment, a laboratory assessment of three VC air conditioners of varying SEER, and a field study of the three VC systems over a California cooling season.

This project evaluated the potential for VCHP DR capability and focused on three high-static ducted systems. The project team leveraged lab and field testing to evaluate the VCHP systems response to demand control signals. An appropriate signaling and controlling method (OpenADR 2.0) was selected, to enable DR testing under a variety of operating conditions. The study demonstrates the potential efficiency and DR capabilities of the VC equipment for California residences and utility programs.

Findings

The project team evaluated VC equipment using OFF-cycle controls to operating for DR functionality. One of the systems claimed to have OFF-cycle and low-stage capacity modulation controls. The outdoor units required manual dry-contact adjustment. Two of the systems also required controls and thermostat setting adjustments. None of the tested equipment was readily able to receive or respond to DR event signals.

During the laboratory evaluation, it was discovered that the low stage DR capacity modulation controls of VC system 2 were not functioning. The manufacturer identified that a software update would have to be developed, and the issue was not resolved at the time of the investigation. During several DR tests of the VC equipment, the indoor blower continued to operate during the active DR time frame. In a field situation, continued operation of the indoor blower may circulate warm air throughout the air.

Next Steps

While there is an interest and opportunity by the manufacturers to further develop the software to enable the DR capacity modulation at a later date, a revisit of those capabilities is needed to provide a more quantitative analysis of the DR load impacts. As the VC equipment becomes more commercialized, the manufacturer will be encouraged to revisit the DR capabilities and re-submit their interest for future DR program participation as an enabling technology.

For more information on the data analyses and detailed results, the final report is available at:

https://www.etcc-ca.com/reports/residential-vc-space-conditioningbuildings-iii-sub-project

DR13.07 EPRI EB III B – HVAC & Refrigeration Systems Using Advanced Refrigerants

This study was a subset of an EPRI research project and was combined with an ET project. The study explored and documented progress in advanced refrigerant product development, in applications fueled by natural gas and electricity. The goal was to identify EE and DR opportunities through laboratory evaluation and field deployment. First, the systems were selected and laboratory tested. Then, they were field tested at multiple sites in SCE's service territory. The field tests used advanced refrigerants in commercial and small industrial applications.

The advanced refrigerant system used ammonia as the primary fluid, and CO_2 as a pumped, volatile secondary fluid. This allowed the ammonia charge to be smaller than an equivalent all-ammonia system, and distributed only CO_2 into the building. The study documented differences in energy and power consumption, as well as observations from transitioning a new, alternative-refrigerant approach.

The project test scenarios included simulated demand response events, including pre-cooling and load shedding. This was performed manually on-site with the help of the host facility personnel. The temperature set-points in the freezer were adjusted by about 5°F in either direction. The control was simple set-point adjustment. Defrost heaters were not controlled in this study.

Findings

The new system tested used less energy in similar operating conditions than the baseline equipment. Comparing days in April with similar weather, the baseline system used 220 kWh more per day than the new equipment, a savings of 21%. During hotter weather in summer, the savings was 16-25%.

The average power during the events was 14-21 kW lower during the first hour than the same baseline hours. The ability to pre-cool was limited by the pressure setting of the CO2 receiver, which could not be quickly adjusted for these evaluations. Since the CO2 liquid is held at a fixed pressure, the supply temperature in the freezer is limited by that pressure; subsequent research efforts should evaluate the effect of adjusting this pressure setting to further pre-cool.

Next Steps

Overall DR performance in the future for these types of systems needs to be automated and could improve by increasing control capability. The study demonstrated that DR load impacts are possible. Developing the ability to shift defrosting forward or backward in time, and to adjust CO_2 conditions to facilitate deeper pre-cooling, would potentially offer a greater DR resource. As the CO2 equipment becomes more commercialized, the refrigeration industry will be encouraged to assess their interest for future DR program participation as future models of DR evolve.

For more information on the data analyses and detailed results, the final report is available at:

https://www.etcc-ca.com/reports/ammoniaco2-refrigeration-system-evaluation-food-processing-facility

DR13.08 EPRI EB III D – Automated Demand Response in Data Centers

This study investigated and tested recently-developed server management software to limit power in response to external signals, for potential data center DR opportunities. The technology uses the built-in power supply-limiting functionality found in modern Information Technology (IT) equipment hardware, such as server, storage, and network equipment.

SCE in collaboration with EPRI field tested a software program that has the following characteristics and potential:

- Reduces computer power demand in response to OpenADR signals.
- Uses liquid cooling technology.
- Replaces existing computer servers with efficient equipment.

This study seeks to better understand the capabilities of this software feature in terms of power reduction, time to respond, impact to operations, and post-event rebound, as well as to show the ability for this feature to be initiated as an automated response to an external DR signal. The evaluation covered performance, customer acceptance, operational viability, demand reduction, DR dispatchability, and cost effectiveness.

Findings

Results from laboratory tests of power capping demonstrate this feature can successfully limit the instantaneous power draw of a server to a defined level. Various-sized benchmarks were run, to determine the impact of power capping on increasingly CPU-intensive workloads. These workloads were run with decreasing power caps (lower power levels) from a baseline of 152 W (100%) down to a minimum power level of 72 watts (W) [~50%]. These results indicate power caps successfully limit the power draw of the server under workload, and show more pronounced impact on all workloads at the lower power levels.

Next Steps

The demonstration showed that data servers quickly responded to power cap commands, indicating this technique may be useful for fast-dispatch DR signals. Although data center workloads are often considered mission critical (one reason data centers are reluctant to adopt DR) not all workloads are the same. It is recommended that additional testing be done to evaluate power capping with additional real-world applications, such as e-mail server, database, etc., so the impact to workloads with different needs may be evaluated (comparing processor-intensive workloads to memory or data-limited applications). Such a study could be performed in both laboratory and field conditions, so that basic functionality, response to stochastic load, and user impacts can be quantified.

For more information on the data analyses and detailed results, the final report is available at:

https://www.etcc-ca.com/reports/data-center-demand-response-server-power-management

4. Projects Continued Q3 – Q4 2017

DR13.05 Demonstrating Grid Integration of ZNE Communities

Overview

This project is a partnership to design, build, and monitor a new residential community of 20 new single-family homes with ZNE solutions. California's ZNE policy goal, "Big Bold Energy Efficiency Strategies" (transforming new residential construction to ZNE by 2020, as published in the California Long Term Energy Efficiency Strategic Plan, September 2008) drives this project.

This is an opportunity for SCE to prove ZNE technologies can be accepted by helping to overcome barriers. SCE's key project goals are to evaluate the impact of ZNE communities on the electric grid, apply technology strategies to enhance grid benefit, and demonstrate cost-effective ZNE homes and high photovoltaic (PV) adoption.

ZNE Residential Community in Fontana, California
Twenty homes in the Sierra Crest Development of San Bernardino County.

The project will also evaluate viable measures that could provide EE and DR capabilities, as well as DER optimization in individual residential units. A detailed report will summarize findings and make recommendations on how to overcome technology and market adoption barriers.

Project results will inform T24 codes and neighborhood planning tools. They will also help developers and builders achieve cost-effective ZNE, and enhance utility distribution system planning by helping to take expected ZNE community home load performance into consideration.

Collaboration

The project team consists of these stakeholders and roles:

- CPUC/California Solar Initiative (CSI) – developed the solicitation and awarded the demonstration project.
- EPRI – the grantee and overall project lead.
- Meritage – large production homebuilder and community developer.
- SCE – the host utility, and the lead on technology, the grid-side, DSM, and battery storage technologies.
- BIRAenergy – ZNE subject matter experts providing energy modeling engineering support.
- Community homeowners – all engaged and supporting the project.

Status

The community is built, and all 20 homes are occupied and generating data. The post-occupancy monitoring phase is also complete, and circuit-level data monitoring is being collected. The project team analyzed data from the evaluation period and published it in a CSI report titled *Grid Integration of Zero Net Energy Communities* in January 2017. The final post-occupancy evaluation report is expected by Q2 2018. Once the final report is review and approved, it will be published on the ETCC website.

Data Collection System (in progress)

Home battery energy storage system: Battery, battery inverter, PV inverter, battery energy management, data collection box, battery auto-transfer switch, and critical load panel.

Next Steps

The ongoing data collection activity will create post-occupancy energy load profiles for California's first Zero Net Energy residential community. A final report will include both EE and DR outcomes later in 2018. This information will enhance and calibrate the energy modeling and assumptions from the interim CSI report.

DR14.01 Deep Retrofits in Low-Income Multi-Family Housing

Overview

Low-income households, whether owned or rented, typically occupy substandard energy-inefficient dwellings. This results in high energy usage and costs. A study by the U.S. Department of Health and Human Services stated that low-income households can spend as much as 16.4 percent of their incomes on utilities (more than double what average households spend). The Deep Retrofits in Low-Income Multi-Family Housing (DRLIMFH) project addresses these concerns through improved EE with deep building envelope and end-use system retrofits. The project also examines DR opportunities through improved HVAC systems.

This project showcases a range of high-efficiency IDSM technologies in a 30-unit subset of a 100-unit, 1970s Low-Income Multi-Family (LIMF) development. The project advances SCE's renewable and EE retrofits for LIMF developments, illustrating available cost-effective and incentive-ready emerging building technologies.

Low Income Multi-Family (LIMF) Development

This project also provides direct comparisons from the baseline to a deep energy-efficient retrofit, demonstrating the effectiveness of integrating renewables to approach ZNE. Another project objective is to produce a practical and cost-effective retrofit package of technologies for building owners to replicate at LIMF developments.

Project deliverables include:

- Smart thermostats, wall and roof insulation, ductwork and insulation, weather stripping, water heaters and boilers, high-efficiency shower heads, and refrigerators.

- Renewable energy technologies, including solar hot water heaters and PV systems.
- A final report to summarize data collection, results, and recommendations. The final report is targeted to be published on the ETCC website Q1 2018.

The DRLIMFH project demonstrates the technical effectiveness of a comprehensive package of renewable and EE measures. It identifies hidden costs, market and technical barriers, mitigation approaches, and tenant coordination. The energy savings evaluation will benefit the Multi-Family (MF) program, and will:

- Develop a practical business model around comprehensive EE and solar retrofits for builders and developers.
- Increase knowledge of occupant comfort before, during, and after installing energy-efficient improvements.
- Build a knowledge base of real-world cost estimates, to demonstrate the cost effectiveness and synergies of packaging multiple technologies for LIMF retrofit projects.
- Evaluate upgrades and suggest improvements to existing financial models and associated tools that could enable scaling across LIFM developer housing portfolios.

Collaboration

Stakeholders and their respective engagement levels for the DRLIMFH project are:

- California Energy Commission (CEC) – innovative electric technology investments through the Electric Program Investment Charge (EPIC) program.
- Electric Power Research Institute (EPRI) – stakeholder fulfilling EPIC 309 project goals, including DER strategy integration; collected and analyzed the site data; project lead for the CEC.
- Southern California Edison (SCE) – electricity IOU; DR and EE technology subject matter expert; supports design, energy modeling, and field implementation.
- Southern California Gas Company (SoCalGas) – Natural Gas (NG) IOU; installed Advanced Meter Infrastructure (AMI) NG meters; collected and analyzed NG data.
- BIRAEnergy (BIRA) – energy consultants; conducted energy modeling, identified energy measures, and provided overall energy consulting services.
- LINC Housing (LINC) – building owner, affordable housing developer, and manager with holdings throughout California; provided site access and resource support.

