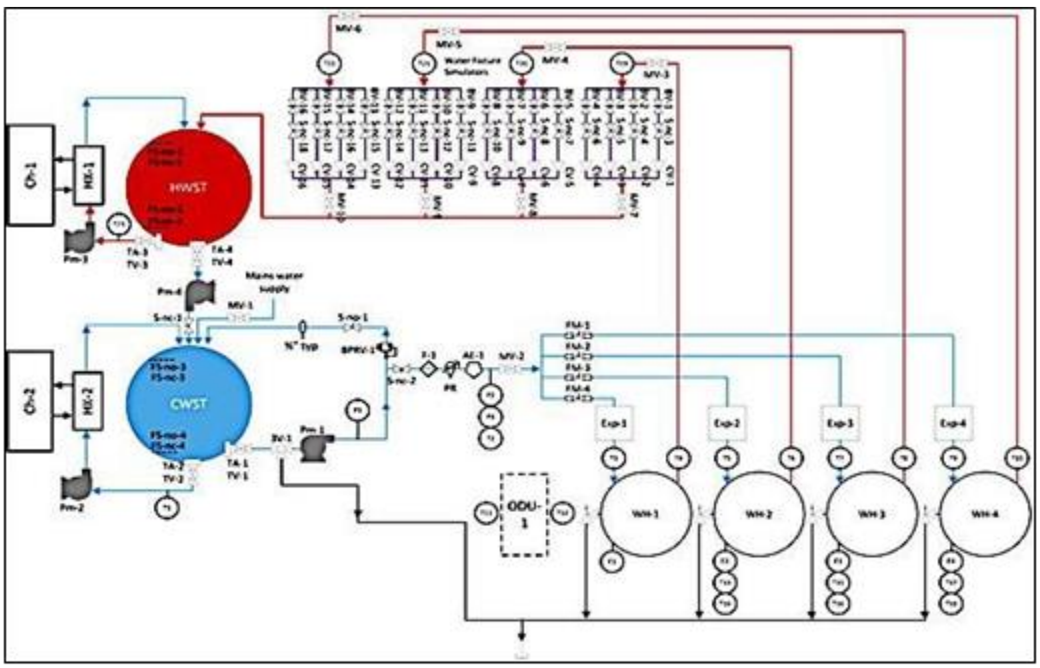
SCE EM&T PROJECT: DR18.04 HEAT PUMP WATER HEATER SYSTEMS

Status: In progress

Overview

The project has been developed to facilitate a test environment to assess how electric Heat Pump Water Heater (HPWH) systems can securely communicate and provide time-based operational flexibility under various laboratory conditions. To support that research, SCE is designing and constructing a Flexible DR Secure Communications Demonstration Lab for Water Heating Systems at the SCE Energy Education Center. The project will create a lab-demonstration for HPWH Open AutoDR testing using various transport media, and study communication capabilities and integration with the OpenADR 2.0a and 2.0b VEN architecture and CTA-2045 physical layer.



HPWH EEC Lab Design Schematic (LDS-1A)

Much like an air conditioner, HPWHs use electricity to transfer (or "pump") via a vapor compression cycle the ambient heat from the local environment. In the case of the HVAC system, the air is cooled by removing the heat from the internal space. For a HPWH, the water within the storage tank is heated by transferring the heat from the local environment, instead of heating the water directly (as through resistance coils in an electric water heater). Through this compression cycle heating mode, HPWHs are two to three times more energy efficient than conventional electric resistance water heaters. However, these systems are also equipped with resistance elements (coils) as backup, which can be activated during periods of high hot water demand or if the ambient temperature is low. The units can also be deployed in a "negative" demand response mode, meaning if the electricity rate is very low (due to excess renewables at the market level), the HPWH can act as a “take” to heat the water, and thus acts as a “grid responsive” end-use load. This type of operation has not been well demonstrated, and so SCE initiated this project. The test plans include case studies for customer-to-grid integration scenarios to examine how HPWHs can react to dispatch and shift signals and the effect on temperature from water draw during times of high- and low-water usage.

