DR10SCE1.16.02: Demand Response Potential of Residential Appliances – Clothes Washer (GE)

OVERVIEW

Outside of the Irvine Smart Grid Demonstration (ISGD) project, SCE has begun a series of projects to test various Smart Appliances, including those that are part of ISGD. This project evaluated the demand response (DR) capabilities of a residential front-load clothes washer manufactured by General Electric Company (GE) in a laboratory setting. The intention of this laboratory assessment was to provide SCE a better understanding of how the clothes washer will respond to certain DR signals before its installation at customer sites. SCE's Technology Test Centers conducted a series of tests on the clothes washer's actual response to DR signals in the controlled environment test chambers.

Image 1: GE Clothes Dryer

Previously, SCE's Advanced Technology Organization conducted testing on the communications capabilities of the clothes washer. This project collected data on the washer's ability to receive and interpret DR event signals, including event cancellations, respond to multiple events sent simultaneously, as well as other errant event data.

Overall, project findings revealed that the clothes washer performed in a manner compliant with its original intended strategy, but not necessarily in alignment with industry protocols. Because the clothes washer responded to either "high" or "critical" price signals, the DR potential varied depending on DR event price signal, duration, and time of occurrence. The clothes washer demonstrated its capacity to respond to delay load during high or critical price signals. However, these events must be received prior to the start of the washer to have the most beneficial impact. In addition, the clothes washer demonstrated its capacity to reduce load by nearly 50% during critical price signal events during various stages of operation.

Unfortunately, there are discrepancies between the manufacturer-implemented strategy, the DR capabilities and/or definitions proposed in widely recognized guiding documents, as well as the specific needs of electric utilities. These discrepancies must be resolved before the true benefits of a smart grid may be effectively realized.

SMART APPLIANCES

Several appliance manufacturers have begun implementing advanced control features into their products that are focused on energy reduction and the ability to react to adverse grid conditions or price signals. However, little is known about how DR capabilities will be implemented. Additionally, the Association of Home Appliance Manufacturers (AHAM) and efficiency organizations coordinated by the American Council for an Energy-Efficient Economy (ACEEE) have recently come together in a formal agreement with regard to appliances. This agreement, which outlines several requirements for Smart Appliances, has been used by the U.S. Environmental Protection Agency's (EPA) Energy Star

program as a platform for building new programs. This agreement marks a key milestone in promoting the vision of an operating Smart Grid.

In the residential space, a combination of Smart Meters, Home Area Networks (HANs) with energy supervisory software, and Smart Appliances will be needed to fully realize the benefits of the Smart Grid. A key benefit to the utility is the enablement of DR. The smart infrastructure allows the utility to send a signal to a customer's Smart Meter. From the Smart Meter, the signal can take a number of paths to reach the appliance, but ultimately the appliance receives a signal requesting that action be taken to reduce load. The Smart Appliances have built-in algorithms that allow them to determine whether they can respond to the signal while maintaining a minimal level of service to the consumer.

RESEARCH

This study focuses on DR laboratory testing and evaluation of a clothes washer manufactured by GE. Functional testing was performed in Design and Engineering Service's (DES) Technology Test Centers and was complemented by the communication testing performed at the Advanced Technology Organization's HAN lab. This testing will give SCE a better understanding of how this specific appliance will react to certain DR signals. The appliance tested in this project is one of three GE appliances to be installed in customer residences as part of the ISGD project. The appliances will then be field tested to determine real world benefits.

The goal of this assessment is to observe the clothes washer's response to DR signals and quantify the demand reduction that can be expected during different stages of operation. Specifically, the main objectives of this project are to observe and quantify performance when:

1. Operating under various cycle selections – for establishing baseline
2. Critical DR signal is received during fill, wash, rinse, and spin periods
3. Critical DR signal is received for various water temperature settings
4. Critical DR signal is received for various clothing soil levels
5. Critical DR signal is received for various spin speeds
6. Critical and High DR signals are received prior to the start of wash period

Baseline Test Scenarios

Test Name	Description	Clothing Fill Level	Cycle Selector	Wash Water Temperature	Soil Level	Spin Speed
A	Baseline A	Full	Colors/Normal	Tap Cold	Normal	Medium
B	Baseline B	Full	Colors/Normal	Warm	Normal	Medium
C	Baseline C	Full	Colors/Normal	Hot	Normal	Medium
D	Baseline D	2/3	Colors/Normal	Tap Cold	Normal	Medium
E	Baseline E	1/3	Colors/Normal	Tap Cold	Normal	Medium
F	Baseline F	Full	Colors/Normal	Tap Cold	Extra Light	Medium
G	Baseline G	Full	Colors/Normal	Tap Cold	Extra Heavy	Medium
H	Baseline H	Full	Colors/Normal	Tap Cold	Normal	Low
I	Baseline I	Full	Colors/Normal	Tap Cold	Normal	Extra High
J	Baseline J	Full	Colors/Normal	Cold	Normal	Extra High*
K	Baseline K	Full	Whites/Heavy Duty**	Sanitize [supply only cold water]	Normal	Medium
L	Baseline L	Full	Colors/Normal	Hot [steam assist]	Normal	Medium

*On eWash mode, the spin speed defaults on Extra High.

