U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Building America Case Study
Efficient Solutions for New and Existing Homes

Indoor Heat Pump Water Heaters During Summer in a Hot-Dry Climate

Redding, California

PROJECT INFORMATION

Project Name: Redding HPWH Testing

Location: Redding, California

Research Team: Alliance for Residential Building Innovation

Partners: Redding Electric Utility and The Energy Docs

Building Component: Water Heating

Application: New or retrofit

Year Tested: 2014

Applicable Climate Zone(s): Hot-Dry

PERFORMANCE DATA

Cost of Energy-Efficiency Measure: The cost of HPWHs varies based on a variety of factors, including manufacturer and storage volume. The NREL Measures Database indicates measure costs of $2,000 to $2,300. The installing contractor in Redding indicates typical incremental costs of $1,800 relative to an electric storage retrofit.

Projected Energy Savings: 59%–61% based on field monitoring to date.

Simple Paybacks: 5–8 years vs. electric storage for the monitored homes; varies with DHW load and utility rates.

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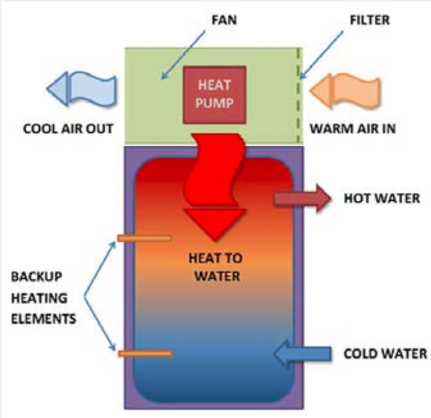
More than 40% of U.S. households heat domestic hot water (DHW) using electric resistance storage water heaters, and heat pump water heaters (HPWHs) offer a significant opportunity to improve water heating performance. The HPWH technology has started to make inroads in some U.S. markets due to aggressive marketing and local utility incentives that often contribute to very favorable economics relative to electric resistance storage water heating. Numerous field studies have also been completed documenting performance in a variety of climates and residential applications.

In this project, the Building America Alliance for Residential Building Innovation (ARBI) team studied the performance of HPWHs installed in two homes in the hot-dry climate of Redding, California (~2000 cooling degree days) during the summer months. Existing indoor electric storage water heaters were monitored for a period before the AirGenerate HPWHs were installed. After installation, the HPWHs were monitored from late May to mid-September in 2014. One of the two sites utilized a ducting kit, which allows for control of the airflow path for air crossing the unit's evaporator. Supply air can either be pulled from outdoors or indoors and exiting air could either be exhausted to indoors or outdoors. This flexibility allows for seasonal control and optimization of space conditioning impacts.

As well as testing the HPWH's performance generating hot water, the amount of cooling delivered off of the evaporator was measured. Over the 2014 summer, space cooling savings ranging from 121–135 kWh were calculated. Although the monitoring was limited to the summer period for this project, ongoing monitoring during the upcoming winter will provide insights on winter performance.



Looking Ahead

HPWH laboratory and field testing has generated significant data characterizing the performance of this highly efficient technology. This information is valuable in moving the technology forward and helping the industry improve and optimize performance and control strategies.

As of April 16, 2015, residential water heaters must comply with the amended DOE standards found in the Code of Federal Regulations (10 CFR 430.329(d)). Among the energy efficiency requirements is the energy factor (EF), which is based on the amount of hot water produced per unit of fuel consumed over a typical day. The higher the EF, the more efficient the water heater. For electric water heaters >55 gallons and <= 120 gallons in volume, the new standards require heat pump technologies to meet the following minimum EF level:

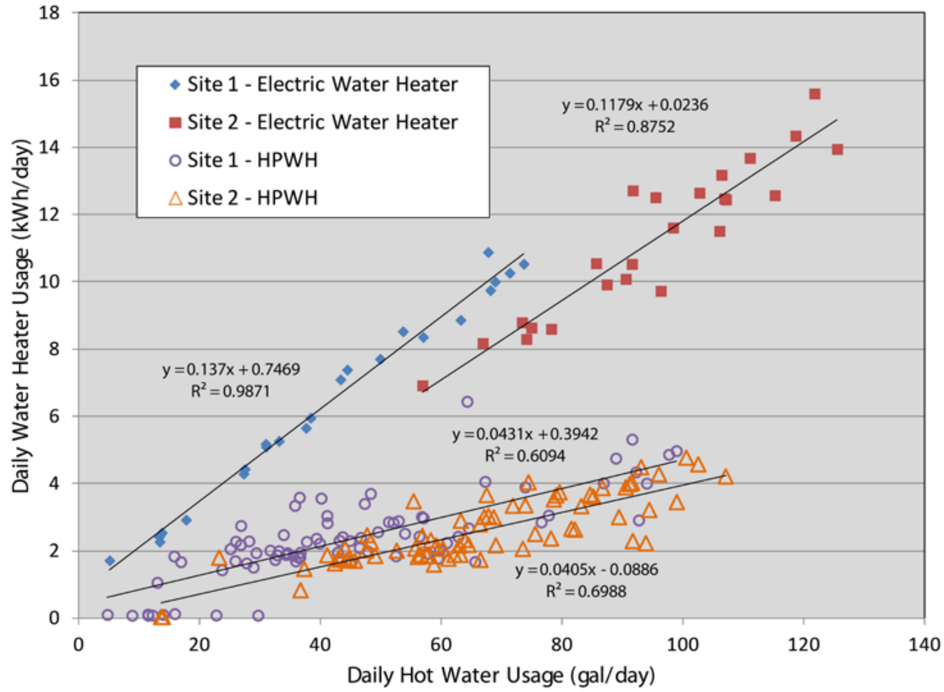
EFmin= 2.057 - (0.00113 x Vs)

Where, Vs= storage volume in gallons.

Efficient electric water heating technologies are not limited to refrigerant-based HPWHs. New technologies such as CO_2 HPWHs are starting to gain attention as another highly efficient electric water heating technology.

For more information, see the Building America report *Summer Indoor Heat Pump Water Heater Evaluation in a Hot-Dry Climate* at *https://www1.eere.energy.gov/buildings/publications/pdfs/building_america/64082.pdf*.

Image credit: All images were created by the ARBI Team



The graph plots measured daily kWh use as a function of hot water use at each site

Lessons Learned

- Even in a very hot climate such as Redding, California, the ability to utilize the space cooling benefit from the HPWH was found to be highly variable. One site, with 50% higher hot water loads than the second site, was expected to generate greater cooling benefit. However, higher cooling thermostat setpoints at that site and an improved thermal envelope resulted in about 1/3 fewer days during the summer when the air conditioner operated. The net effect was that the site with less HPWH operation generated greater cooling benefit in offsetting actual air conditioning use.
- A key consideration for indoor HPWHs is noise. Many manufacturers have paid attention to this issue and deliver products that are quiet. There were no homeowner concerns about noise from the two field test sites with indoor HPWHs.
- Water heating savings of 59–61% are projected relative to a standard electric storage water heater. These savings are significant and would provide simple paybacks in the 6.2–8.8 year range. In California, relatively inexpensive natural gas and high electric rates makes competition against natural gas challenging. Local rates and available incentives will change the economics.

A good resource on HPWHs is the Building America report, *Measure Guideline: Heat Pump Water Heaters in New and Existing Homes*.

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