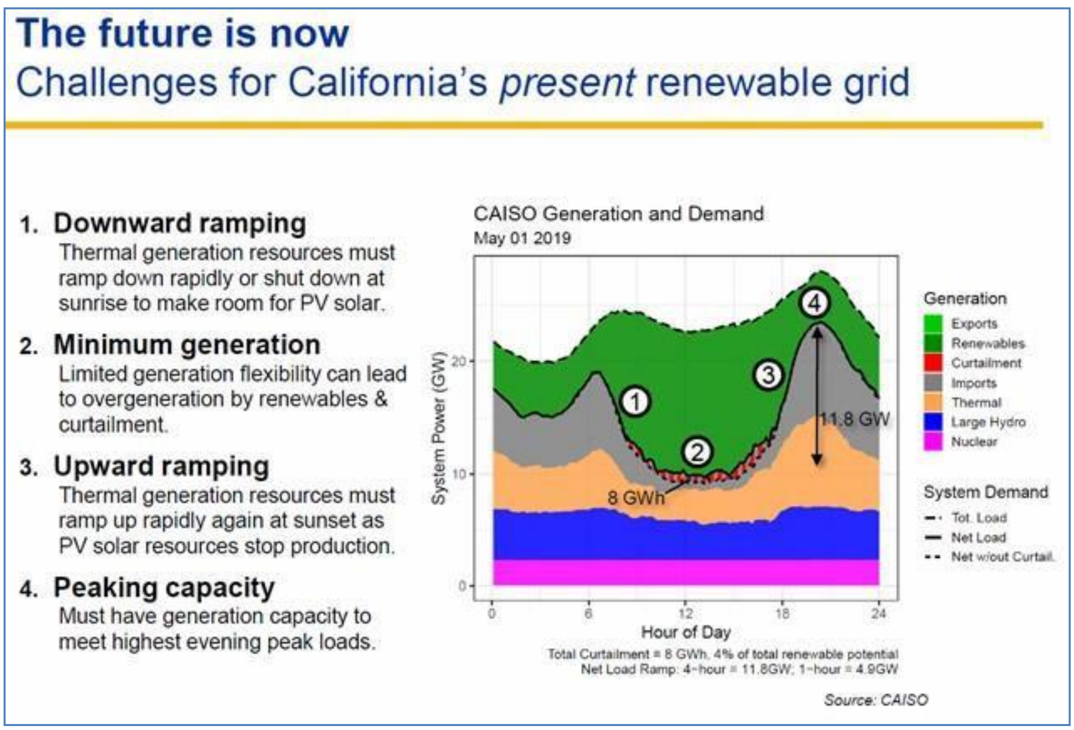
DR20.02 Wedgewood Demand Flex Testing

Overview

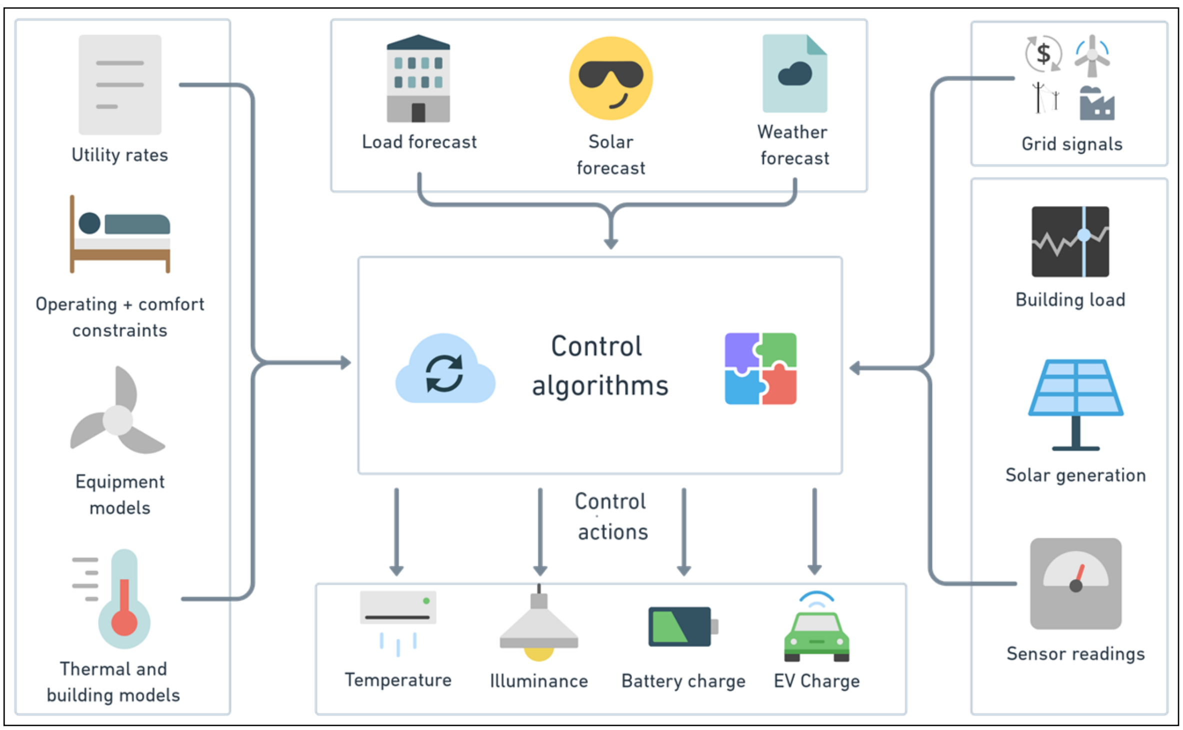
The ability to shift loads without significantly impacting tenant comfort is key to California's ability to address California grid challenges. The grid obstacles include power intermittency, demand peaks, and localized capacity resulting, in part, from rapid growth and scaling of customer self-generation,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



California's Future Renewable Grid Challenges

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

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



Intelligent Load Balancing Software Illustration

The Wedgewood Demand Flex Testing Project evaluated the energy and non-energy impacts and benefits of using an innovative load management software platform. The project evaluated the use of Extensible Energy's DemandEx™ load management software to manage electricity demand in an office building by controlling the HVAC systems in coordination with local solar power generation. DemandEx is designed to reduce a customer's electricity costs by reducing demand peaks and by shifting energy use from more costly demand periods to less costly periods. This is done through strategies such as shifting energy use from periods of low solar generation and high demand to periods where solar is generating power.

Although the software can control a variety of categories of equipment, the evaluation focused only on its ability to control HVAC, as HVAC constitutes a significant portion of the controllable load and is the main driver of demand peaks in office buildings.

The study was conducted at an 83,000-square feet commercial office building located in Redondo Beach, California. The facility has two floors with occupancy capability for over 500 employees working across nine different businesses. The project was kicked off in March 2020 and completed in April 2021. During the project, the occupancy was reduced by 50%-67% due to theCOVID-19 pandemic. The site has a 625-kW solar PV system installed on its rooftop and on top of carport canopies in the parking lot. Major end-use energy consumers at the facility are heating ventilation and air conditioning (HVAC) equipment, electric vehicle (EV) charging stations, lighting systems, and other miscellaneous loads.

The Wedgewood campus has a combination of factors that are favorable for electric load optimization techniques and demand response capability, as follows:

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

Wedgewood Building Demonstration Site

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

1. Load Shift Hypothesis: First, can the software effectively reduce the customer's HVAC-related demand charges by between 10% and 25%, without negatively impacting building tenant comfort, by shifting operations and increasing loads during SCE's non-peak TOU periods, and reducing loads during peak periods?

2. Load Shed Hypothesis: Second, by driving a deeper level of HVAC setback than under normal operating conditions, can the software enable two to four hours of load shift of at least 20% of whole-building load in response to simulated day-ahead, hour-ahead, and 15 minutes-ahead load curtailment signals from SCE?

