SCE DRET Findings
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DR12.13: Demand Response Technology Evaluation of AutoDR Occupant Controlled Smart Thermostats

Demand Response for Occupant Controlled Smart Thermostats

The purpose of this study was to evaluate the demand response (DR) capabilities of occupant controlled smart thermostats (OCSTs). OCSTs are radio thermostats with communication modules that typically serve as direct replacements for existing thermostats for heating, ventilation, and air conditioning (HVAC) units or heat pumps. These devices leverage Open Automated Demand Response (OpenADR) 1.0 protocol, developed by Lawrence Berkley National Laboratory to promote a common communication standard for DR programs and technology manufacturers.

By studying these OCSTs on packaged rooftop HVAC units at two fast food restaurants under different DR settings (that varied in temperature offset and event duration), this project sought to achieve three main objectives: Determine if the OCSTs reliably receive the DR signal, if the OCSTs reduce air conditioning (AC) demand when receiving a DR signal, and if determine how much AC demand was dropped for each setting tested.

The monitoring revealed several key findings regarding the OCST's DR capabilities:

- The OCSTs were able to receive and act on the DR signal sent by SCE. Approximately 71% of the DR event signal implementations could be verified, and instances of testing failure were likely due to intermittent cell coverage.
- AC demand was reduced in 4 of the 10 instances when the OCSTs successfully received the DR signal and increased the cooling temperature setpoint above the normal setpoint.
- The demand savings ranged from 0–12.6 kilowatt (kW) with an average savings of 1.8 kW per AC unit or 20% of the AC load. Because this is a case study, there is no evidence that the demand savings for these sites are typical or can be predicted for these sites.

Analysis also showed that the AC units at the two test sites ran continuously during warm and hot summer days—a sign that the AC units are undersized and may not be sufficient to maintain interior temperatures. In such cases, occupants may perceive an uncomfortably high temperature even when a DR event is not underway. At times, the site temperatures were so high that the DR offset temperature did not rise above the actual zone temperature that signals the AC unit to turn off—and no demand savings were achieved.

INTRODUCTION

Why is OCST important to DR?

tress on an electric grid occurs when demand for electricity nears the capacity of available power generation and is typically most prevalent during hot summer afternoons. To provide a degree of planning for electric load curtailment, utilities can use weather forecasts to predict demand and then develop reduction tactics. SCE has developed air conditioning (AC) cycling programs to control peak demand from participating residential customers.

SCE is studying these concepts to advance the implementation of DR-enabling technologies. Ultimately, the company is considering providing incentives for installation of similar equipment.

Large load reductions can be achieved either by substantially reducing loads at a few major facilities or by aggregating smaller load reductions at a large number of facilities. New technologies are providing methods to coordinate the DR program participation of a larger number of customers in a wider range of groups.

Open Automated Demand Response (OpenADR) 1.0, developed by Lawrence Berkley National Laboratory to promote a common communication standard for DR programs and technology manufacturers, is allowing utilities to effectively implement DR programs at a larger number of sites with small loads.

What was done?

This project tested OCSTs and related communications systems that controlled rooftop packaged AC units at two fast food restaurants. The OCSTs used were equipped to remotely alter the thermostat cooling or heating setpoint temperature in response to a DR event signal. When the OCST raises the cooling setpoint temperature during the cooling season, the AC unit will turn off or operate at a reduced duty cycle.

The main objectives of the project were as follows:

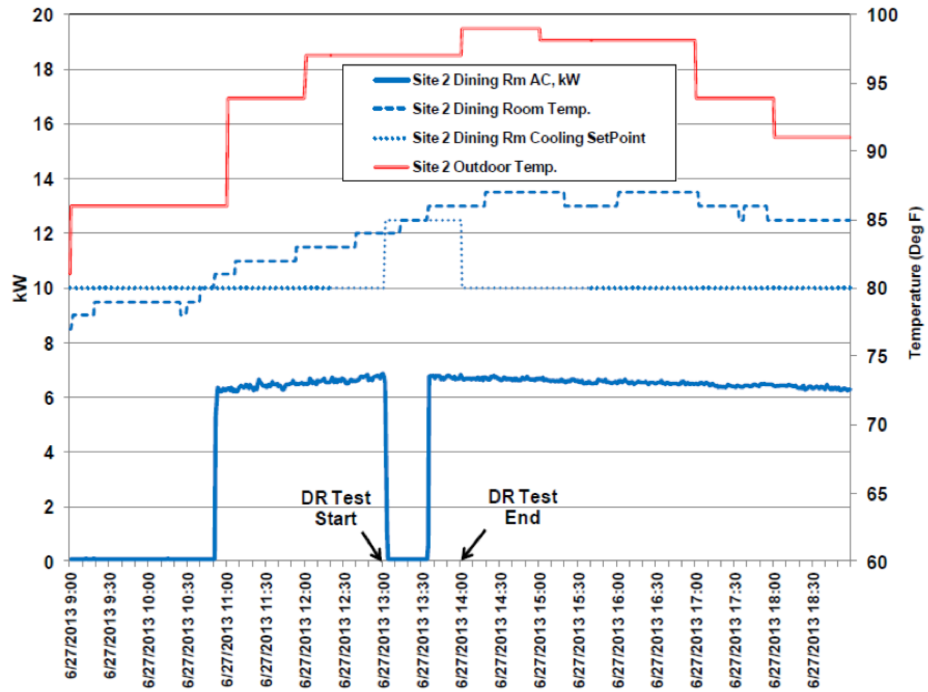
- Determine if the OCSTs reliably received the DR signal.
- Determine if the OCSTs reduced AC demand upon receipt of a DR signal.
- Determine how much AC demand was dropped for each setting tested.