Status

The final report draft is currently under review. The evaluations covered the performance, customer acceptance, operational viability, EE, demand reduction, DR, and cost-effectiveness of the selected technologies. To date, all field construction work, commissioning, analyses, and surveys are complete.

Next Steps

When the final report is reviewed and approved, it will be posted on the ETCC website in mid-2018. The long-term benefits of this implementation will be communicated to housing developers to include better health, cost savings, and economic opportunities for low-income tenants.

DR14.07 Conditioned Crawl Space (CCS)

Overview

Nearly a quarter of all California single-family residences built since 1971 have unconditioned vented crawl spaces. Sealing and conditioning these underfloor spaces can improve building envelope air tightness and reduce duct losses. It may also improve DR effectiveness by increasing available cool air and thermal protection during DR events. The project will explore the benefits of a DR measure in homes in four Climate Zones (CZs) that retrofit to Conditioned Crawl Spaces (CCS).

Conditioned Crawl Space (CCS) Implementation

Smart communicating thermostats are often installed to allow HVAC systems to adjust space temperature set points. During DR events, leaks can reduce the efficacy of thermal latency, and occupant comfort may be impaired. One project goal is to examine how smart thermostats can shut off AC compressors, but still run air handler fans to circulate cool air from beneath the house, keeping the house cool during DR events.

The anticipated benefits of CCS for residential dwellings include:

- Reduced electrical demand from HVAC equipment during DR events.
- Improved EE and cost savings.
- Enhanced HVAC system capacity and effectiveness.
- Greater occupant comfort and Indoor Air Quality (IAQ).
- Increased protection of the building structure against humidity-related issues.

Project outcomes will provide future planning that may help lead to a residential DR measure for homes with CCS. Findings may also be incorporated into Building Energy Efficiency Standards supporting the California Energy Code (CEC), if the energy benefits are cost effective. In addition, the performance of effective DR strategies may improve over non-CCS dwellings.

Collaboration

This project leverages SCE's ET program for the DR assessment. ET has collaborated with other SCE internal organizations, and has provided subject matter experts supporting this field study during design, implementation, commissioning, testing, data acquisition, and analysis. Key stakeholders are participating homeowners in SCE's service area, as well as installation contractors building the CCS envelope and installing HVAC system upgrades. Additional stakeholders include SCE's C&S organization, which is providing support for alignment with the California Building Energy Efficiency Standards (Title-24).

Status

This project has been substantially completed. The consultant's draft report will be submitted for internal review in January 2018. Based on the current schedule, the final report is expected to be completed in Q2 2018. Once the report is approved, it will be published on the ETCC website.

Next Steps

Project outcomes related to EE improvement and potential DR adoption appear to be positive. However, market economic challenges appear to be a barrier for widespread CCS adoption as a cost-effective building retrofit technology. Additional learnings are needed at the market facilitation level, to understand how to leverage the cost benefits of conditioned crawl spaces, as well as resulting energy savings.

Preliminary results suggest:

- Occupant comfort and IAQ was improved after CCS implementation.
- DR response was demonstrated at all test sites; in some cases, challenges remain in maintaining set-point setback for the entire DR event.
- In most cases, energy savings occurred on an annual basis, but challenges sometimes occur in the heating season.
- Hotter and dryer climates appear to respond better to CCS retrofits.
- Challenges remain for the overall cost effectiveness of CCS, considering energy costs only; non-energy benefits were not quantified, and may help improve this retrofit's simple payback; new construction may prove to be more cost effective for CSS.
- Current energy modeling tools do not directly address the energy benefits of the CCS measure, which may present a barrier to wider market transformation.

DR15.18 Wastewater Treatment Plant Demand Response

Overview

Wastewater (WW) processing is an energy-intensive and continuous industrial process, subject to varying hourly surges and a critical process that cannot be interrupted. Typical WW Treatment Plants (WWTPs) have limited capacity to store incoming WW, prohibiting effective DR strategies. This may require shifts or changes in process operations. WWTPs are also subject to rigorous State and Federal WW discharge permit requirements.

Recent technological developments have shown a significant reduction in electrical power may be possible for WWTPs, improving their efficiency, as well as presenting an opportunity for DR. Aeration blowers are used as part of the secondary treatment stage (activated sludge). They may account for 50% of a plant's energy demand and usage, and can be controlled through new technology to significantly reduce power requirements, making effective DR event responses possible.

OTE Analyzer with Opto-22 Automation Unit

The Oxygen Transfer Efficiency (OTE) Analyzer is a key technology breakthrough. The OTE allows modifying the operational parameters of WWTPs to support DR events, while maintaining the WWTP permit process.

The technology shows potential for DR event participation, supporting the EM&T and DR program drivers of providing greater grid security through energy load reduction on demand, and increasing EE through precision process control.

Project deliverables include:

- A report including methods, site data logs, results of DR effectiveness, and recommendations for future development and application.
- A permanent advanced OTE analyzer installed at the Chino, California site.

An effective DR response, plus sustained process control, will enable WW treatment facilities throughout Southern California to adopt this technology. The DR results could be of significant value.

Collaboration

Multiple stakeholders have come together to provide support, helping to ensure project success though meaningful engagement:

- DrH2O, the prime contractor who developed the OTE Analyzer, responsible for all field work and technical expertise.
- UC Irvine, supporting this work as a subcontractor to DrH2O.
- SCE's field engineering staff, working with the DrH2O team supporting the field and technical work.
- The Inland Empire Utility Authority (IEUA) WW facility in Chino, who provided the installation site.

Status

Telemetry development and data collection is ongoing. All stakeholders, including those at the host test site, are satisfied with the progress. Preliminary results support the project goals of providing greater grid security through on-demand energy load reduction, as well as increasing EE through using the OTE analyzer for precision WWTP aeration system process control. Preliminary findings are significant and promising and completed work to date and planned activities are:

1. The OTE analyzer has been fabricated, tested, and installed at the Inland Empire Utility Authority (IEUA) WW facility in Chino.
2. The data collection systems are operational, allowing the project team to gather preliminary data to assess the functionality of the off-gas analyzer and calibrate it accordingly.
3. The DO probe calibration is complete.
4. Aeration blower sub-meter installation is complete.
5. The power demand interface will be developed, and at its completion, the actual WW plant power demand will be compared to the interface data.
6. The analyzer will continue to be tested, with upgrades and modifications as needed.
7. The data from 2017, along with new data, will continue to be analyzed.

Next Steps

This project is testing several changes to a WW treatment facility's aeration operations to facilitate DR capabilities and impacts. The goal of the testing is to find the optimum configuration that meets the DR objectives without compromising the process operations and also providing the least impact to the plant's operation, with the highest impact on power demand reduction. The test will also examine additional benefits that include reduced maintenance and energy costs.

DR15.20 Dispatchable Condenser Air Pre-Cooler

Overview

As outdoor air temperature increases, AC efficiency quickly reduces, taking more energy to deliver the same amount of space cooling. This is compounded by the fact that during hotter periods, cooling needs increase. SCE seeks viable solutions for increasing EE and implementing DR during high-temperature operating conditions, and applying these solutions to the most prevalent type of RTU.

This is a project to conduct laboratory and field studies to determine the impacts after an evaporative pre-cooler is turned on to pre-cool condenser air coming into the RTU. We will study the transient response of cooled inlet condenser air and its impact on improved compression cycle efficiency and demand load profile reduction.

UC Davis Pre-Cooler Test Assembly

A dispatchable pre-cooler technology will be field tested at a site that has an existing pre-cooler installation. The data will be used to determine the potential of using pre-coolers as dispatchable load balancing resources. This may lead to a solution for utility load management, and help enable and expand DR adoption.

Project deliverables include one lab test report, and one field test report on dispatchable pre-coolers for DR. The reports will incorporate the following information:

- Specific methodologies used.
- Detailed laboratory and field test plans.
- Executed data analysis.
- Test outcomes, and recommendations based on findings.

Findings will provide information on using dispatchable pre-coolers for utility load management. They will establish whether pre-coolers can be demonstrated as guaranteed demand reduction resources.

Collaboration

The key entity undertaking this project is UC Davis' Western Cooling Efficiency Center. The Center is located at UC Davis and SCE is a supporting partner along with many other HVAC industry stakeholders. The Center educates and collaborates with industry stakeholders to stimulate the development of cooling technologies that can reduce building energy demand and water consumption, and this effort will be shared through those partnerships.

Status

The laboratory test has been completed and the results are compiled in a report. The data verifies single-compressor RTU demand reduction after a pre-cooler is activated. A review of the manufacturer's RTU literature has been completed, to investigate delays required to turn off compressors in multiple-compressor units.

SCE conducted the site selection, and instrumented the equipment with sensors to access vital performance indicators. Preliminary results show a power reduction of 20 percent for the RTU, while yielding a coincident 10-percent increase in cooling capacity. Power reduction findings are 75 percent in one minute of DR signal dispatch, and 100 percent power reduction within 13 minutes of DR signal dispatch.

Next Steps

Findings from laboratory testing, manufacturer literature, and the field testing have resulted in a better understanding of how this system provides DR capabilities. SCE will assess whether to incorporate this strategy, and UC Davis has gained further research in the operation, benefits, and strategies for Air-Handling Unit (AHU) pre-coolers.

Final project results will be available in the first quarter of 2018. They will be incorporated in the overall UC Davis report, and posted to the ETCC website in mid-2018.

DR15.21 LINC Housing – Low-Income Multi-Family ZNE New Construction

Overview

A large percentage of new residential construction in California is MF. This project provides SCE a living laboratory in which to demonstrate ZNE in new MF construction. This will help overcome barriers and lead to greater adoption. The goal is to conduct a field test to evaluate viable measures that could provide EE and DR capabilities in individual residential units, and possibly in entire residential complexes.

In Pomona, California, a three-story LIMF residential development consists of forty-six apartment units on an infill lot. The units vary in size from one to three bedrooms. Designed to the LEED Platinum standard, this development includes underground parking, community laundry, management offices, a community lounge with internet terminals, and a courtyard playground area. The targeted tenants are low-income, with half the units designated for those who are homeless.

Multi-Family Low-Income Residential Development

Renewable technologies implemented at this development include 34 kW of rooftop PV arrays, complimented by a grid-tied storage battery. The interaction of these systems is fundamental to attaining ZNE goals.

The project will include the following DR features:

- Smart communicating thermostats, to reduce electricity demand in response to an OpenADR signal or other DR initiation.

- Battery storage and advanced controls for the entire building complex, using Virtual Net Energy Metering (VNEM) to support grid stabilization.
- Other possible DR options the design team and stakeholders agree to use.

As part of this unique field assessment, the evaluation will cover the performance, customer acceptance, operational viability, EE, demand reduction, and cost-effectiveness of the applied technologies. We expect to gain a comprehensive understanding of installation costs and barriers to ZNE in new construction.

We will explore the benefits of DR controls through wireless communicating thermostats and DER interaction. The technology is expected to provide improvements to LIMF community management and operations, and improved tenant comfort with low energy costs.