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

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

Collaboration

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

Results/Status

This project demonstrated that significant demand reductions can be achieved during peak demand hours through a simple control software installation with no changes to building operations. These results also showed that the control software successfully achieved the Load Shift and Load Shed hypotheses targets (repeated below for reference):

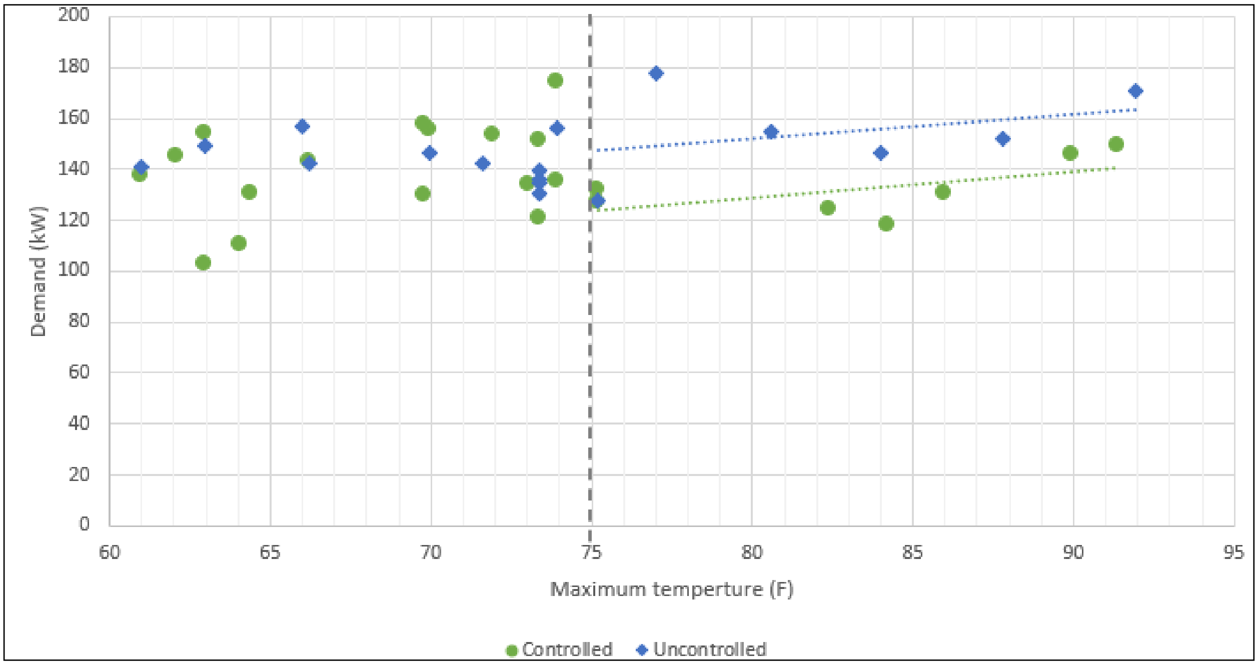
- Load Shift Hypothesis: First, can the software effectively reduce the customer's HVAC-related demand charges by between 10% and 25%, without negatively impacting building tenant comfort, by shifting operations and increasing loads during SCE's non-peak (Mid- and Off-peak) TOU periods, and reducing loads during peak periods?

- Load Shed Hypothesis**:** Second, by driving a deeper level of HVAC setback than under normal operating conditions, can the software enable two to four hours of load shift of at least 20% of whole-building load in response to simulated day-ahead, hour ahead, and 15 minutes ahead load curtailment signals from SCE?

