DR12.08.02: Demand Response Ready Pool Pumps for Residential Retrofit Using ZigBee/Wi-Fi

This study evaluates the operation and capabilities of Demand Response (DR) controllers applied to single-speed residential pool pumps using ZigBee as the communication link between the SCE smart meter and the gateway. Communication to the DR controller is a component of the tested systems. DR can be achieved when the utility sends a signal to turn off the pump motor during demand response events.

The main objectives of the project were to evaluate the controller response to the DR signal, determine the state of the pool pump motor before the DR event, and determine the DR reduction attributable to the controller.

Four residential sites with pools were selected to test the controller operation and its DR potential. Two types of DR control products were tested in this study. The products installed used two primary pieces of hardware; a load controller (a switch that turns the pump motor on or off), and a communication gateway to receive and transmit DR signal using ZigBee wireless signal protocols. Power was monitored on the test pumps in 5-minute intervals.

Equipment problems were encountered during the implementation and testing of the DR control devices. The primary problem encountered was establishing clean and stable communication between the gateway, the load controller and the smart meter. A summary of the issues that occurred during this trial are described here. The gateway had trouble communicating with the load controller due to signal interference at all houses. When it did work it would turn the pumps off but not turn them back on after the event concluded. Repeaters were added that temporarily resolved the issue for some houses.

Power line carrier devices were added to get gateway signals closer to the load controller, but this also had temporary improvement to the signal. New firmware was added, but it did not fix the whole problem. After continued problems and multiple attempts to troubleshoot and solve the communication problem the trials were abandoned.

Neither of the two systems were successful at communicating signals reliably to initiate DR events for the pool pump motor load controllers during this trial. As a result of these failures and internal discussion with SCE's Advanced Technology Organization, no further testing of the ZigBee 1.X products will be pursued by SCE.

INTRODUCTION

Why are Pool pumps important to DR?

Residential swimming pool pumps are used to circulate and filter swimming pool water in order to maintain clarity and sanitation. In residential properties, pool pumps are generally the largest single electrical end-user. Residential pump motors range in size from one half to three horsepower (hp), are operated an average of about 5.2 hours per day and draw an average of 1.364 kW. They often run during the day so they don't create noise at night and disturb sleeping residents or neighbors. Operation during the day often is coincident with utility peak periods

What was done?

This is a field study of DR controls for single-speed pool pumps. Four similar residential pools were selected to test the product operation and savings potential and two different systems were tested at these four sites. SCE tested the implementation of DR controls added to existing pool pump systems. The DR control was installed on single-speed pumps to test the potential demand reduction during DR events. The main objectives of the project were to:

• Evaluate the controller response to the DR signal for the duration of the DR event
• Determine the state of the pool pump motor before the DR event is initiated
• Determine the DR reduction attributable to the controller

In order to verify the project objectives, electric load monitoring was conducted.

Both of the systems tested had an architecture as shown in Figure 1. There were two main components; a communication gateway and Load Control Switch. The gateway sends DR signals to the load controller and also communicates to the customers SCE smart meter. The gateway communicates using ZigBee SE 1.X protocol.
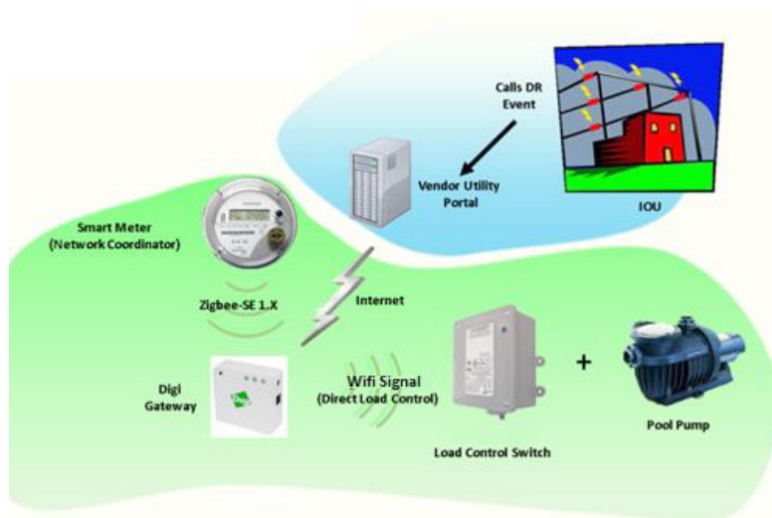