AC energy use is weather-dependent, meaning that energy savings are influenced by the ambient conditions. For this project, the testing was conducted in the summer. The demand reduction and energy savings will likely differ during other times of the year.

The project team monitored the electric load of the AC units in each participating facility. The team also developed and conducted a schedule of automated DR tests.

Restaurants are in the same chain, owned and operated by the parent corporation, and located within 30 miles of each other. Further they shared similarities in building size and HVAC equipment type.

DR PROFILES In Figure 6, the cooling setpoint for the dining room AC rises 5°F at 1:00 PM (13:00) from 80°F to 85°F and lowers back to 80°F at 2:00 PM (14:00)—readings that indicate successful transmission of the DR signal to the thermostat. In response to the setpoint change, the AC turns off for about 33 minutes, and turns back on once cooling is required, and a demand reduction is seen during the beginning of the DR period.



DR PROFILES The conditions of each DR test event and the observed demand savings are presented in Table 5. The right-hand column tabulates average demand savings in kW for each DR event. Of the 14 DR test events, 4 showed demand savings. These demand savings ranged from 0 kW to 12.6 kW, with an average of 1.8 kW per unit or 20% of the AC load.

2013 TEST DATES	TARGET TEMPERATURE OFFSET	TARGET OFFSET PERIOD	SITE/AC UNIT*	OUTDOOR TEMPERATURE	INITIAL AC COOLING SETPOINT	INITIAL AREA TEMPERATURE	AVERAGE KW DEMAND SAVINGS DURING EVENT
June 24	5°F	1:00 PM – 2:00 PM	Site 1/AC1	71°F	73°F	73°F	2.1
June 24	5°F	1:00 PM – 2:00 PM	Site 1/AC2	71°F	73°F	74°F	6.7
June 27	10°F	1:00 PM – 2:00 PM	Site 1/AC1	96°F	72°F	76°F	12.6
June 27	10°F	1:00 PM – 2:00 PM	Site 1/AC2	96°F	66°F	83°F	0
June 27	5°F	1:00 PM – 2:00 PM	Site 2/AC1	97°F	80°F	84°F	3.6
June 27	5°F	1:00 PM – 2:00 PM	Site 2/AC2	97°F	72°F	84°F	0
June 28	5°F	1:00 PM – 2:00 PM	Site 2/AC1	99°F	70°F	85°F	0

* Where AC1 = Dining room AC unit and AC2 = Kitchen AC Unit

CONCLUSIONS

What We Concluded?

Based on the testing performed during this project, the following can be concluded:

- The OCSTs reliably received DR signal during approximately 71% of the tests. The cell service signal is suspect in the cases where the signal was not received. This underlines the importance of a strong, reliable internet connection as part of the communication chain.
- The OCSTs were able to reduce demand in 4 of the 10 successful events (that is, the OCST received the DR signal and changed the cooling temperature offset accordingly). AC demand was reduced when the temperature at the OCST was lower than the temperature offset requested by the DR signal. If the AC unit was not meeting the load before the DR signal was received, and if the temperature had drifted above the new setpoint, the demand could be reduced.
- The study found a single quantitative result for AC demand drop: an average demand savings of 1.8 kW, or about 20%, per AC unit measured. This result represents what actually happened on the test event days during one case study.

These Findings are based on the report "Demand Response Technology Evaluation of AutoDR Occupant Controlled Smart Thermostats" which is available from the ETCC program website, https://www.etcc-ca.com/reports/dr-technology-evaluation-autodr-occupant-controlled-smart-thermostats.

Lessons Learned

Many factors influence the demand savings results, including occasionally intermittent cell coverage at the site, unstable temperature setpoints due to manual adjustments, and AC units that are not properly sized for the cooling load. The savings realization rate will be less than 100% if manual override is allowed.

The results of this field evaluation show that demand savings can be achieved through the use of OCSTs responding to a demand reduction request. The study implied that the demand savings could be greater at sites with correctly sized HVAC units.

As with some new technologies, the OCST system had compatibility issues that need to be addressed during specification of equipment prior to installation. For example, the project team recommends specifying hardwired network connection to an internet router at the facility, whether provided by the customer or as part of an installation package.

Also, in facilities that have remote temperature sensors, it should be noted if the OCST is capable of using these sensors. In order to effectively reduce demand, the AC units cannot be undersized. If the space is overheating, raising the cooling setpoint may not turn the AC unit off, and no DR will be realized.

The DR period for AC units should not be set too short or much of the DR savings will be lost during the period immediately following the event, when the AC unit attempts to restore the space to the original temperature. However, since the largest demand reduction occurs at the beginning of the DR period, units should be staged so that the starts of the DR periods are staggered for sites with multiple units. In addition, HVAC installation technicians must be trained on how to pair the units with network routers that may exist at customer facilities.