Additional predictive outcomes from this project are expected to provide:

- Information for future planning, which could lead to MF residential DR measures, as well as optimized DER use.
- New information on interaction of the grid-tied battery with PV, and other grid-tied DR testing, in an MF environment.
- Insights into grid modernization.
- Access to detailed real-world information on the interaction of building technologies with LIMF residents.
- Energy and cost savings for tenants and owners.
- Assistance in educating LIMF occupants on how to live in a high-performance building to take advantage of dynamic energy features.
- Increased understanding of ZNE installation costs and barriers.
- Lessons learned captured in the final report, providing insights to the high-performance building industry in planning future MF developments.

Collaboration

These stakeholders are collaborating in this multi-faceted project, demonstrating success toward project goals:

- SCE's ET program, leveraging resources to investigate DR and DER opportunities and providing SMEs.
- SCE's Savings By Design group, helping the owner identify measures that qualify for incentive payments.
- SCE's C&S group, providing SMEs to support the project throughout the design and construction process.
- LINC Housing, the facility owner, a key entity and early adopter of new technologies and ETs.
- The CEC, providing support through EPRI to collect and analyze data demonstrating project performance.

Status

Construction is nearing completion. Due to heavy rains last spring and other construction-related delays, the project is several months behind schedule. Other construction milestones include:

- Construction best practices and cost data is being identified and documented.
- Measurement and Verification (M&V) equipment supporting data acquisition is being installed; data will be collected for a year after occupancy, including any PV and battery storage interaction (data collection is not yet fully operational across all data points).

- The PV array is installed and awaiting authorization to operate.
- LINC is recruiting tenants. Full occupancy is expected to take place sometime in early 2018, depending on recruitment outcomes.
- Interior finishes are complete in some units.
- Construction data was gathered for developing the C&S new MF commercial code.

Next Steps

A compilation of lessons learned during design and construction will be included in the final report, and will be available to the construction industry and MF building owners. During each step of the construction process, information is being gathered and documented for the final report. Some outcomes are becoming apparent:

- Most site management is in place and occupying offices that were completed early. This represents proactive planning and helps management understand the many building systems supporting ZNE goals.
- A training session is planned for the first two quarters of 2018, to educate site personnel on proper equipment use, including a dashboard, thermostats, etc.
- The grid-tied battery is expected to be installed by mid-2018. Adequate space was reserved for this equipment during design, to enable quick installation.
- The networked wireless thermostat installations came after the split-system heat pumps, which caused some apartments to undergo installation while occupied, complicating system initialization and final finishing. However, the thermostats use a wireless self-generating network which quickly becomes fully operational and useful. These thermostats support commissioning data from the heat pumps, and are valuable in assisting contractors during installation.

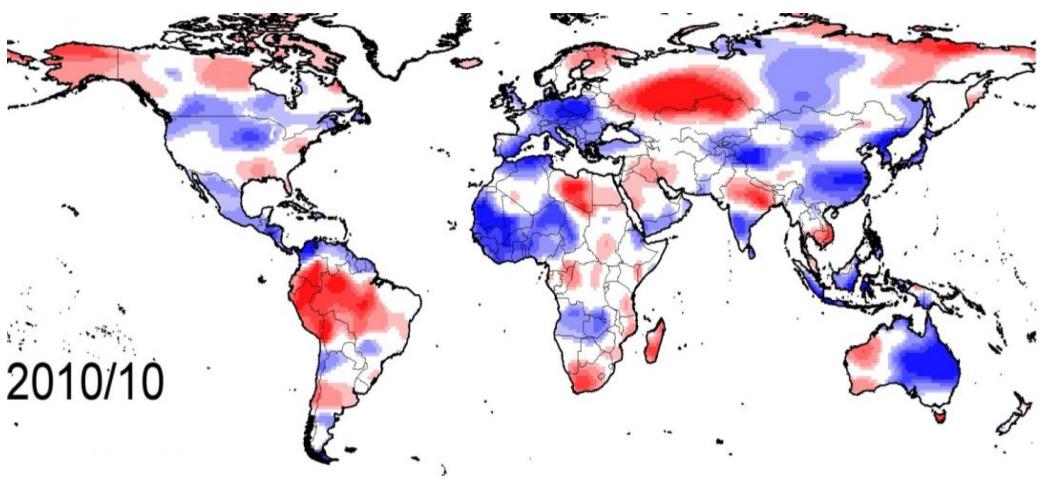
DR15.23 EPIC 14-309 Building a Climate Change-Resilient Electrical System

Overview

On November 19, 2014, the CEC released a competitive solicitation to fund applied research and development projects through the Electric Program Investment Charge (EPIC). The goal of these projects is to reduce the environmental impacts of electricity generation, and make the electric system less vulnerable to climate impacts.

EPIC funds clean energy technology projects that promote greater electricity reliability, lower costs, and increased safety. Projects must lead to technological advancement and breakthroughs to overcome barriers to achieving the state's statutory energy goals. In addition, projects must benefit California IOU electricity ratepayers.

In response to the subject Program Opportunity Notice (PON), the UCI Advanced Power and Energy Program (APEP) proposed a project to identify climate change impacts, as well as steps for building resilience against their effect on the electric system.



GHG Climate Models Representing Hydrological Patterns

This project includes:

1. Identifying, characterizing, and quantifying impacts of climate change-affected atmospheric and hydrological conditions on electricity system generation, renewable potential, and demand management and control (forms of DR).
2. Determining the implications for meeting GHG reduction and Renewable Portfolio Standard (RPS) targets.
3. Developing solutions to mitigate these impacts through improved grid management.
4. Developing resource and technology planning roadmaps for IOUs and state policymakers to use in building resilience to climate change impacts into the system.

Collaboration

The project team consists of the Advanced Power and Energy Program and Center for Hydrometeorology and Remote Sensing at UCI, and SCE's Emerging Products team.

UCI is in charge of developing, enhancing, and testing new methods to produce probabilistic climate forecasts for the electric system. These methods will also improve probabilistic forecasts to estimate effects on electricity demand and generating capacity.

Status

The UCI team has begun conducting multiple studies. Several interim reports have been reviewed, and SCE is actively developing climate models and data inputs. The climate models will determine spatially- and temporally-resolved precipitation, streamflow, runoff, and temperature anomalies for the state of California. These inputs will be used to characterize and quantify the impact on electricity generation, renewable capacity potential, and demand. The utility and policymaker roadmap is in progress.

Next Steps

Project deliverables include:

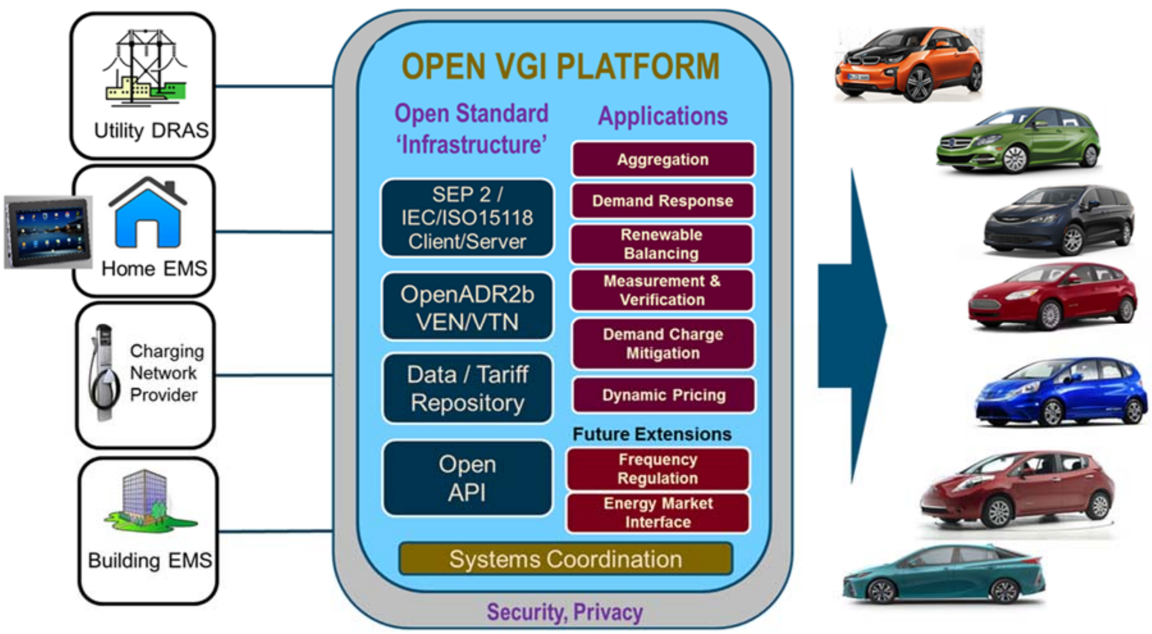
1. Determine the spatially- and temporally- resolved changes in precipitation, runoff, streamflow, and ambient temperature due to climate change.
2. Determine the impacts of climate change on electricity generation fleet (including conventional resources and large hydropower) performance and behavior.
3. Determine the impact of climate change on renewable resource (such as solar and geothermal) capacity potential and behavior.
4. Determine the impact of climate change on electricity demand magnitude and distribution.
5. Assess the combined effect of the identified impacts on statewide electricity system GHG, as well as the renewable utilization performance of currently-projected strategies for meeting GHG reduction and RPS targets.
6. Identify and evaluate modifications to strategies for meeting GHG reduction and RPS targets which resist the impacts of climate change on the electric system.
7. Develop a utility and policymaker roadmap for evolving the electricity system resource mix to build a system resilient to climate change impacts.

DR16.02 Open Vehicle Grid Integration Platform (OVGIP)

Overview

Plug-in Electric Vehicles (PEVs) represent a rapidly-growing class of smart, connected loads with increasing nationwide adoption. Utilities have an opportunity to manage PEV charging in a manner consistent with DR and DSM objectives. However, the PEV infrastructure and load management landscape is currently fragmented, with PEVs and charging network providers positioning themselves as aggregators seeking to leverage their proprietary telematics, charging networks, and interfaces. This complexity is stifling the integration PEVs into DR and DSM delivery channels, and preventing potential benefits from accruing to utilities, PEV customers, and the public.

EPRI's Electric Transportation program has engaged with eight leading global PEV manufacturers over the last two years, to develop a proof-of-concept for an Open Vehicle Grid Integration Platform (OVGIP) to streamline PEV charging. This platform may enable access to data on vehicle energy use, charging profiles, and consumer responses to various signals or inducements to affect charging. With these capabilities, utilities would be able to integrate all PEVs in their service territories into DR and DSM programs. This work culminated in successfully publicly demonstrating the open platform concept as the Central Server Project with the Sacramento Municipal Utility District (SMUD) in October of 2014. The OVGIP aims to take that work and implement that platform for customer owned vehicles.



OVGIP System Interface and Communication Architecture

The project objective is to advance the open platform concept into the product development and testing stage. It will assess the effectiveness of an open standards-based platform to seamlessly integrate PEV charging with grid objectives through DR and DSM mechanisms.

The project includes:

1. Creating requirements and use cases for a unified grid services platform that is secure, low-cost, open, and extensible.
2. Developing an architecture and functional representation of a platform that enables PEV integration into DR and DSM use cases.
3. Assessing platform performance against industry requirements through field trials at utility host sites.

