SCE DRET Findings
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DR10SCE1.16.03: DEMAND RESPONSE POTENTIAL OF RESIDENTIAL APPLIANCES: DISHWASHER A

LABORATORY TESTING AND EVLUATION OF ENERGY-STAR COMPLIANT DISHWASHER WITH DEMAND RESPONSE CAPABILITIES

To help consumers take advantage of the emerging smart grid, private industry is creating products that put more control of energy use into the hands of users. In particular, some products integrate advanced control features aimed at ensuring demand response (DR)—or the ability to react to adverse grid conditions or price signals.

To better understand the capabilities of smart appliances, Southern California Edison (SCE) has initiated a series of projects to test appliances from various manufacturers in a laboratory environment. This testing seeks to fill current information gaps by examining demand response (DR) capabilities in appliances.

This report focuses on DR laboratory testing and evaluation of a dishwasher (dishwasher A) produced by a manufacturer referred to here as Manufacturer A. This testing is intended give SCE a better understanding of how dishwasher A will react to certain DR signals.

INTRODUCTION

Utilities have taken the lead on the smart grid components of the transmission and distribution system, as well as those of smart meters, which enable communication between the utility and the customer. However, to take full advantage of the smart grid, energy consumers need access to home area networks (HANs) with energy control software and smart appliances, which, together with the smart meter, enable communication of rates and grid conditions and offer integrated control capabilities to respond to the information received.

A key benefit to the utility of the fully enabled smart grid is the enablement of demand response (DR) capabilities, which can help stabilize energy costs and grid impacts by reducing energy consumption during peak periods.

What Is This Technology?

An ENERGY STAR–compliant dishwasher equipped with DR capabilities. Specifically, to achieve DR goals, dishwasher A could either delay its operating wash mode or eliminate an enhanced heated dry mode.

Dishwasher Demand Response Controls

Dishwashers, a common appliance in this market, can have fairly significant peak demand impacts:

Dishwasher power draw may range anywhere from 1.2 to 2.4 kilowatts (kW).8 In California, where about dishwasher 67% of households have a (for a total of about 8.7 million dishwashers), dishwashers account for approximately 2.5% of residential energy use. Given that about 67% of SCE households have a dishwasher, nearly 3 million of California's dishwashers reside in SCE territory.

The DR strategy of GE dishwashers is as follows:

***High* price signal: Delay start of operation until event clears.**

- DR delay start will not interrupt a wash cycle that has already started
- The dishwasher also contains its own "delay start" enhancement, independent of DR. The delay from a DR signal will override a manually-set delay start enhancement

***Critical* price signal: Respond as for *High* price signal plus turn heated dry off.**

Communication with smart appliances can be achieved through multiple hardware configurations. It is important to note that the signals do not tell the device to turn off; rather, they alert the device to the existence of an event and allow the device's internal algorithms to determine whether or not a response is feasible.

Though there are three different hardware models that enable communication with smart appliances, SCE uses the following model: Model 1: Smart Meter Gateway Smart Appliance

TABLE 1. SUMMARY PEAK DEMAND REDUCTION FROM DISHWASHER DEMAND RESPONSE CONTROLS*

	ANNUAL ENERGY CONSUMPTION (KWH)	PEAK DEMAND (KW)	DR PEAK DEMAND REDUCTION (KW)
Federal energy consumption regulations for standard sized dishwasher manufactured on/after Jan 1, 2010 (per dishwasher)	355	-	-
Typical dishwasher peak demand (per dishwasher)	-	1.2 – 2.4	-
Dishwasher A energy profile (per dishwasher)	322	1.00	1.00
Estimates for California Assumptions: - 8.7 million dishwashers - Per dishwasher: • 355 kWh/yr energy consumption • 2.4 kW peak demand • 1 kW demand reduction potential	3,088,500,000	20,880,000	8,700,000
SCE Territory Assumptions: - 3 million dishwashers - Per dishwasher: • 355 kWh/yr energy consumption • 2.4 kW peak demand • 1 kW demand reduction potential	1,065,000,000	7,200,000	3,000,000

What We Did?

