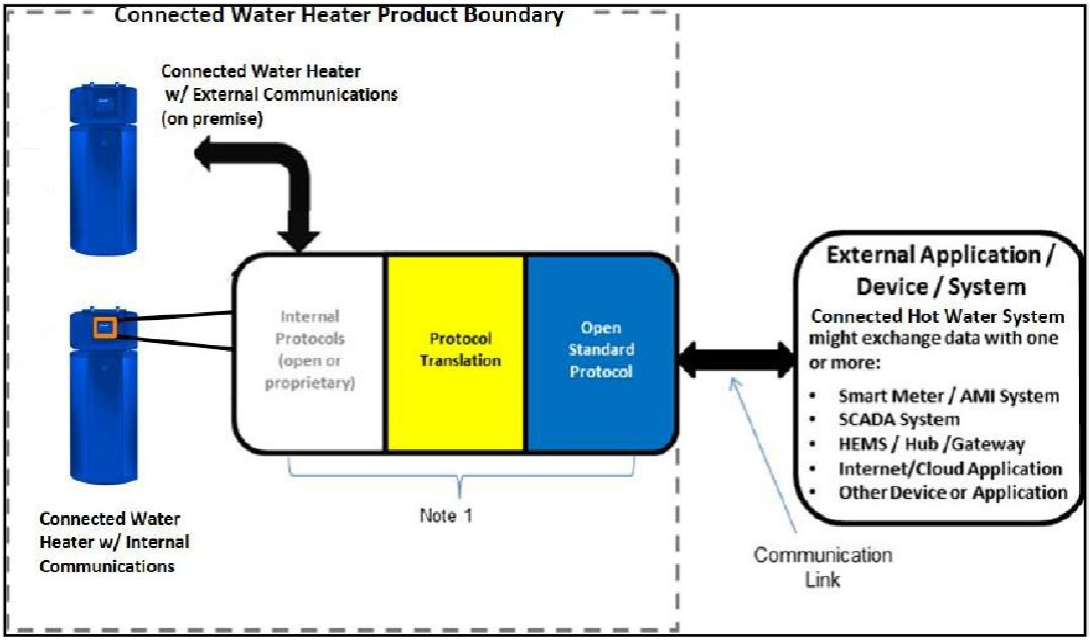
DR19.08 Grid Responsive Heat Pump Water Heater Study

Overview

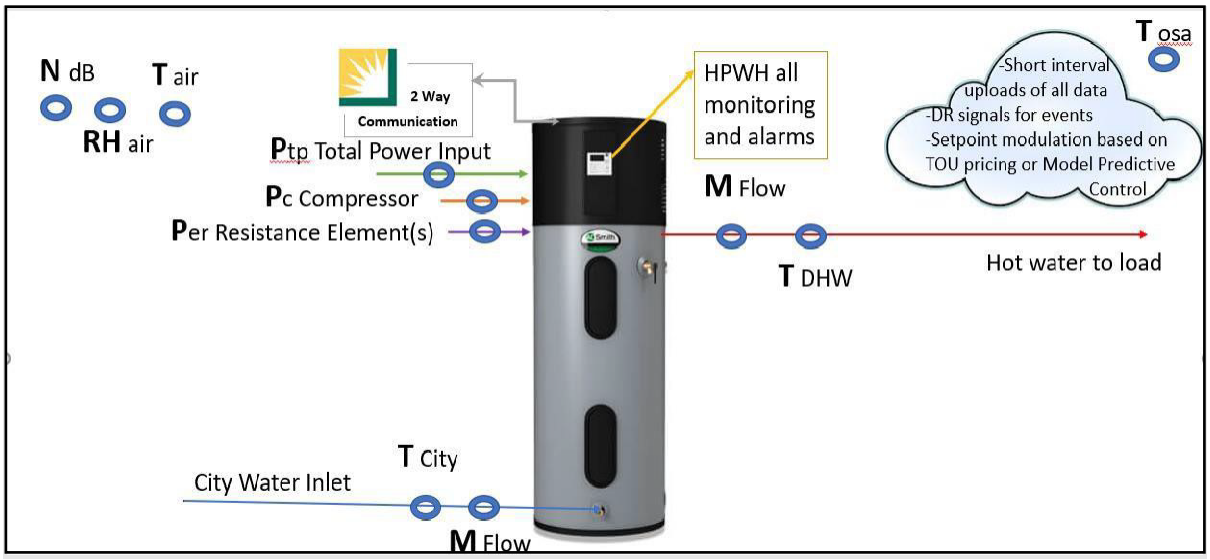
SCE's Emerging Technologies Program (ETP) and Emerging Markets and Technology (EM&T) Program have been conducting joint technology assessment studies of heat pump water heaters (HPWHs), and this study is a continuation of those efforts. The research team has been examining innovative emerging data management technologies that are applied and implemented for the deployment of the HPWH controls and their associated communication equipment, and for the test instrumentation and data collection of field studies when installed in customer homes.

The study is in response to CPUC orders which stipulated: "Target installing local preset controls and/or digital communications technologies on 150 heat pump water heaters in each of PG&E and SCE's service territories." In response, SCE proposed the "SCE San Joaquin Valley Disadvantaged Communities Electric Pilot Implementation Plan" (SJV Pilot PIP), submitted to the CPUC through Advice Letter 3971-E filed on March 19, 2019.



