Building America Case Study

Technology Solutions for New and Existing Homes

Field Performance of Heat Pump Water Heaters in the Northeast

Massachusetts and Rhode Island

PROJECT INFORMATION

Project Name: HPWH Evaluation

Location: Northeast

Partners:

National Grid
www.nationalgridus.com

NSTAR
www.nstar.com

Cape Light Compact
www.capelightcompact.org

Consortium for Advanced Residential Buildings
www.carb-swa.com

Building Component: Water heating

Application: New and retrofit, single and multifamily homes

Years Tested: 2010-2012

Applicable Climate Zone(s): All climates, but this research focused on cold climate regions

PERFORMANCE DATA

Cost of Energy Efficiency Measure: (including labor): $1,900–$3,600

Projected Energy Savings: 36%–63% water heating savings

Projected Energy Cost Savings: $182/year versus a traditional electric resistance water heater

Building America SM U.S. Department of Energy

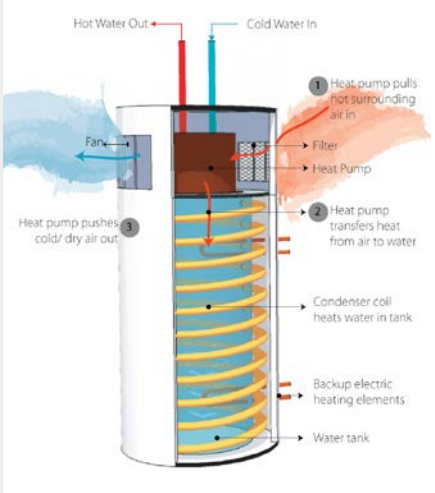
Heat pump water heaters (HPWHs) are primarily designed as replacements for traditional electric resistance water heaters (ERWHs) and achieve higher efficiencies by using the vapor compression heat pump cycle. The U.S. Department of Energy Building America team Consortium for Advanced Residential Buildings (CARB) quantified the in-situ performance of three recently released HPWH products for more than one year. Of the 14 units monitored, ten were General Electric GeoSpring models (50-gallon units), two were Stiebel Eltron Accelera300 models (80-gallon units), and two were AO Smith Voltex models (one 60-gallon and one 80-gallon unit).

Generally speaking, heat pumps are devices—such as air conditioners and refrigerators—that move thermal energy from one location to another. Although a refrigerator moves heat from the inside of the appliance into the kitchen, a HPWH moves heat from the surrounding air into the hot water storage tank.

Most HPWHs are hybrid devices that combine a heat pump, backup electric resistance element(s), and a storage tank. Although the heat pumps in these hybrid water heaters can heat water at high efficiencies, the recovery rate of these mechanisms is significantly slower than traditional electric resistance heating mechanisms. A typical 4.5-kilowatt (kW) electric resistance element can reliably heat more than 20 gallons of water per hour. The heat pump has a lower heating rate—General Electric, for example, publishes a rate of eight gallons per hour at 68°F air temperature. As a result, auxiliary electric resistance elements are also installed in HPWHs for reliability and quicker hot water recovery. Most HPWHs use the heat pump whenever possible, but built-in controls switch to conventional resistance heating when there are large hot water needs.

The efficiency of HPWHs is profoundly affected by the way hot water is used. When large quantities of hot water are used in clusters, HPWHs will revert to electric resistance mode, reducing the efficiency of the unit. Homeowners can reduce this effect by purchasing a larger HPWH, increasing the set point

HPWH Basics



The most common arrangement of current HPWHs is an integrated water heater with a wraparound condenser and two backup electric elements. The figure above describes the typical components and operation of modern HPWHs in the U.S. market. Among the systems evaluated in this study, the only model to deviate from this configuration is the Stiebel Eltron unit, which has only one smaller (1.7 kW) upper element and always operates in hybrid mode.

Looking Ahead

This study provides considerable data about the remarkable potential of HPWHs in unconditioned basements in the Northeast; however, more research is needed in several areas. Understanding the affects of HPWH installation in unconditioned basements is vital for quantifying HPWH impacts on total building energy use. Calculating the interaction between the HPWH, conditioned space, buffer space, ground, and ambient is not a trivial task.

For more information, see the Building America report, *Field Performance of Heat Pump Water Heaters in the Northeast,* at *www.buildings.energy.gov*

Image credit: All images were created by the CARB team.

temperature, or changing behavior. By increasing the size and temperature of a HPWH, more hot water can be delivered at a given time before the resistance elements are needed. Spreading the water load over a greater period of time may also provide similar benefits and reduce standby losses.

Performance Summary of Monitored HPWHs by Model

Model	Capacity (gal)	Rated Energy Factor	First Hour Rating (gal/hr)	Measured COP Range
General Electric	50	2.35	63.0	1.5–2.1
A.O. Smith	60/80	2.33	68.0/84.0	2.1
Stiebel Eltron	80	2.51	78.6	2.0 – 2.6

When compared to ERWHs, the energy and cost savings potential of HPWHs is tremendous. By moving thermal energy instead of converting electricity to heat, heat pumps are more efficient, operating at efficiencies of more than 200% in most cases. Converting all ERWHs to HPWHs could save American consumers $7.8 billion annually ($182 per household) in water heating operating costs and cut annual residential source energy consumption for water heating by 0.70 quads.

Lessons Learned

- Despite a slower recovery rate compared to ERWHs, the hybrid nature of these HPWHs enabled them to deliver hot water at temperatures above 110°F during the vast majority of draws.
- The primary variables that affect HPWH performance are hot water use (daily volume and draw pattern) and ambient temperature.
- The standby losses of the systems are higher than traditional ERWHs.
- Installation of HPWHs in confined spaces reduced efficiency by approximately 16%.
- Annual operating costs and source energy consumption for the monitored HPWHs were less than all alternative storage tank water heaters.
- Annualized energy-related costs (accounts for first cost and operating cost) for HPWHs were slightly less than ERWHs and considerably less than propane and fuel oil fired systems. Natural gas water heaters, however, are still the least-cost storage water heater option on an annualized energy-related cost basis.

Although HPWHs are a promising technology, successful installation requires careful consideration of clearance and weight, drain pans and condensate pumps, filter maintenance, and noise. Many of these details are discussed in more depth in the reports, *Measure Guideline: Heat Pump Water Heaters in New and Existing Homes* and *Selection and Quality Installation Guide for Heat Pump Water Heaters,* that were developed for the utility partners of this evaluation for use in their rebate programs.

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