Approach

The current project, conducted under the larger SCE effort, focused on DR laboratory testing and evaluation of an ENERGY STAR–compliant dishwasher (produced by a manufacturer referred to as Dishwasher A) equipped with DR capabilities. Specifically, to achieve DR goals, dishwasher A could either delay its operating wash mode or eliminate an enhanced heated dry mode. The objectives of the testing were to quantify the DR potential for dishwasher A and characterize its response to DR signals under varying operational scenarios. The project included two types of tests:

- Acquire the power profile data of dishwasher A under various operational settings
- Quantify the demand reduction potential for dishwasher A
- Characterize the response of dishwasher A to DR signals under varying operational scenarios

These laboratory tests were conducted on DR-capable dishwasher A. This appliance includes a module that allows for automatic adjusting of each cycle based on soil level, water temperature, and water hardness (manually set/calibrated). Dishwasher A was coupled with a communication module to enable the connectivity needed to utilize the smart appliance features. Dishwasher A is rated by its manufacturer to consume 322 kWh/year and is therefore compliant with the 324 kWh/year requirement of ENERGY STAR Version 4.116. The 1 kW peak demand of this dishwasher places it below the anticipated threshold

(1.2 kW – 2.4 kW) of most typical dishwashers.

The dishwasher was installed as recommended by the manufacturer, ensuring that it was freestanding and level. All connections, such as for supply water, drain lines, and power, were completed with guidance from the installation instructions provided by the manufacturer. A water recirculation loop was employed to maintain water temperature and pressure at the inlet to the dishwasher.

FINDINGS

Findings

The testing program led to the following findings:

- Dishwasher A consistently demonstrated compliance with its intended DR strategy. The report includes details on various operational nuances, including influences of DR event type, length, and time of occurrence in relationship to dishwasher operations
- The dishwasher had the potential to eliminate or delay up to 1 kilowatt (kW) of demand
- DR delay scenarios did not impact the energy consumption of the dishwasher
- The heated dry enhancement increased the energy consumption of a normal wash mode by 40%, indicating the potential for significant energy use reductions by eliminating this enhancement
- The dishwasher met manufacturer specifications

CONCLUSIONS

What We Concluded?

Generally, dishwasher A consistently performed in a manner compliant with its originally intended strategy and has the potential to avoid its peak demand of roughly 1 kW. **Overall, the DR benefits from this dishwasher that could be realized by an electric utility are dependent upon the price signal, the duration of the DR event, and the timing of the DR event relative to the dishwasher's operating stage.**

The main objectives and conclusions of the project are:

- **High Event:** The dishwasher responds to a high price signal by delaying the start of a new wash mode during the DR event; the dishwasher does not change a wash mode already in progress. When the duration of the DR event was longer than a user-input delay start mode enhancement, the DR event took priority. When the duration of the DR event was shorter than a user-input delay start mode enhancement, the delay start mode enhancement was not impacted.
- **Critical Event:** In response to a critical event, the dishwasher responds as with the high event, but also has the capacity to reduce average wattage during its heated dry cycle. Specifically, it can reduce wattage by well over 50% by deactivating the electric heating elements, but only during the heated dry cycle. However, if the duration of a critical DR event is shorter than the original allotment of time for the heated dry cycle, the heated dry cycle will re-activate in its entirety once the critical DR event ceases.

  The dishwasher cannot reduce wattage during any operating point other than the heated dry cycle, even though other cycles use the heating elements. Depending on the dishwashing modes and enhancements selected by the user, various cycles, such as steam pre-wash, main wash, or rinsing, may also use the heating element. Thus, DR event would have little to no effect on the demand under many scenarios. Further, the benefits that can be derived are not likely to be immediate, as they require the dishwasher to enter the drying cycle.