Project deliverables are:

- A report describing the technical requirements, architecture, design, and open-interface specifications.
- Open grid services platform software, to integrate and apply to future extensions of other end-use devices and additional grid services.
- An EPRI final report, posted on the ETCC website.

Collaboration

Original Equipment Manufacturers (OEMs) are enhancing their platforms to enable accurate DR action when dispatch events are received. The project is in collaboration with EPRI, multiple industry vehicle OEMs, and utilities. EPRI is coordinating the participating utilities, and will prepare the final report.

Automotive industry participants include BMW, Daimler, Fiat Chrysler, Ford, Honda, Nissan, and Toyota (GM, Tesla and VW Group: Observers).

These utilities form the development team: PG&E, SDG&E, SMUD, Puget Sound Energy, Hawaiian Electric, New York Power Authority, Southern Company, Duke Energy, American Electric Power, and Con Edison.

Internal SCE stakeholders are: Advanced Technologies Organization (ATO) and Customer Programs and Services. ATO is assisting with the use case definitions and project history, as they participated in the Central Server Project. ATO provides vehicle testing as required.

Status

- SCE has defined the use cases.
- EPRI is coordinating this effort for other participating utilities.
- The architecture requirements and interface specification are complete.
- One of the participating OEMs has completed the architecture buildout.
- OVGIP functional testing (i.e. compatibility) is complete.
- Architecture testing is underway.

Due to reorganizations in one participating OEM's firm, the project has been delayed by two quarters. Once testing is complete, customer field trial enrollment will begin. Customer DR enrollment is expected to begin in April of 2018. Testing will be conducted during Q2-Q3 of 2018, and the final EPRI report, including a DR communications assessment, is targeted for completion by the end of 2018.

Next Steps

So far, the information gathered from this project is promising. One setback is the project's schedule being extended due to OEM restructuring. The OEMs are engaged, and preliminary findings show promise toward the objective of using PEVs as a viable option for meeting DR and DSM long-term goals. PEV owners, IOUs, and associated communities will benefit from the knowledge disseminated through developing the software, specification, and final report, which is expected to include:

Deliverable 1: Technical Documentation

- A subgroup will develop use cases and requirements.
- The subgroup will develop common terms and conditions.
- The subgroup will develop protocol mappings to requirements.
- An activity summary will be comprised of the subgroup's results, and will identify which communication protocols can meet the use cases.

Deliverable 2: Protocol Cost/Benefits

- The VGI group will evaluate categorized costs (to EV, grid, site host, etc.) of adopting or not adopting a protocol. The subgroup will also develop and examine a broad range of benefits.
- This work will determine whether adopting one or more protocol, or an alternative, generates the greatest benefit for each use case.

Deliverable 3: Policy Recommendation

- The VGI group will evaluate Deliverables 2 and 3, provide recommendations on market or policy actions.
- This activity is expected to continue into 2018, and will result in one or more mandated protocols supported in SCE's EV infrastructure pilots.

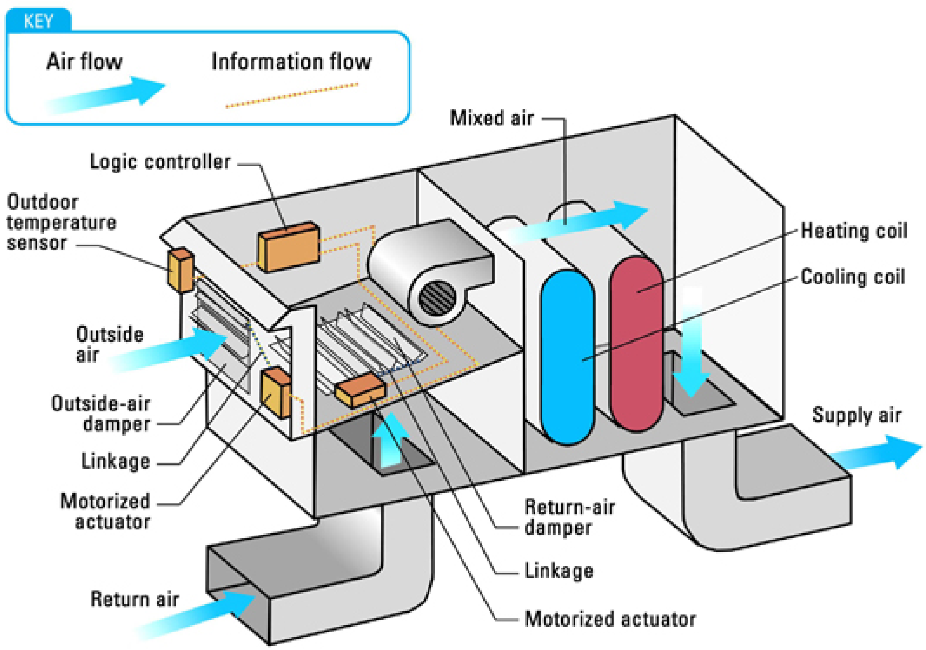
DR16.05 Laboratory Assessment of Demand Response Roof Top Unit Air Conditioner Controller

Overview

The majority of California's electrical power demand and energy consumption during summer months is due to residential and commercial AC units. Growing demand during heat storms in constrained areas can negatively affect grid reliability. To manage these issues, utilities offer DR programs, with economic incentives to reduce power demand and usage at certain times of the day. However, to fully take advantage of these programs, customers need access to:

1. Equipment and appliances that enable rate and grid condition communications.
2. Equipment and appliances that offer integrated control capabilities to respond to the information received.

These DR capabilities can be achieved at the factory level, or by retrofitting and installing add-on devices to existing equipment.



Typical RTU AC System

This project was conducted in SCE's Technology Test Center's (TTC) controlled environment test chambers to assess the ability of a typical RTU AC system to communicate via the OpenADR protocol for demand response operations. A controller was preprogrammed with strategies to respond to two distinct DR events ("high" and "moderate"). Eight tests quantified power demand reductions for each strategy under two indoor and outdoor climate conditions. The indoor conditions were Dry-Bulb Temperature (DBT) of 80 degrees Fahrenheit (°F) and Wet-Bulb Temperature (WBT) of 67°F, as well as DBT of 75°F and WBT of 63°F. The outdoor DBTs were 95°F and 105°F.

Collaboration

The manufacturer's certified contractor installed and set up the controller. The OpenADR Alliance was consulted for OpenADR 2.0 protocols. Cooling capacities and performance characteristics were determined in accordance with the Air-Conditioning, Heating, and Refrigeration Institute (AHRI) Standard 210/240. This standard adopts Test Standard 37, developed by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). TTC staff assisted with the test set-up and execution, as well as data collection.

SCE Technology Test Center Laboratory Setup

Status

Project results indicate the controller was capable of responding to both moderate and high DR signals through a central gateway. Tests also confirmed each event's pre-programmed DR controller strategy was executed properly. Results also indicate demand reduction is possible as part of an overall EE/DR strategy.

For moderate DR events, average total power demand was reduced by up to 33 percent. For high DR events, average total power can potentially be reduced by 60 percent. These DR events, however, resulted in a rise in indoor DBT, as expected. For moderate DR events, the rise in indoor DBT was 6°F to 9°F. The rise in indoor DBT was more evident for high DR events, with temperatures ranging between 14°F and 17°F.

Next Steps

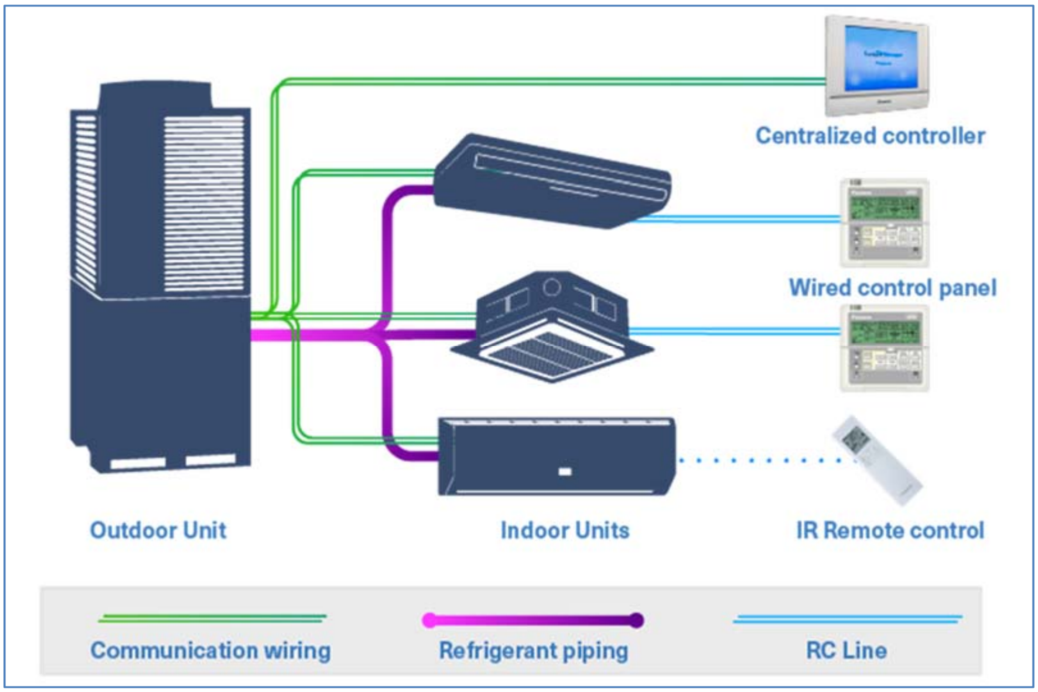
This project is substantially complete, and SCE personnel are reviewing the data to develop a comprehensive report. The final copy will be posted on the ETCC website in mid-2018.

DR16.06 Market Characterization Study of Automated Demand Response Capabilities of Variable Refrigerant Flow (VRF)

Overview

Variable Refrigerant Flow (VRF) for AC systems may be well suited to DR integration, because of its high efficiency and inherently flexible design. Additionally, sophisticated factory VFR controls are available. Although VRF has been successfully used for EE programs, its applicability to ADR is still unclear.

The objectives of this study are to understand the status of DR-capable controls across VRF manufacturers, and to report on their compliance with ASHRAE and California building energy code DR requirements.



Typical VRF System Structure

Project deliverables include identifying the status of ADR-capable VRF controls among various VRF manufacturers, determining whether VRF controls meet DR requirements in the California energy code, and reporting on VRF manufacturer plans to offer ADR-capable controls. Project outcomes and findings will encourage developing these controls, resulting in new products that can be included in future DR measures.

Collaboration

VRF manufacturers were key project stakeholders. SCE's EM&T and ETP teams, as well as other program groups, have been consulted and engaged to provide feedback. The ASHRAE technical audience will use findings from this project for future technical programs, handbooks, and research projects associated with VRF and DR capabilities. SCE also plans to share this information with its stakeholders in the ETCC and other forums.

Status

Data collection is being completed, and the final report should be ready for upload before the end of the second quarter of 2018. Project information will be merged into another project phase. Next steps include:

- Develop a laboratory and field test facility for DR testing.
- Coordinate with SCE's TTC to develop test procedures.
- Work with a consultant to develop a DR outreach workshop for manufacturers and other industry stakeholders.