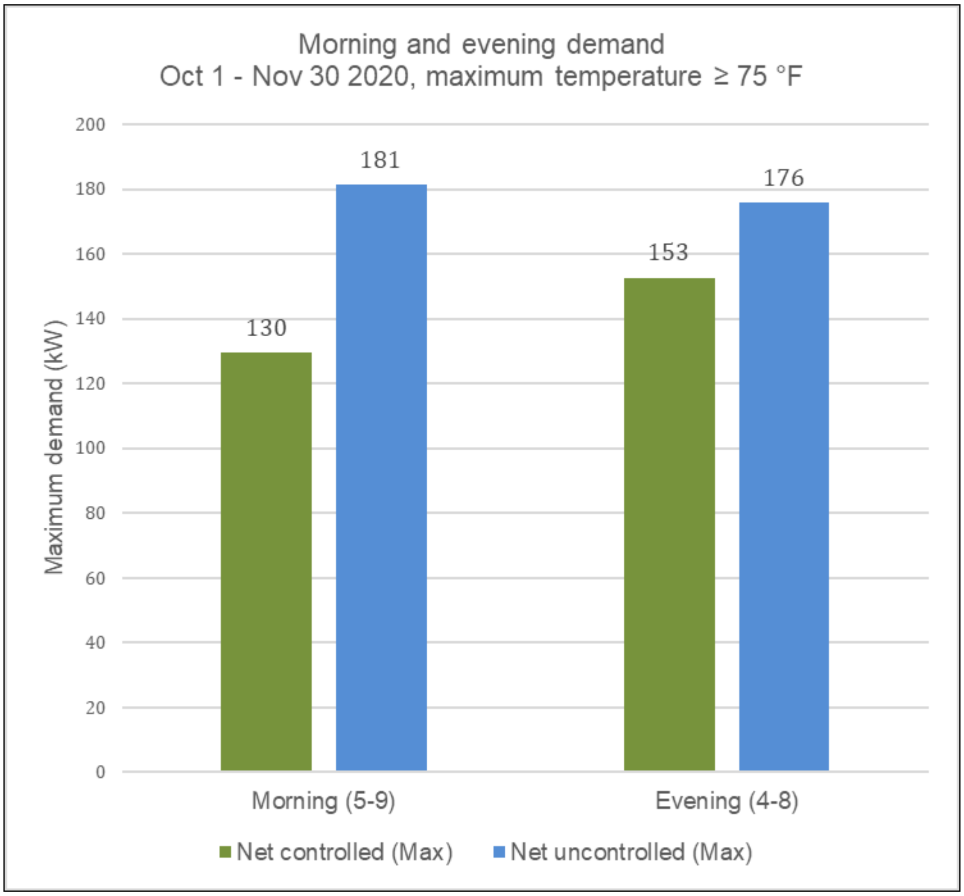
DemandEx changes the operation of the building by sending control signals to the equipment in the building that, in turn, adjusts energy use. At Wedgewood, this was accomplished by sending control signals via the gateway computer to the HVAC control system which then changed the temperature setpoints in individual zones. DemandEx maintained temperatures within a comfort range based on the existing temperature ranges that were already configured in the building management system.

Control tests were run on alternating controlled and uncontrolled days. By alternating control days, multiple days with similar characteristics were captured, such as similar temperature ranges. On controlled days, setpoints were changed to shift demand out of the early morning peak period as well as out of the late afternoon / early evening peaks. On uncontrolled days, the system operated as it did before, without DemandEx control. Weekend days were reserved for tests or left uncontrolled and were not part of the analyses. From a DR perspective, these alternating day tests can be considered day-ahead tests, simulating a situation where the utility called for a reduction in demand on the following day.

The figure below shows daily maximum demand for controlled and uncontrolled days during the months of October 2020 and November 2020 (testing period). The data demonstrated that the technology was able to reduce the facility demand when daily maximum outdoor air temperature (OAT) exceeded 75°F, as shown by the regression lines in the figure below.



As shown in the figure below, the project demonstrated that significant demand reductions can be achieved during peak demand times through load shift. Demand was reduced 15.5% on warmer days when cooling was needed, with reductions of 28% in the morning and 13% in the evening. In addition, the control software was able to reduce energy consumption in the evening hours by 19%, while compensating with increased energy consumption in the afternoon when there is substantial renewable solar generation. Additionally, the system was able to shed load of approximately 14% compared to the maximum observed peak demand for the one-hour DR test.