Figure 1. Communication Architecture

DR PROFILES

DR events are typically scheduled during summer afternoons on weekdays. Data was processed from the two sites where data was collected during the summer. The average percent load for the two pool pumps was calculated for the entire summer of 2013 and is charted below. Both pumps operated only during the day. One typically runs four hours per day and the other eight hours per day. The average percent load during the California statewide grid peak period of 2:00 P.M. to 5:00 P.M. is approximately 45%. The data presented in the chart does *not* represent actual data collected on site. It only represents the demand reduction that *could* be obtained if the pool pump loads could be turned off using DR controls during a typical event. It is an indication that pool pumps are a good source of DR potential.

Figure 2: Average Daily Load Profiles of Two Pool Pump Motors during the Summer
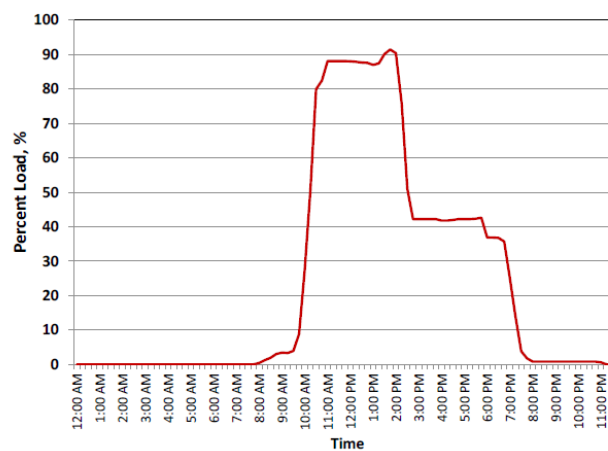
DR System Control and Communications

During initial setup and commissioning of System 1 the installers ran into a variety of obstacles while trying to perform DR event testing. The primary problem encountered was establishing clean and stable communication between the gateway, the load controller, and the smart meter using ZigBee (refer to Figure 1.) After continued problems and multiple attempts to troubleshoot and solve the communication problem the trials of System 1 were abandoned. Although there is not the same documentation for System 2, the problems encountered were similar in the sense that the controller and the gateway were unable to maintain reliable and consistent connection among themselves as well as the smart meter. As a result the pool pumps were unable to turn on and off at the programmed schedules and were starting to grow green. Due to these issues and the issues seen during the implementation of System 1, further commissioning efforts for System 2 were abandoned as well.

CONCLUSIONS

What We Concluded?

The following conclusions are based on the main objectives of this project.

1. Evaluate the controller response to the DR signal for the duration of the DR event: The controllers did not consistently respond to DR event test signals. Too often they did not respond at all to the request to turn off or end the event and turn back on.

2. State of the pool pump motor before the DR event was initiated: There were no real test events but some testing occurred as part of controller commissioning. Those tests were unsuccessful and did not show any consistent change in the state of the pool pump.

3. Demand Reduction attributable to the controller: No DR was attributed to the controller for this project because it was abandoned due to unsuccessful commissioning.

Lessons Learned

Neither of the two systems were successful at communicating signals reliably to initiate DR events for the pool pump motor load controllers during this trial. As a result of these failures, and internal discussion with SCE's Advanced Technology Organization, no further testing of the ZigBee 1.X products will be pursued by SCE.

However, important data gathered for the project such as when a certain percentage of pumps are on during the day, magnitude of pool pump load, etc., may be useful information for studies related to pool pumps.

These Findings are based on the report "Demand Response Ready Pool Pumps for Residential Retrofit using Zigbee/Wi-Fi" which is available from the ETCC program website; https://www.etcc-ca.com/reports/dr-ready-pool-pumps-residential-retrofit