Next Steps

The potential for increasing and enhancing California's DR programs require significant development and coordination with manufacturers to take advantage of the flexibility of commercial VRF systems with advanced controls. There is a need to educate manufacturers on minimum code requirements and additional requirements for voluntary program participation, including OpenADR certification and the SCE DRAS configuration.

Significant default controls allow existing control capabilities to include adjusting variable speed compressors for demand limiting, cycling or rotating indoor units, improved displays, and DR event reporting. California's IOUs should offer manufacturer incentives to develop additional built-in demand reduction commands. Despite having sophisticated controls and a built-in communication network between system components, VRF systems to implement turn-key ADR are not yet fully available.

DR16.08 Demand Response and Demand Flexibility Codes and Standards Enhancement

Overview

The CEC, a division of the California Natural Resources Agency, is responsible for activities including forecasting future energy needs, promoting EE through appliance and building standards, and supporting renewable energy technologies. One of its primary responsibilities is to maintain California's energy code.

California's Building Energy Efficiency Standards are updated on a three-year cycle. Their compliance code is Title 24 (Part 6). The 2016 Standards improve upon 2013 Standards for residential and non-residential building new construction, additions, and alterations. The 2019 Standards will go into effect on January 1, 2020.

This project's objective is to better define and clarify existing DR requirements from the Title 24 2016 version, so it will be properly scripted for the 2019 version. All sections of the standards must be upgraded to use consistent terminology and approach. The goal is to make the DR requirements easier to comply with and understand, ultimately making it easier for building occupants to receive economic benefits of utility DR programs.

Building System	When DR Requirement Applies	Required Automatic Response to DR Signal	Technology Required for Compliance	Compliance Verification
Nonresidential Lighting	• Building area ≥10,000 square feet • Habitable spaces where lighting power density >0.5 watts/square foot	Reduce lighting power by ≥ 15%	• Lighting system capable of reducing lighting power (e.g., dimming) • DR lighting control (could be an EMCS)	Acceptance Test
Nonresidential HVAC (with DDC to zone level)	All building types	Adjust temperature setpoints in non-critical zones ≥ 4° F	DR HVAC control (could be an EMCS)	Acceptance Test
Nonresidential HVAC (without DDC to zone level)	All building with single-zone AC or heat pumps*	Adjust temperature setpoints ≥ 4° F	OCST	Certified OCST installed
Sign Lighting	• Electronic Message Centers • Connected load ≥15kW	Reduce lighting power by ≥ 30%	• System capable of reducing lighting power • DR control (could be EMCS)	design review

Title 24, Part 6: Existing DR Requirements for Non-residential Buildings

The Codes and Standards Enhancement (CASE) initiative presents recommendations to support the CEC's efforts to update California's Building Energy Efficiency Standards (Title 24, Part 6) to include new requirements (or upgrade existing requirements) for various technologies. This project focuses on the DR and Demand Flexibility Codes and Standards Enhancement Project report, which will be submitted to the CEC for consideration in the 2019 Title 24 rulemaking.

Collaboration

Various stakeholders worked together on this project, including SCE, the CEC, and the statewide C&S team, which includes PG&E, SDG&E, SCE, SoCalGas, and two publicly-owned utilities: Los Angeles DWP and SMUD. The consulting firms Energy Solutions and ASWB Engineering will conduct the 2016 evaluation, and will consider upgrades to the 2019 and associated evaluations.

California utilities, builders, occupants, building operators, and various government entities with EE goals will all benefit from this project.

Status

The Demand Response and Demand Flexibility Codes and Standards Enhancement Study was submitted to the CEC for review on September 1, 2017. The CEC provided the Review and Comments Stage for the 45-Day Language, which was released in January 2018.

This table lists the CEC's proposed Title 24, 2019 DR modifications:

Section of Existing Standards	Summary of Proposed Revision(s)
10-103(b)	Adds language to clarify that building owners/occupants should receive information about the building's control systems, including DR control systems.
110.X (new section)	• Adds a new section that contains all requirements for DR controls. • Clarifies and harmonizes communications protocol requirements for all DR controls other than thermostatic controls that comply with JA5 (revisions to JA5 include modifications to communication protocols requirements that harmonize with the communication requirements for all other DR control systems required by the standards). • Other non-DR-related changes.
120.2	• Moves DR control requirements from this section to section 110.X. This section directs readers to section 110.X. • Other non-DR-related changes.

Section of Existing Standards	Summary of Proposed Revision(s)
130.3	• Moves DR control requirements from this section to section 110.X. This section directs readers to section 110.X. • Other non-DR-related changes.
130.5 (e)	• Moves DR control requirements from this section to section 110.X. This section directs readers to section 110.X. • Other non-DR-related changes.

Next Steps

After the 45-day Review and Comment Period in 2018, the CEC will publish a final version of the 2019 Title 24 Code. Initially, the scope of this project also included an assessment of the feasibility of adding demand flexibility to the Title 24 2019 version. However, the team decided to defer demand flexibility to future code cycles.

Depending on the outcome of the CEC Title 24 stakeholder process, the project team will review their opportunities for examining future DR requirements (through the updated statewide codes and standards requirements). They will then provide recommendations for DR measure compliance.

DR16.09 Predicative Energy Optimization

Overview

This project is a field assessment of the Predictive Energy Optimization™ (PEO) solution. The goal is to assess the capabilities of enabling DR strategies on existing commercial HVAC systems with the PEO system.

The PEO acts as an automated supervisory control system for HVAC systems in commercial buildings. It is designed to reduce energy consumption, operating costs, and CO_2 emissions. The system connects to most existing Building Management and Control Systems (BMCS) using industry-standard interfaces, and is compatible with new and existing building stock. Using this product as an appliance software solution requires no infrastructure upgrades or capital expenditures.

By leveraging their AMI interface, PEO software works with Building Automation Systems (BAS) to regulate HVAC usage. The software provides dynamic intelligence that enables the BAS to automatically update its set points based on algorithm forecasts. This improves EE savings and enables DR while occupants are kept comfortable.

PEO Building Applications

The system is designed to work only with utility data to build a weather-corrected baseline referencing the previous years' data. This approach can significantly reduce upfront costs and time delays, as well as improve accuracy by using utility-quality systems. The PEO is a designed to improve the EE of large, complex buildings, whether commercial, public, or academic. Running as a software-as-service, the PEO optimizes system efficiency and comfort.

The DR portion of this project includes research into ADR program responses using OpenADR. BuildingIQ's ADR service enables building owners and operators to participate and benefit from utility DR programs simply, easily, repeatedly, and measurably. DR is similar to a specialized form of PEO, but instead of following an energy cost-driven optimization model, DR uses a more aggressive, time-based curtailment strategy that also seeks to optimize comfort. BuildingIQ's DR automatically controls the BMS down to the zone, leveraging models of the building's thermal behavior, BMS capabilities, and tenant comfort.

Collaboration

This project leverages SCE's ET program to assess EE measure development and DR benefits, in conjunction with the EM&T program. The key external entity is the PEO solution provider, who is conducting site surveys to determine where the system can be installed.

Status

Customer sites are being identified. As of December 2017, a potential customer site has been found, and the process of finalizing the terms and customer agreement is underway.

The only obstacle encountered so far has been the lack of optimal installation sites. The forecasted goals and objectives for identifying the benefits of the PEO solution to enable and expand the DR adoption are on track.

Next Steps

A final report expected in late 2018 will cover the methodology, PEO installation, field test plan, data analysis, outcomes, and recommendations. Project outcomes will inform future DR planning toward a potential commercial DR measure that can provide customers with additional tools to participate in DR programs, and the energy savings information may be developed for an EE deemed or customized measure that will benefit EE programs.

DR17.04 Energy Management Circuit Breakers (EMCB)-EPRI

Overview

Circuit breakers are standard home and building electricity service components. They automatically protect electrical circuits from damage caused by overcurrent, typically resulting from an overload or short circuit. They interrupt current flow after a fault is detected. Most circuit breakers are simple, electromechanical safety devices that remain closed. Until recently, they were not designed for frequent switching. Millions of circuit breakers are now incorporated into panels installed in California commercial, industrial, and residential buildings.

Smart Circuit Breaker Installation

The project will assess a new approach to end-use energy management through a low-cost, simple-to-install Energy Management Circuit Breaker (EMCB). This equipment could merge control and energy measurement capabilities across diverse end uses, to enable:

- Low-cost DR.
- Low-cost DER (solar, battery) monitoring and integration.
- Low-cost, streamlined facility energy management.
- PEV fast charging.
- Energy bill settlement.
- Device and energy load control system remote control.
- EMCB design for end-use management via the electrical service panel.

This project will validate the EMCB's DR capabilities, as well as meter-grade end-use load monitoring, down to individual circuits in homes and buildings.

A major goal is to understand the functionality and potential value propositions for each device circuit currently in service on utility-owned use cases. The EMCB may prove to be a powerful device to control solar power generation, to control electrical battery storage, and as an M&V device. If the breakers are intelligent, circuit meters and relays are not required. They are also particularly useful for EV applications, because the can serve all the requirements of 240-volt EV charging equipment (the charging infrastructure is being integrated into the EMCBs).

The EMCB can be used with secure Wi-Fi communications, utility-grade metering, and load control to help support remote-controlled grid optimization. The circuit breakers also leverage the simple-to-install and maintain Internet of Things (IoT) connectivity platform from IoT and cloud computing.

Collaboration

SCE is participating in this project, with EPRI as the lead project coordinator. There are 11 other participating nationwide utilities, including Duke Energy, Southern Company, CenterPoint, ComEd and Pepco. EMCBs have been installed in 500 homes throughout the nation. EPRI is testing the capability of accurately collecting and sharing data, receiving and sending controls to other smart equipment (such as thermostats and water heaters), and shifting home on- and off-grid connections during emergencies.

Status

Data collection throughout various SCE service territories has been in progress since Q3 of 2017. EPRI created a test plan, and SCE is providing feedback. Use cases of interest to SCE will be further developed.

Participating end-use loads fall into these major categories:

- HVAC
- Water heaters
- Vehicle charging (via standard EMCB or dedicated EV-EMCB)

Next steps include:

- Collaboration with EPRI to finalize the proposed test plan.
- Field test the installed devices, based on the finalized test plan (expected to start in Q2 2018).
- Complete the final report in mid-2018.

Next Steps

At least four use cases are determined for EMCB evaluation, including:

- Access up to 30 EMCBs per utility.
- Access up to 3 EMCB-PEVs per utility.
- Summary report on laboratory findings per use case.
- Summary report from the field trials per use case.

A final report on platform options in the EMCB design will summarize these use cases. That report will be summarized by EPRI and is expected at the end of 2018.

DR17.06 Aquanta Smart Water Heater Controller

Overview

SCE's EM&T program develops and delivers emerging, technology-driven EE and DR initiatives, projects, and studies. These activities facilitate customer acceptance of cost-effective DR, and promote behavioral change. The rapid proliferation of web-based equipment controllers has made a profound impact on utility IDSM efforts, and is an EM&T area of focus.

A recent CPUC-commissioned report, driven by AB 2672, explored cost-effective technology options for providing domestic water heat to residential customers. Part of the study's focus included Disadvantaged Communities (DACs) that do not have natural gas access. The study evaluated how the technologies interact with the grid, the Net Present Value (NPV) of the total cost of ownership, and total CO_2 emissions for each water heater technology.

