SCE DRET FINDINGS
December 2012

DR10SCE1.05.01: Demand Response Technology Evaluation of AutoDR Programmable Communicating Thermostats

TESTING DR CAPABILITIES IN PROGRAMMABLE COMMUNICATING THERMOSTATS

Eight Programmable Communicating Thermostats (PCTs) were installed in three fast food restaurants of the same chain in the Inland Empire (California Climate Zone 10). The purpose of this study was to conduct field measurements to evaluate the demand response (DR) capabilities of PCTs leveraging Open Automated Demand Response (OpenADR). This evaluation specifically relates to packaged rooftop HVAC units at fast food restaurants, a market segment generally outside of the OpenADR scope.

PCTs have the ability to remotely alter the thermostat cooling or heating set point temperature in response to a DR event signal. By raising the cooling set point temperature during the cooling season, the AC unit will turn off or operate at a reduced duty cycle.

This project examined a low-cost entry for this market segment to explore the potential demand savings. The main objectives of the project were to:

1. Determine whether the PCTs reliably received the DR signal
2. Determine whether the PCTs reduced Air Conditioning (AC) demand when receiving a DR signal
3. Determine how much AC demand was dropped for each setting tested

By testing in real-world settings, researchers were able to verify that the technology proposed by the participating manufacturer performed to the published specifications by delivering the DR signal needed to reliably reduce demand. Additionally, it allowed for quantification of the benefit of participating in a DR event by leveraging this technology.

INTRODUCTION

What Is This Technology?

PROGRAMMABLE COMMUNICATING THERMOSTATS

This study examined one brand of remotely controlled thermostats that enables DR by altering the thermostat set points of packaged rooftop HVAC units. The thermostat has a built-in communication module. This module communicates through a wireless network to the internet, allowing all features and functions of the thermostat to be accessed remotely. The module is compatible with the OpenADR standard.

Figure 1: PCT Mounted on Wall

The communication vendor facilitates the control by providing a web interface for managing multiple thermostats for clients. Clients can log on to the secure website to program heating and cooling schedules and set points, to establish OpenADR moderate and high temperature offsets, and to lockout local thermostat control. The website also displays groups of thermostats, showing their connection status, temperature and humidity at the thermostat, cooling and heating set points, operating mode, and fan state.

The thermostat is compatible with most HVAC units, including heat pumps. Generally, it can be a direct replacement for an existing manual or programmable thermostat. The thermostat can operate one- and two-stage AC units, and can be programmed with up to seven schedules per day. Demand response periods can be scheduled in advance. The thermostat also has a large, easy-to-read temperature display.

What We Did?

BASELINE AND OFFSET POINTS

The baseline HVAC demand was monitored and the units' response to signals sent to the thermostats were tested. A schedule of DR tests was developed to determine how the systems respond to DR requests and to quantify the achievable demand savings.

Several temperature offsets, offset period start times, and durations were planned for the DR testing. Altering thermostat set points can have significantly different results depending on the amount of offset, the time of day of the offset period, the length of the offset period, and the outdoor temperature before, during, and after the offset period. Only one set of conditions was scheduled for each test day. At the end of the DR test period, the thermostat set points were returned to the set point before the start of the test. Power was recorded at 1-minute intervals all day for test days. Non-test days were also record by the data loggers as a comparison to demand during the test days.

DEMAND RESPONSE AUTOMATED SERVER

SCE personnel implemented the DR testing by using the Demand Response Automated Server (DRAS), and DR events were sent using the OpenADR specification. Various event-mode levels were tested in order to determine the manufacturer's abilities to respond to a range of DR levels.

A DR test signal was sent from the test DRAS to the devices at the specified time and included the duration and event-start time. This information was received from the server by the thermostat, which then changed the set point per the OpenADR policy and maintained this change until either the event was completed or the signal was overridden.