Connected Water Heater Communications Architecture

As part of San Joaquin Valley (SJV) Disadvantaged Communities Pilot Projects, SCE will deploy electric HPWHs equipped with smart-grid communication technology that will allow the water heater to be used as a grid-responsive heating technology element of the pilot to electrify homes and reduce emissions within the SJV and California City. The EM&T project will provide twelve (12) HPWHs with hardware and software to allow grid-responsive communication between the HPWH and the grid to control tank temperature and HPWH operation. The same 12 HPWHs will be instrumented to monitor, at a minimum, the performance of the water heater, signals between the grid and HPWH, operation of the HPWH, water flow and temperatures, local grid conditions, and ambient conditions.



Metering Diagram for HPWH Performance Testing

The EM&T study is designed to address the following research issues:

- Assist SCE in understanding integration of renewables and load dispatch as well as helping inform SCE if and how effectively a grid responsive HPWH can provide flexible load control and hot water storage over various time frames. SCE hopes to gain insight into how heat pump water heaters acting as aggregated distributed resources can be used to benefit the grid and simultaneously offer residents the ability to manage energy consumption through time-of-use (TOU) management of their energy consumption.
- Inform how hot water storage over various time frames can be used to add load or shed load. The demonstration research will provide anecdotal results that should enhance SCE and other stakeholders' understanding of utilizing heat pumps for assisting in the integration of renewables and offering a resource for load dispatch. This will be achieved through detailed monitoring and analysis of the technical performance of HPWHs, including the technical capability of providing local grid impacts from grid responsive HPWHs as well as their performance in supplying hot water for the customers.
- In addition, SCE will gather information on customer experience, technical performance, grid benefits, and impacts of actual performance of the grid-responsive HPWHs as electric appliances in underserved communities.

All 12 homes selected have a garage for the HPWH, no recirculation system, and are part of a larger SCE pilot to electrify 150 homes and reduce emissions within the SJV. The prime General Contractor (GC) and Community Energy Navigator (CEN) of the larger project will be responsible for the customer selection and the selection and installation of the grid controlled HPWH and a proposed communication package to be used by SCE for the grid responsive signals.

In order to minimize the risk of any failures of the technology that might occur at the customer's home, the HPWH controls and the grid-responsive communications technology will first be functionally tested in a laboratory environment prior to deployment in the homes.

The SCE Grid Responsive HPWH study sought to minimize the impact of its M&V installation activities on the participating customers by coordinating with the larger pilot's HPWH installers, and by using a modular M&V setup and using a HPWH installation "mock-up".
The SCE Grid Responsive HPWH study plans to minimize the risk of any failures of the HPWH technology that might occur at the customer's home; therefore, the HPWH controls and the grid-responsive communications technology will be functionally tested in a laboratory environment simultaneously along with HPWH deployment in the pilot homes.

The project is funded under the EM&T Technology Assessments and Technology Transfer investment categories, as there are elements of both research goals in this study. The Technology Assessments category assesses and reviews the performance of DR-enabling technologies through lab and field tests and demonstrations designed to verify or enable DR technical capabilities. The Technology Transfer category advances DR-enabling technologies to the next step in the adoption process by raising awareness, developing capabilities, and informing stakeholders during the early stages of emerging technology development for potential DR program and product offerings.

Collaboration

The research team consists of SCE's Engineering Services group under the direction of the ETP and EM&T program managers and will be assisted by SCE's technology consultants. The SCE Income Qualified Program group will oversee the SJV DAC and will work with the research team to select the customers for the study.

Community leaders from the San Joaquin Valley and the communities of California City, Ducor, and West Goshen will also be involved. The project is jointly funded by the EE, DR, and the Energy Savings Assistance (ESA) and California Alternate Rates for Energy (CARE) programs.

Results/Status

The field work for the study is still ongoing. Data collection and analysis/baseline characterization was conducted on an ongoing basis from Q1 - Q2 of 2023.

Preliminary findings across all 12 sites for ~ 6 months (January through June 2023) indicate the following metrics:

- Avg Daily Energy Usage = 3.8 kWh/day
- Avg Daily Peak Demand = 4.2 kW
  - Avg % time above 1 kW = 1.3% (minimal usage time of heating elements)
- Avg Energy Factor = 2.6 (Rated UEFs were 3.75 and 3.61)
- Avg Delivered Temperatures of 125.2 F
- Avg Daily Hot Water Use = 69.4 gal/day
- Avg Daily Hot Water Events = 64 events/day

*Note = One of the field test sites was discovered to have had its power shut off in June. It is unclear if the HPWH will be reconnected, and the project team will conduct outreach/investigation.

Previous preliminary findings across all 12 sites for ~ 4 months (September through December 2022) indicated the following metrics:

- Avg Daily Energy Usage = 2.6 kWh/day
- Avg Daily Peak Demand = 3.4 kW
  - Avg % time above 1 kW = 0.6% (minimal usage time of heating elements)
- Avg Energy Factor = 2.8 (Rated UEFs were ~~3.88 and 3.45~~, 3.75 and 3.61)
- Avg Delivered Temperatures of 125.6 F Avg Daily Hot Water Use = ~~358 gal/day~~ (error)
- Avg Daily Hot Water Events = 66 events/day

Next Steps

The project team will continue to collect and analyze data at each of the remote customer sites. Comprehensive investigation/outreach shall be conducted for the singular test site with disconnected power. The project team will finalize the design of the demand response field tests and subsequently implement them in the latter months of 2023. Testing and validation of demand response communication is planned for later in 2023. The project is targeted for completion in Q1 - Q2 2024.