SCE is interested in learning more about advanced Electric Water Heater (EWH) control systems, and has selected Aquanta, a water heater controller, for initial evaluation and assessment. SCE has started a process to conduct lab testing in Phase 1 and field testing in a potential Phase 2. This testing will help understand the controller's communication technology, how the device may give customers better energy management, and how utilities may use it for strategic Flexible DR initiatives with improved GHG benefits.

Sample Aquanta Installation

Aquanta is a "smart" controller for storage water heaters. Utility use cases include fast-payback EE- and GHG-reduction programs, DR, Time-of-Use (TOU) pricing enablement, and excess renewable generation alleviation. End-use applications include electric and gas water heater controls in residential and small commercial applications (for 120-gallon or less storage water heaters). The SCE project will assess the device's DR control strategies for local "learning" control algorithms, as well as advanced capabilities for DR flexibility.

Collaboration

This project was initiated by the ETCC, with stakeholders from PG&E, SCE, SoCalGas, SDG&E, the CEC, SMUD, and L.A. DWP. SCE's ET division was selected to investigate OpenADR compliance with Aquanta's cloud-based system. The SCE TTC developed a test bed to evaluate Aquanta's control with other water heaters.

Status

The project is on track with its lab test bed, and has started testing the Aquanta system, identifying the performance architecture to achieve water EE. This effort includes system installation activities scheduled to begin in Q1 2018.

The scope of work includes these major milestones:

1. Baseline testing and controller conditioning: Run for two weeks under a normal water draw profile, with no controller operational influence.
2. Load curtailment testing via portal: Run a 24-hour test, and schedule a two-hour load curtailment event at 6:00 p.m.
3. TOU pricing controls: Run two 24-hour tests for TOU-DA-weekdays and weekends.
4. GIWH thermal storage: Run 24-hour tests under a thermal storage profile test for flexible DR opportunities.

Next Steps

SCE's TTC investigated the Aquanta controller to confirm the product is an adoptable retrofit solution. This technology has the capability to facilitate comparisons between the cost and value created from having a diverse set of flexible loads. SCE worked with the LBNL – CPUC study that created a new DR services taxonomy and analytic framework that groups these services into four core categories: Shape, Shift, Shed, and Shimmy. The ability to provide these types of services through electric water heating as a potential new technology solution will be significant to inform future DR technology options, and may enhance the role of EWH in DR to align with California's resource planning needs and operational requirements.

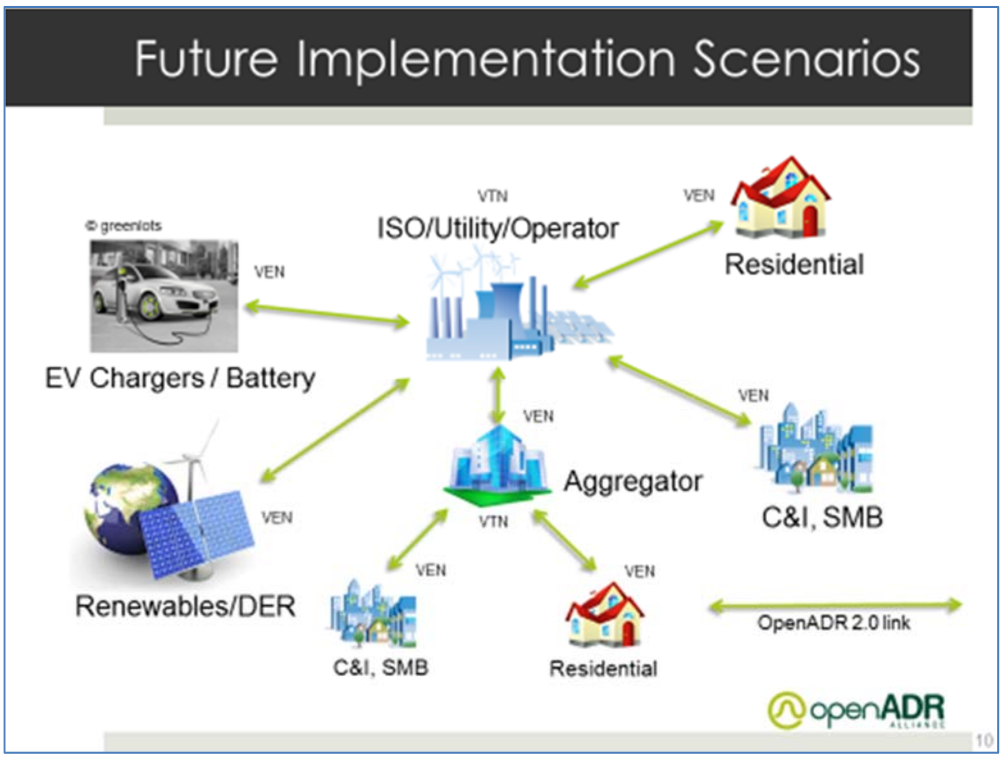
5. Projects Initiated Q3 – Q4 2017

DR17.01 SCE OpenADR Test Lab Development

Overview

To support the development of flexible DR strategies, SCE seeks to conduct a laboratory test on various technology systems compatible with OpenADR 2.0a/b. This effort will help advance DR technologies and smart grid communication systems.

SCE's TTC is motivated to help develop DR solutions to respond to utility DR events through SCE's Demand Response Automation Server (DRAS). SCE intends to improve the ADR setup validation process by establishing a neutral test lab to verify new technology requirements, and document their benefits and opportunities for future incentive programs.



Open ADR for DER Communications

SCE envisions validating existing and emerging technologies for adoption into future ADR programs by assessing equipment functionality and performance, as well as control processes and strategies, before they are deployed in the field. This new approach will save future SCE ADR programs significant time and effort in implementing new technologies.

Collaboration

SCE continues to be on the cutting edge of technologies and their implementation, and has asked industry partners to collaborate in two primary areas:

- Build an SCE ADR lab where vendors can submit their equipment for ADR functionality and strategy testing. The lab will have cross-cutting Virtual End Nodes (VENs) with various capabilities and DR strategies to which the SCE lab can attach devices and select scenarios for testing ADR capability at the equipment level, without a gateway.

- Build a hands-on ADR demonstration that provides an interactive learning experience of ADR integrated with the IoT. Its initial focus will be on ADR for thermostats and lighting controls, where the customer can learn about the equipment and the commissioning necessary for OpenADR to participate in flexible DR. Educational materials will show how devices work together to deliver load, and will explain terminology.

Status

Phase 1 to improve the test lab so vendors can submit their equipment for SCE to conduct ADR assessments has been completed. The test board is currently undergoing improvements to possess multiple VENs with various capabilities, so the SCE lab can select from a variety of test scenarios.

Phase 2 will be finalized in Q2-2018, and will consist of:

1. An interactive DR VEN installation learning experience, with outputs to show various ADR measures, as well as the control capabilities they use. Thermostat, lighting control, and standalone VENs will link to one DRAS account.
2. A function for customers to create events on the DRAS, and select which (or any combination) of the three clients will initiate load shed. The display will show (and possibly trend) light-level curtailment through foot-candle or kW output from the fixture, cooling set points, and a small motor spinning a gear (to represent industrial process lines or pumps) that show immediate load shed event confirmation.

Next Steps

SCE is using open-source OpenADR (OADR) VTN software, which was developed by EPRI as a tool to evaluate OADR 2.0a/b communications and potential use cases with various loads. The TTC is able to evaluate ADR-compatible VRF HVAC systems, lighting systems, plug loads, and more, in controlled conditions. The TTC will be able to support field OADR evaluations using a cloud-based version of EPRI’s OpenADR VTN server. The open-source VTN server application will help the lab in setting up user accounts, assigning clients (VENs), and creating and scheduling DR events.

DR17.02 Customer Centric Approach to Scaling IDSM Retrofits

Overview

California's leading Building Energy Efficiency Standards are moving the state closer to achieving its ZNE goals. All new low-rise residential buildings are to be ZNE by 2020, and all new commercial buildings by 2030. Achieving these goals is a decisive change in the construction industry's building practices. It presents occupants with energy, cost, and GHG reduction opportunities. While the state's ZNE goals are a major step forward, they represent only a fraction of the energy, cost, and GHG reductions that buildings can achieve.

California's Appliance Energy Efficiency Standards are critically important to reducing energy consumption in buildings, saving Californians money and reducing GHG emissions. For example, electric appliances use more than half the electricity consumed in buildings. Reducing plug load consumption is necessary for California to reach its ZNE goals.

Low-Income Multi-Family Building with Upgrade Opportunities

This project is a partnership through an EPIC solicitation, with EPRI as the awardee. Additional stakeholders are involved, including an affordable housing owner and operator. The EPIC solicitation is titled *Scaling Customer-Centric Energy Efficiency Retrofits with Integrated Demand Side Management (IDSM)*.

The project's primary goal is to demonstrate and evaluate an innovative methodology combining a traditional technical approach with customer-centric needs. The focus is on designing IDSM/ZNE packages for EE retrofits that could enable scaling EE in existing low-income communities.

This project is intended to demonstrate IDSM and ZNE solutions in the MF sector category. A LIMF property will be used in the demonstration.

Project objectives are:

- Formulate IDSM and ZNE solutions for MF residences.
- Create new resources for IDSM retrofit solutions to meet ZNE goals.
- Create IDSM retrofit guidelines for residences in low-income communities.
- Develop a list of technologies that create customer-centric packages for future retrofits.

Collaboration

This project is in collaboration with CEC, EPRI, LINC Housing, BIRAenergy, and several other entities. EPRI is the overall project lead. LINC Housing is providing the property, BIRAenergy will provide sustainability consulting, and SCE will act as the host utility, technology lead, and grid-side lead.

Status

Work has begun on the analysis of the implementation of measures, as well as the Efficient Retrofit Packages. The apartment units are undergoing HVAC retrofits at a pace of ten units per week. Energy monitors are up and running, and data is being collected.

Next Steps

Based on work completed so far, project outcomes are on track to provide information via active feedback to various project and industry stakeholders to demonstrate appropriate ZNE and IDSM technologies. The final report is expected by January of 2020. After review and approval, it will be posted on the ETCC website.

DR17.03 Demonstration of Affordable, Comfortable, and Grid Integrated ZNE Communities

Overview

A large percentage of residential new construction in California is MF. In alignment with California's goal of residential ZNE by 2020, this project gives SCE an opportunity to demonstrate ZNE in new MF construction. In this partnership with other stakeholders, Meritage Homes, a large production homebuilder, will design, build, and monitor a new 44-unit ZNE MF residential community. The project will demonstrate ZNE solutions within the MF category, and aim to overcome existing barriers, leading to greater adoption.

The project's primary goal is to demonstrate the technical and economic feasibility of ZNE homes. Another objective is to study ZNE home integration to the electric grid.

Typical ZNE Multi-Family Residence

The main project deliverable is a detailed report summarizing project findings and recommendations to help overcome technology and market barriers to MF ZNE homes. The project will also evaluate viable measures that may provide EE and DR capabilities in individual residential units.

Project outcomes will provide input to the development of Title 24 code, help develop neighborhood planning tools, assist cost-effective ZNE developers and builders, and inform utility distribution system planning to factor in the expected ZNE home load performance. This project will also provide information on voice-activated DR and grid-interactive heat pump water heaters.