The results showed that the control software reduced demand by 15.5% overall without negatively impacting tenant comfort. The software also reduced energy consumption in the evening while increasing energy consumption in the afternoon by shifting loads to the Off-Peak hours. This could provide a significant demand shifting capability for utilities, if deployed at multiple sites. It also demonstrates the potential for significant direct savings to the customer, creating a win-win for the utility and customer. Further, the ability to shift demand from periods with less solar generation into periods with more solar generation should support the state's transition to renewable generation which results in reduced emissions. These effects were achieved in a region with mild climates and in a building with significant configuration issues. The team expects even greater effects in regions with hotter climates in California and elsewhere.

To evaluate load shed capabilities, the initial project approach was to designate several days during the control period and respond to a day-ahead, hour ahead, and 15 minute ahead simulated DR dispatch event notification. Based on limited control period, as a result of COVID-19 delays, the team elected to perform a single one-hour ahead test to demonstrate the system's overall DR capabilities. For load shed, alternating control schedules effectively simulated multiple day-ahead signals. In addition, evening energy consumption was reduced by 19% on average on warmer controlled days (when the maximum temperature was at least 75°F). The single hour-ahead test reduced demand by 14%. Due to practical challenges and schedule constraints, the project was not able to simulate a 15-minute ahead load curtailment signal. These savings were achieved even though the building had a significantly misconfigured HVAC control system.

During the calibration phase, it was discovered that the building's control systems had significant configuration issues that pre-dated the installation of the project's energy management system. Additional demand reductions should be possible if these configuration issues are corrected by Wedgewood's controls contractor. If corrected, a rough estimate of demand reductions of as much as 20-25% might be achievable. Some of the main lessons learned involved installation, network connectivity, and interactions with the building's equipment.

With respect to customer comfort, temperatures were maintained within existing scheduled ranges throughout the testing. During the control software implementation, customer contacts relayed that there was no impact on comfort. Additional efforts were made by SCE to ensure the customer understood the purpose of the tests and how to adjust temperatures, if needed, in coordination with the testing.

For installation of the eGauge data logger devices, the team involved the electrician who regularly provides services to the site. This helped provide a smooth interaction with the building personnel and ensured that the electrician was familiar with the building. AESC staff were on site for the initial site survey to identify equipment requirements and to assist in the installation. This contributed to successful installation of the data loggers.

Early involvement of IT staff is important. Each site has different network configurations. IT staff are needed to address security concerns and network configuration to ensure that the gateway and data loggers have the necessary network connectivity. The earlier the IT staff become involved, the more the installation is likely to proceed quickly.

Extensible Energy's staff studied the building carefully once connectivity was established. During this time, they communicated with the building's controls contractor, which helped to ensure access to the BAS and to understand how to interface with it. Eventually, they discovered significant, though previously unknown, misconfigurations in the building's controls. They also discovered that some control points — which had appeared to be exposed — were in fact inaccessible. A list of issues to check at a new site should incorporate validation of the equipment's operation and access to necessary control points. The earlier these issues are identified, the more time there will be to address them or work around them.

The rate schedule can have a significant impact on the potential savings and grid impacts from load flexibility. Wedgewood is on the GS-3-TOU Option R tariff. This rate schedule has high energy costs in the middle of the day, precisely when solar generation is at a maximum. The cost of energy drops in the evening on GS-3-TOU Option R, when solar generation is reduced and generation sources with higher marginal costs and emissions account for a larger portion of the energy mix on the grid. GS-3-TOU Option R has been replaced with Option E, which has lower energy costs in the middle of the dayand has significantly higher energy costs in the evening. In contrast, Option E favors shifting energy use into periods of high solar generation and out of the later afternoon and early evening, when high demand on the grid is more problematic.

Next Steps

The final report will be uploaded to the Emerging Technologies Coordinating Councilcollaborate website (https://www.etcc-ca.com/) by September 30, 2021.