Table 1: Demand Response Test Schedule

Test Dates	Temp Offset	Offset Period	Testing Site
Sept 27	2°F	2 PM – 6 PM	Corona–Temscal Canyon
Sept 28	2°F	2 PM – 6 PM	Corona–Magnolia Ave.
Nov 2	4°F	12 PM – 2 PM	All Three Sites
Nov 5	8°F	12 PM – 4 PM	All Three Sites
Nov 6	8°F	4 PM – 6 PM	All Three Sites
Nov 7	6°F	12 PM – 4 PM	All Three Sites
Nov 8	6°F	4 PM – 6 PM	All Three Sites

THE ENERGY SAVINGS FOR THE DR EVENTS WAS APPROXIMATELY 25%.

There were many factors influencing the demand savings results. These include communication module firmware issues, manual override of set points during DR tests, occasionally intermittent WiFi at the site, non-optimal test conditions, AC units that were turned off, and AC units that may not be properly sized for the cooling load.

THE MAIN OBJECTIVES AND CONCULSIONS FROM THIS STUDY:

1. DETERMINE WHETHER THE PCTS RELIABLY RECEIVE THE DR SIGNAL.

The DR signal was received in approximately 87% of the tests. The WiFi signal is suspect in some of the cases where the signal was not received, which indicates that a strong reliable wireless signal at the PCTs is an important part of the communication chain.

2. DETERMINE WHETHER THE PCTS REDUCE AC DEMAND WHEN RECEIVING A DR SIGNAL

The PCTs were able to reduce demand after receiving a DR signal. AC demand was reduced when the PCTs received the DR signal and increased the cooling temperature set point above the temperature at the thermostat. Generally, this is the case for properly sized AC units. If the AC unit does not meet the load before the DR signal is received, and if the temperature has drifted above the new set point, then the demand cannot be reduced.

3. DETERMINE HOW MUCH AC DEMAND IS DROPPED FOR EACH SETTING TESTED

To drive a shift to better understanding of the benefits of DR in the hospitality market, outreach and education would be a crucial first step. 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.

CONCLUSIONS

What We Concluded?

COMPATILITY IMPROVEMENTS, INSTALLATION TRAINING AND ADDITIONAL TESTING NEEDED

As with some new technologies, there are compatibility issues that need to be addressed during specification of equipment prior to installation. One of the specifications is that the PCT is not compatible with thermostats using remote temperature sensors.

Because these are new technologies, HVAC installation technicians must be trained on how to pair the units with any wireless networks that already exist at customer facilities.

The DR period for AC units should not be set too short or much of the savings will be lost during the period immediately afterward, 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 initiation of DR periods are staggered.

The savings realization rate will be less than 100% if manual override is allowed. Although manual override should be allowed to increase participation, additional research is needed to determine what impact it would have on an actual DR event.

Additionally, further study of these installations should be conducted during summer conditions in order to determine how much savings are achievable during conditions similar to actual DR events.

These Findings are based on the report "Demand Response Technology Evaluation of AutoDR Programmable Communicating

Thermostats," which is available from the ETCC program website, https://www.etcc-ca.com/reports.

Lessons Learned

There are a few gaps for managing demand response using PCTs at present that should be addressed before implementing PCTs for DR on a large scale:

AC UNITS

In order to effectively reduce demand, the AC units cannot be undersized. If the space is overheating, raising the cooling set point may not turn the AC unit off and no demand reduction will be realized.

Improperly working HVAC units may also encounter issues with realizing DR savings. They may be non-functional, in which case no load can be reduced, or are inefficient, resulting in their capacity being reduced below the nameplate. This could cause the unit to be unable to meet the load, similar to an undersized unit.

NETWORK CONNECTION

The PCTs require a constant wireless network connection to perform to their intended capabilities. Although the thermostat will continue to operate without wireless communication, the ability to log activity or remotely change settings is lost. Therefore, it is important to install the PCTs where they will have a reliable wireless network connection. During the study, a cellular service provider hotspot device was installed along with the PCTs, but there were some intermittent connection issues. In response, the communication vendor replaced the original hotspots with an alternative vendor's hotspot devices.