Collaboration

This project is a collaboration with EPRI, Meritage Homes, BIRAenergy, and several other entities. EPRI is the overall project lead. Meritage Homes will build and sell the MF units, BIRAenergy will provide sustainability consulting, and SCE will act as the host utility, technology lead, and grid-side lead.

Status

Value engineering meetings were held in the last half of 2017, to demonstrate cost-effective measure packages to builders. The measure packages were evaluated using a whole-building approach, and the builder incorporated many ETs into their design. The first submittals are expected by the end of January 2018.

Meritage is expected to install a measure package consisting of the following ETs:

1. Induction cooktops.
2. Connected API-controllable heat pump water heaters.
3. Heat pump dryers.
4. Electric barbeque grills.
5. Higher-performance windows.
6. High-efficiency connected Title 24-compliant multi-split heat pumps (we are still working with manufacturers on their capabilities).
7. Voice assistant-driven EMS and smart home systems.
8. Smart intermittent ventilation systems, to reduce peak load.
9. Schneider integrated smart panels, with built-in circuit energy monitoring.
10. Integrated distribution planning for ZNE.
11. Integrated DR controls for load shaping.

Next Steps

Based on the preliminary work completed so far, project outcomes are on track to provide information to the various stakeholders, to enable future designers and homebuilders of MF ZNE homes to include in their offerings residences with with-built in DR features. Construction is expected to be complete by June 30, 2018. Testing and information gathering will begin when the units are sold, and will continue until June 30, 2019. The final report is expected by December 31, 2019. After review and approval, it will be posted to the ETCC website.

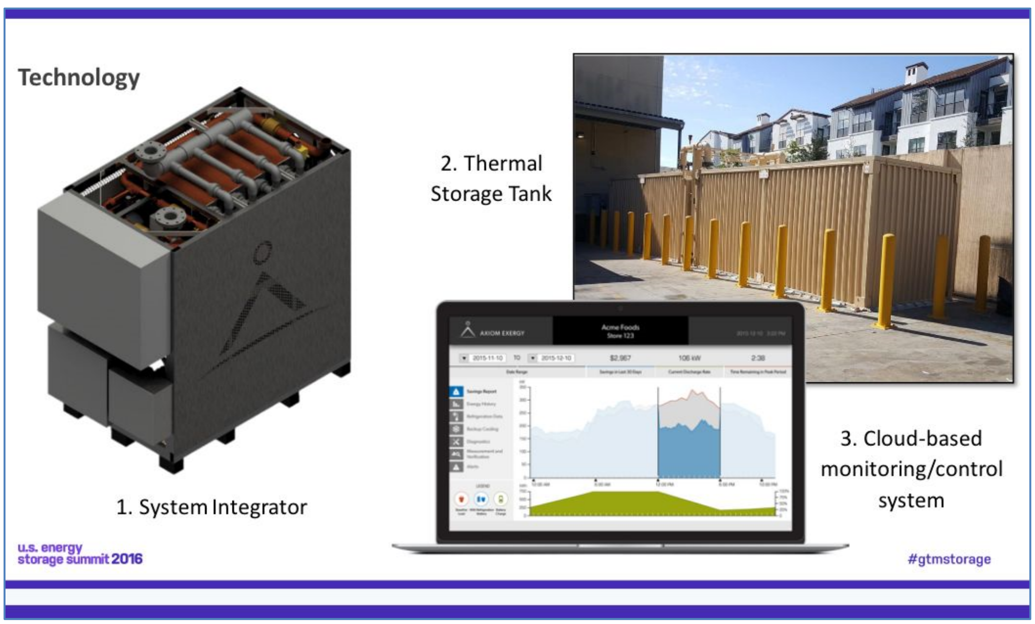
DR17.05 Refrigeration Battery

Overview

SCE's ET team partnered with SDG&E's ET division, kW Engineering, and Axiom Exergy to study the potential of their Refrigeration Battery™ thermal energy storage system. The battery provides Permanent Load Shifting (PLS) for commercial refrigeration systems, similar to the HVAC thermal energy storage systems used for PLS at many facilities with central plants.

The Refrigeration Battery is a plug-and-play retrofit for central refrigeration systems in supermarkets and other refrigerated facilities. It enables installed refrigeration storage for later use by freezing a tank of water with common additives. Its approach is to help supermarkets protect and increase their razor-thin profit margins in two ways:

1. Load Shifting: The Refrigeration Battery reduces supermarket electricity bills by shifting refrigeration loads away from on-peak afternoon hours (when electricity prices skyrocket) to off-peak night hours (when electricity prices are low).
2. Refrigeration Backup: The Refrigeration Battery can be configured to keep food cool during power outages, protecting against catastrophic food spoilage events.[i]



Axiom Energy Thermal Energy Storage System

Project scope:

1. kW Engineering will provide M&V services at a selected grocery store, to evaluate Axiom's specific performance claims.
2. kW Engineering will assess the annual energy savings (or penalty) associated with Axiom's technology.
3. Confirm the Refrigeration Battery stores refrigeration when electricity costs are lowest, and deploys it when electricity costs are highest, offsetting a significant portion of expensive on-peak demand charges.

4. A technology assessment report will quantify Axiom's specific claims to permanently offset peak load with little or no impact to the refrigerated product.
5. A final technology assessment report will detail permanent load shifting and energy-saving capabilities based on M&V analyses.

Collaboration

This project was initiated with the ETCC, and includes stakeholders from PG&E, SCE, SoCalGas, SDG&E, and the CEC, along with other municipal utilities (SMUD and L.A. DWP).

SCE's TTC will observe the installation to affirm the M&V approach, opportunities in flexible DR, refrigeration best practices and policies, and the C&S established from California Building Code-Title 24 and ASHRAE.

Status

SDG&E indicates the site selection and contracts have been finalized. As part of SCE co-funding, kW has implemented data collection and started to evaluate sample sizes. This effort is prior to the battery system installation, which will commence in the first quarter of 2018.

Next Steps

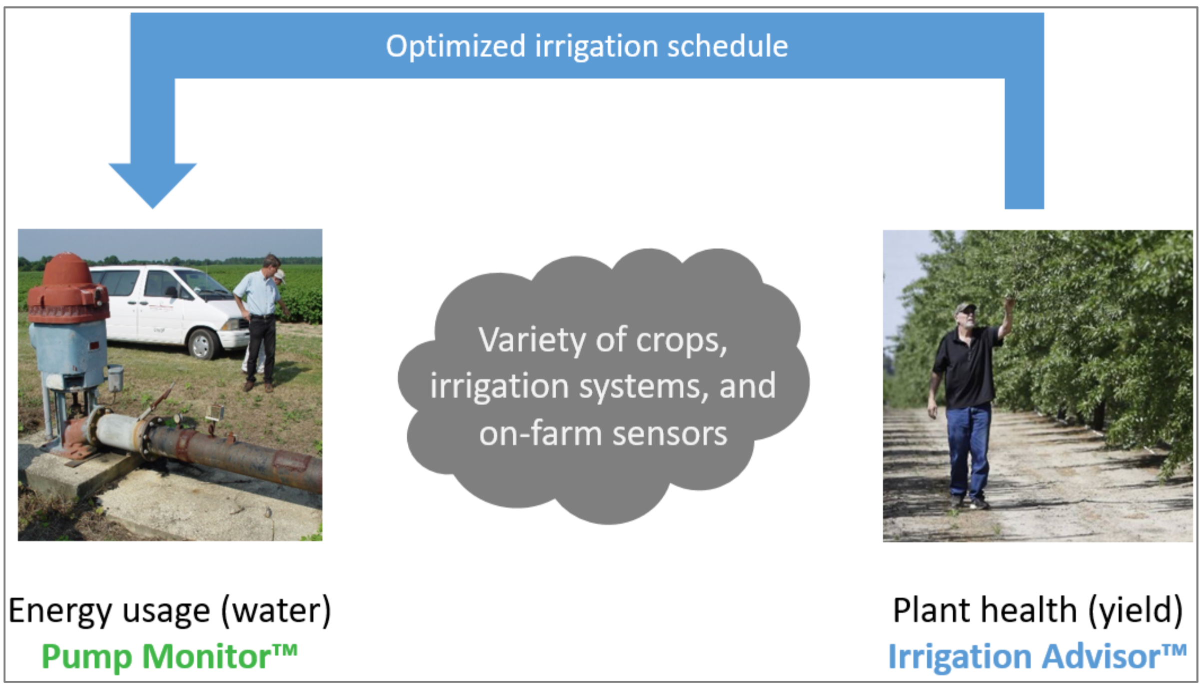
The customer has demonstrated acceptance of the Axiom Refrigeration Battery System as a potential new technology solution to enhance their role in DR. This technology has the capability to facilitate comparisons between the cost and value created from having a diverse set of flexible loads. This capability will be examined during the data collection phase in early 2018. Future opportunities for more flexible DR "shift" operations will be examined in the context of future DR program models.

DR17.09 Ag Pump AMI Analytics PowWow Study

Overview

The goal of this study is to evaluate the effectiveness of PowWow AMI-Pump Monitor™ software. The study will evaluate energy savings, as well as the opportunity for flexible DR as a result of subscription to PowWow's software.

AMI-Pump Monitor is an annual software subscription that uses historical pump test reports and leverages the Green Button Program to collect electric interval meter data. The software analyzes data with proprietary algorithms, to diagnose impending (or occurring) system decline. Feedback is sent to the customer via text message or web surveillance, to notify of system alerts. The customer is then able to proactively repair or change operations, to minimize water and energy waste. No supplemental hardware is needed.



Pow-Wow Energy Pump Monitor Schema

Successful project implementation will enable the proposed technology to move from its current pre-commercial stage to widespread market adoption. By significantly increasing the efficiency of energy consumption associated with irrigation operations, the proposed technology will benefit IOU ratepayers by reducing their expenses, and will contribute to energy security by relieving strain on the power grid.

The technology will also improve the efficiency of water use for irrigation, and provide growers with a simple, scalable means of monitoring groundwater extraction. This will be required under the Sustainable Groundwater Management Act (SB1168) as part of a comprehensive effort to develop a sustainable groundwater management policy for California.

In alignment with the CPUC Energy Division-Lawrence Berkeley National Laboratory (LBNL) study to support DR policymaking, concurrent with rulemaking R.013-09-011, this project seeks DR opportunities that give customers a better understanding of their irrigation systems and water-energy usage. LBNL estimated DR could provide grid services in 2020 and 2025 across a range of scenarios for the DR market and technology options. SCE's EM&T continues to drive the investigation of these new solutions.

Collaboration

Together with the University of California, PowWow Energy developed patent-pending software that uses energy data from smart meters to calculate water extraction and application volumes for irrigation well and booster pumps. The technology leverages existing infrastructure, and does not require any new hardware installation. Growers are offered software that provides automated water flow data records, and sends simple text message alerts with information for optimizing irrigation efficiency. The system achieved energy savings of up to 30% during proof-of-concept trials.

Status

The project started in January 31, 2017, and was impacted by the drought. It was to last for two seasons and include historical data from 2016 to help establish baseline data for water use and energy use. This will extend through 2018. PowWow reported on pump size and the types of crops in three main agricultural regions: Tulare, Ventura, and Riverside, and on-boarded 2,900 acres and 65 pumps as of June 30, 2017 for the 2017 growing season. For 2017, most growers received 100% surface water allocation, which will lower the irrigation energy intensity compared to 2016.