**Sanitize mode can be activated by dialing cycle selector to Whites/Heavy Duty.

FINDINGS

DR CAPABILITIES VALIDATED AND DEPENDENT ON EVENT TYPE: Overall, project findings revealed that the clothes washer performed in a manner compliant with its original intended strategy, but not necessarily in alignment with industry protocols. Because the clothes washer responded to either "high" or "critical" price signals, the DR potential varied depending on DR event price signal, duration, and time of occurrence. The clothes washer demonstrated its capacity to respond to delay load during high or critical price signals. However, these events must be received prior to the start of the washer to have the most beneficial impact. In addition, the clothes washer demonstrated its capacity to reduce load by nearly 50% during critical price signal events during various stages of operation.

POTENTIAL DISCREPANCIES IDENTIFIED REGARDING INDUSTRY STANDARDS: Unfortunately, there are discrepancies between the manufacturer-implemented strategy, the DR capabilities and/or definitions proposed in widely recognized guiding documents, as well as the specific needs of electric utilities. These discrepancies must be resolved before the true benefits of a smart grid may be effectively realized. The DR responses do not fully comply with the Association of Home Appliance Manufacturers (AHAM) guidelines and would likely provide less beneficial demand reduction to the utility. Further simulation and better understanding of the DR programs used to activate these systems are required to fully evaluate the grid-level impacts of various schemes. Subsequent testing and future increased interaction with AHAM and standards-setting agencies will attempt to address these issues.

EVENT TIMING AND SELECTED WASH MODE ARE KEY SAVINGS VARIABLES: Clearly, the savings potential varied as a function of when the DR event was initiated and the selected wash mode setting. The lowest and highest reductions in the average total power during critical price signal events during various stages of operation were 9% and 53%, respectively. Similar reductions were seen in total energy, and savings potential varied as a function of when the DR event was initiated and the selected wash mode setting.

SHIFTING WASH CYCLE STAGES: The results indicate that DR events may or may not yield reduction in peak demand, due to the washer responding to DR events by reducing the duty cycle. Thus, the reductions in max total power are largely due to shifting the stages of the wash cycle.

CONCLUSION & LESSONS LEARNED

Generally, the clothes washer consistently performed in a manner compliant with its originally intended strategy and has the potential to avoid its peak demand of roughly 600W. The DR benefits depend on factors such as price signal, duration and time of event occurrence vs. washer stage of operation.

The clothes washer responds to "high" price signals by delaying the start of a new wash cycle during the event. It does not affect a cycle already in progress. In response to a "critical" event, the dishwasher performs the "high" response but also has the capacity to reduce average wattage via a reduction in motor and heater duty cycles. It has the capability to reduce wattage by up to 53%. The magnitude of reduction depends on the wash modes selected by the user and the point in the wash cycle when the signal is received by the appliance.

Overall, the clothes washer performed as intended by the manufacturer. However, there appear to be discrepancies between the implemented clothes washer DR strategy and the proposed definitions and requirements in the AHAM/ACEEE Joint Petition. There also seem to be disparities between utility needs during DR events and the proposed AHAM/ACEEE definitions of Spinning Reserve and Delay Load.

The DR scheme adopted by GE may not provide optimal benefit to the utility for two reasons:

1. For a High event, no immediate reduction in power is guaranteed. The only response is to postpone the start of a new wash cycle. Wash cycles already in progress will continue unchanged.

2. For a Critical event, there is a reduction in load attributable to the duty cycle alteration of the motor and heater. The remaining components operate at normal power conditions.

These responses do not fully comply with the AHAM guidelines and would likely provide less beneficial demand reduction to the utility. Further simulation and better understanding of the DR programs used to activate these systems are required to fully evaluate the grid-level impacts of various schemes. It is unclear how this problem may be further impacted by other types of DR-capable appliances. Subsequent testing and future increased interaction with AHAM and standards-setting agencies will attempt to address these issues.

These Findings are based on the report "Demand Response Potential of Residential Appliances – Clothes Washer (GE)" which is available from dret-ca.com.