Typical Residential HPWH Installation

The HPWHs in the SCE Lab will be modified, if needed, to be converted to a grid-responsive device by either adding a two-way communication device or accessing the existing communications module within the system. This will allow the HPWH to be controlled remotely by SCE. The communication device can signal the HPWH to increase the thermostat temperature control during low-electric consumption times and will lower the water heater thermostat control during high-energy consumption periods throughout the day. During peak energy consumption times, customers will use water that is already hot. The HPWH’s electricity usage is reduced during this peak consumption period, which leads to a decrease in the amount of energy drawn from the grid.

The key research items to be examined in this project are:

- Load shape and energy demand case studies for HPWHs, based on a wide range of water usage and temperature set point profiles.
- Demand response value propositions for developing flexible load shifting strategies and their effect on water supply, water temperature, and energy usage and demand.
- Test realistic hot water draw events for demonstration purposes and study 24-hour profiles for performance evaluation.
- Provide a test bed to serve as both a showcase for emerging DR enabling technology for HPWHs, and a highly capable working laboratory for long-term performance studies.

The project was 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 demonstration lab is being installed in SCE's Irwindale Energy Education Center (EEC) and funded by the EM&T program and the EEC. It will serve as both a fully functioning working lab and an opportunity to engage customers, vendors, and others to assess and review HPWH technologies. While the EM&T program is funding the project directly and through a supplemental contract with EPRI, SCE is also leveraging its membership in EPRI with learnings and best practices from the parallel research by other EPRI utility members as a cost-sharing strategy. Also, as a corporate funding member of EPRI, SCE is co-funding parallel research investments with other utilities and leveraging that research to assist in this study, but no other direct cost-sharing or co-funding with any other parties was enabled.

This project will coordinate its research findings with SCE's research partner EPRI and will also inform the grid responsive HPWH investigations underway in the San Joaquin Valley (SJV) Electric Pilot and the Demand Response Pilot for Disadvantaged Communities (DR DAC). Future collaboration with the CEC's EPIC program with participation in their research and possible coordination with the OpenADR Alliance in the development of the CTA-2045 certification testing protocol is planned for 2021.

Results/Status

Major construction aspects of the laboratory have been completed while still working in accordance with SCE COVID-19 safety protocols to achieve commissioning of the HPWH Test Lab systems. The SCE project team is finalizing and testing telemetry points for the data acquisition system.

HPWH Test Lab at the SCE Energy Education Center Irwindale, CA

SCE is working in collaboration with the field study to deploy HPWHs equipped with communication technology that will allow the water heater to be used as a grid-responsive heating technology for the San Joaquin Valley Disadvantaged Communities (SJV-DAC) pilot. This study will only be conducted in twelve residential single-family dwellings of customers participating in the SJV pilots. SCE plans to minimize the risk of any failures of the technology that might occur at the customers' homes by thoroughly testing the communications in the HPWH Test Lab using a variety of cyber-secure transport mechanisms and software schema designed for rural areas. Currently the deployment of the SJV HPWH pilot (as well as the work at the HPWH lab) has been delayed by the ongoing COVID-19 field travel and customer access restrictions at the EEC, but remote programming work is still ongoing and safe-site visits at the EEC are conducted in accordance with SCE Visitor and Employee protocols.

Next Steps

The next important step will be to complete the system(s) commissioning of the HPWH Test Lab to properly assess the operational capabilities of the entire installed system in terms of electrical and hydraulic functionality. Staff training will then commence on the operations of the lab and initiate preliminary testing of acquired HPWH products. The project team will develop video display content on the real-time operations of the SCADA system and the individual products in test bays. The

HPWH controls and the grid-responsive communications technology will first be functionally tested in the HPWH laboratory environment prior to deployment in the SJV-DAC test homes. Once installation and testing are complete, the lab may serve as a platform for continued assessment and demonstrations of HPWHs through 2022 and beyond (depending on funding).