Next Steps

Energy and water usage, as well as crop yields, will be monitored over a one-year period, to capture the strong seasonality of agricultural operations and environmental conditions. SCE's Tulare service team and PG&E-certified pump testers will provide third-party energy and water measurement verification. The Bren School of Environmental Science and Management at UC Santa Barbara will perform a Life Cycle Assessment (LCA) of irrigation energy savings.

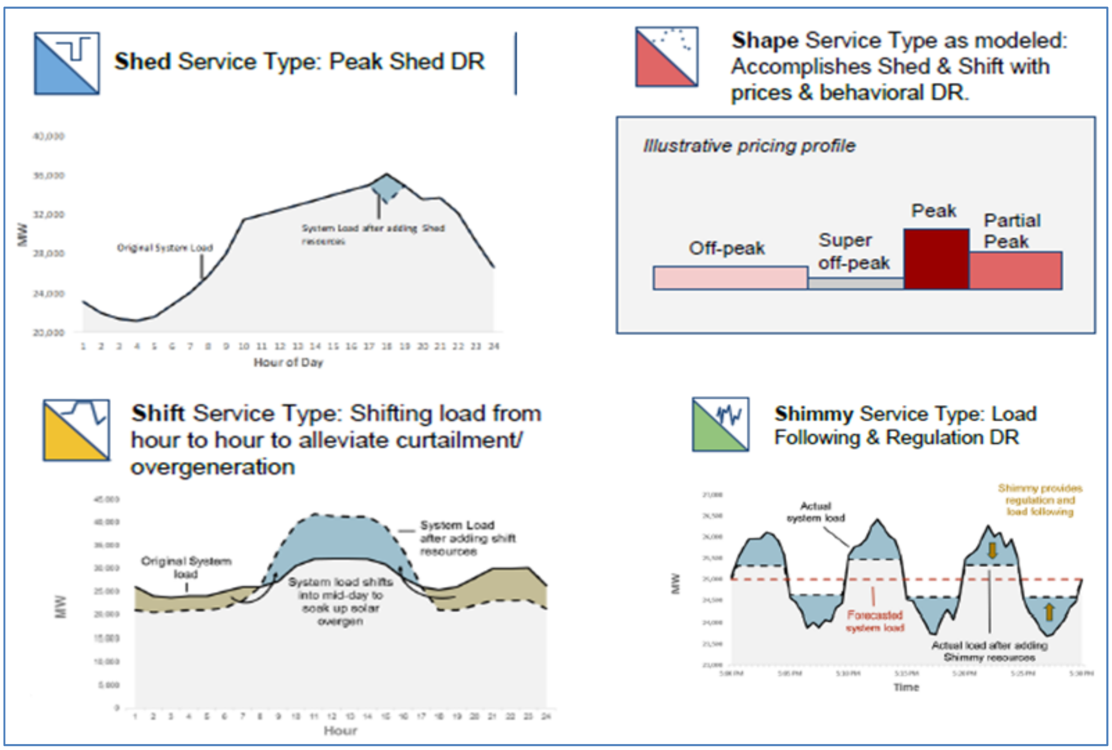
DR17.11 Develop DR Enabling Technology Roadmap

Overview

SCE is fully committed to supplying a continuous 24-hour stream of electricity to every customer, every day. To do this, SCE uses DR events that help customers save money when energy demand increases and electricity costs rise. Customers are invited to participate in DR programs to reduce energy use in return for lower energy costs. This keeps energy costs down and helps prevent power shortages.

This project is to develop a roadmap for enabling ADR technologies and customer outreach efforts. The goal is to effectively migrate existing and new ADR capabilities to meet the new performance requirements identified in the LBNL Phase 2 DR Potential Study, which represents four different types of DR services – Shape, Shift, Shed, and Shimmy.

Specific deliverables include a roadmap that will identify key advanced enabling technologies, customer behaviors, and SCE activities that support the potential associated with fast and flexible DR outcomes.



Demand Response Service Types

Specific project tasks include: 1) identify and assess innovative enabling technologies that can be leveraged for system and local market needs, and facilitate deployment of cost-effective DR technologies; and 2) identify approaches for packaging these technologies as a value-added service offering.

SCE will rely on outcomes of roadmap discussions with internal stakeholders and with regulatory guidance, as a framework for DR technology engagement and customer outreach.

Collaboration

LBNL is a key project stakeholder. Several SCE organizations have been consulted and engaged to provide feedback. Navigant was hired to assist with report development.

Status

The DR Enabling Technologies Roadmap report was completed in December 2017, and covered these technologies:

- Residential HVAC.
- EVs.
- Transactive energy software and systems.
- Behind-the-meter batteries.
- Customer engagement and analytics.
- Innovative controls with FM signals.
- Commercial HVAC.
- Lighting controls and dimming services.
- Refrigerated warehouses.
- Industrial processes.
- Wastewater treatment and pumping.
- Data centers and high-intensity computational services.
- Agricultural sector technologies.

In early 2018, Navigant will acquire SCE internal stakeholder feedback on the roadmap findings, to assess strategic interests drive future EM&T project categories.

Next Steps

Based on the work completed so far, the project outcomes are on track to provide forward looking technical potential information for SCE to assess and demonstrate advanced DR enabling technologies and to identify opportunities for cost-effective solutions for residential DR and TOU dynamic pricing programs. This will also provide enabling technology support for the future models of DR that may involve shift products.

DR17.14 Packaged Ultra Low Charge NH3 Refrigeration Field Monitoring

Overview

In very large refrigeration systems (such as those in food processing facilities) ammonia (NH_3) is a common refrigerant. Reasons for choosing ammonia include:

- Ammonia's physical properties make it an effective refrigerant, which is important for large systems that are operated 24 hours a day.
- It breaks down quickly in the environment, with minimal environmental impact and zero Global Warming Potential (GWP).

According to the International Institute of Ammonia Refrigeration (IIAR), ammonia is 3 to 20 percent more thermodynamically efficient than competitive synthetic refrigerants. This allows ammonia-based refrigeration systems to use less power to reach their cooling levels. As a result, ammonia (where appropriate) can offer lower long-term operation costs.

This assessment will demonstrate replacement (HFC) refrigerants with GWP ammonia provide EE and flexible DR benefits to California cold storage users in various refrigeration applications.

Refrigeration Facility Field Test Site

Findings from a Port of Long Beach study will determine the site equipment control strategies to be implemented at a South Gate location. The goal is to achieve at least 20% demand reduction by taking advantage of the NXTCOLD equipment manufacturer's design features and inherent (built-in) site storage capabilities. The strategy is based on the thermal mass of frozen or refrigerated food, which will allow customers to temporarily shed load, meet permanent peak shift requirements, or adjust power demand upward. These customer options are key enablers for the fast and flexible DR the technology facilitates.

The project will be based on the new-to-market, but commercially-available packaged refrigeration system technology developed by NXTCOLD. The technology is characterized by:

- Packaged high efficiency.
- Ultra-low NH3 charge.
- Zero GWP.
- Flexible tonnage.
- Low- and high-temperature capabilities.

Ongoing performance monitoring of all energy and demand metrics will enable real-time data acquisition and analytics, metering, and DR controls. These activities will verify usage and flexible DR abilities (to add load, reduce load, and shift load) and will help build a calculation tool to support the technology's market adoption and knowledge transfer.

One example of adjusting demand upward is an electric defrost control, which will be tested as a possible measure for adding load to ameliorate renewable grid effects. Another is to adjust VSDs to full load, in response to grid requirements. Other on-site loads, such as electric fork lifts, will also be included.

Collaboration

Project stakeholders include NXTCOLD/Hillphoenix, General Cold Storage, Cypress Ltd., and SCE's EM&T and SCE Emerging Products teams.

Stakeholder levels of engagement are:

- NXTCOLD/Hillphoenix – equipment manufacturer
- General Cold Storage – field test site, customer
- SCE Emerging Products – Project Lead/Designer
- Cypress Ltd. – M&V, Project Consultant

Status

As of the end of 2017, the project is in the beginning stages. Instrumentation for monitoring DR process performance is being installed at the Port of Long Beach site. Based on the Burtis-South Gate new construction site cold storage and blast freeze operational requirements, this project will define a set of flexible DR control options and strategies, and will test and measure results. These will inform opportunities for the development of cost effective measures for the AutoDR incentive program.

Next Steps

The final project report will include the results of energy, demand, temperature, and power metering resulting from DR testing strategies. Calculation tool recommendations will be provided in the report, which will be available in draft by mid-2018, depending on the availability of testing strategies and customer schedules.

6. Budget

Emerging Markets and Technology Program
2017 Authorized Funding[3]
$2,922,000
2017 Total Expenditures[4]
$1,390,936

In accordance with CPUC authorized DR program and funding flexibility guidelines, the EM&T program will carry over unspent 2017 authorized funding that has been committed for 2017 projects into the subsequent calendar year (2018). Those funds will be identified in SCE's ERRA filing in 2018.

As per AL 3695-E-A, Preliminary Statement, Section Y: Demand Response Program Balancing Account (DRPBA), 3. Program and Funding Flexibility, filed December 22, 2017:

> *c. Carry-Over Amounts*
>
> *Any unspent DRP funds in each budget category (as defined in Section 3.a.) as of December 31 of each year shall be carried over in the account, within each respective budget category, into the subsequent calendar year through 2022.*

[3] Funding for SCE's 2017 DR programs and activities were approved in D.16-06-029.

[4] R.13-09-011, A.08-06-001 et al, and A.11-03-001 et al, Report of Southern California Edison Company (U 338-E) on Interruptible Load Programs and Demand Response Programs, January 22, 2018.

7. SCE's Third-Party Collaborative DR Stakeholders

- Air-Conditioning, Heating, and Refrigeration Institute (AHRI)
- American Council for an Energy-Efficient Economy (ACEEE)
- American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)
- Association of Energy Services Professionals (AESP)
- California Energy Commission (CEC)
- California Independent System Operator (CAISO)
- California Lighting Technology Center (CLTC)
- California Public Utilities Commission (CPUC)
- Consortium for Energy Efficiency (CEE)
- Consumer Electronics Association (CEA)
- Electric Power Research Institute (EPRI)
- Emerging Technologies Coordinating Council (ETCC)
- Federal Energy Regulatory Commission (FERC)
- Illuminating Engineering Society of North America (IESNA)
- Lawrence Berkeley National Laboratory (LBNL)
- Los Angeles Department of Water and Power (LADWP)
- National Renewable Energy Laboratory (NREL)
- New York State Energy Research and Development Authority (NYSERDA)
- Northwest Energy Efficiency Alliance (NEEA)
- Open Automated Demand Response (OpenADR) Alliance
- Pacific Gas & Electric (PG&E)
- Peak Load Management Alliance (PLMA)
- Rocky Mountain Institute (RMI)
- Sacramento Municipal Utility District (SMUD)
- San Diego Gas & Electric (SDG&E)
- Smart Electric Power Alliance (SEPA)
- University of California, Davis (UCD)
- University of California, Irvine (UCI)
- U.S. Green Building Council (USGBC)