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

Building America Case Study
Efficient Solutions for New and Existing Homes

Side-by-Side Testing of Water Heating Systems: Results from the 2013–2014 Evaluation Final Report

Cocoa, Florida

PROJECT INFORMATION

Project Name: Hot Water Systems Laboratory Year 4 Testing

Location Cocoa, Florida

Research Team: Building America Partnership for Improved Residential Construction (BA-PIRC)

Building Component: Water Heating

Year Tested: 2013–2014

Applicable Climate Zone: Hot-Humid

PERFORMANCE DATA

Projected Annual Energy Savings:

- Electric HPWH-80: 1,821 kWh/yr
- Electric HPWH-60: 1,690 kWh/yr
- Solar thermal (polymer): 891 kWh/yr
- Hybrid tankless NG (with 24-gallon storage): 5.6 therms/year
- Improved efficiency NG tank (EF 0.59 to EF 0.62): 4.8 therms/year
- 50-gallon electric heater with thermal blanket and insulation cap: 84 kWh/yr

Monitored energy data:
www.infomonitors.com/hws/

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From 2013 to 2014, the Building America Partnership for Improved Residential Construction (BA-PIRC) at the Florida Solar Energy Center (FSEC) evaluated seven water heating systems: two baseline models and five high-efficiency models. These systems are housed at the Hot Water Systems (HWS) Laboratory, a 160-ft^2 unconditioned building that approximates or exceeds garage-like temperature conditions in central Florida. Simultaneously, automated hot water draw schedules were used to evaluate and compare performance.

The systems evaluated (Figure 1, left to right, and Figure 3) include:

1. Standard 50-gallon (baseline)
2. Electric heat pump water heater 80-gallon
3. Electric heat pump water heater 60-gallon
4. Solar thermal single tank 80-gallon storage with polymer collectors (glazed), active-pumped via differential controller
5. Hybrid integrated tankless condensing unit with 27-gallon storage
6. Standard 40-gallon natural gas (NG) (improved efficiency baseline), which should meet the minimum requirements of 2015
7. Standard electric 50-gallon with CapWrap insulation.

Residential heat pump water heaters (HPWH) of medium and large capacity (60 and 80 gallons) are efficient electric water heating systems for larger residential homes (bedrooms >4). On average, these high-efficiency systems—which have a coefficient of performance (COP) >2.2—demonstrated energy savings of 62.5% at 60 gallons per day (gpd) over a standard electric water heater operating in a hot-humid climate. Cooling and dehumidification, although not the subject presented, are byproducts that can benefit conditioned or unconditioned spaces in hot climates.

Figure 1. 2013-14 HWS Lab Systems Lineup. See numbered list above.

HOT WATER SYSTEMS RESEARCH

Figure 3. Hybrid gas heater (pictured left) with small hot water storage—relative to tankless—reduces hot water delay to point of use, promoting water conservation with a relative high efficiency (COP 0.74).

Adding a blanket-wrap and an additional insulation cap at the top of a standard electric water heater (pictured right) increases performance efficiency by 5%. Higher energy savings are achieved in colder climates.

Figure 4. The solar polymer system with lightweight collectors (27 lbs. each) has a lower installed cost potential than standard solar systems. It also demonstrated an average electric reduction of 36%, partly impaired by long length (72 ft. one-way) circulation lines. The polymer open-loop system is also freeze tolerant.

For more information see the Building America report Side-by-Side Testing of Water Heating Systems: Results from the 2013-2014 Evaluation at *https://www1.eere.energy.gov/buildings/publications/pdfs/building_america/65403.pdf*.

Image credit: All images were created by the BA-PIRC Team.

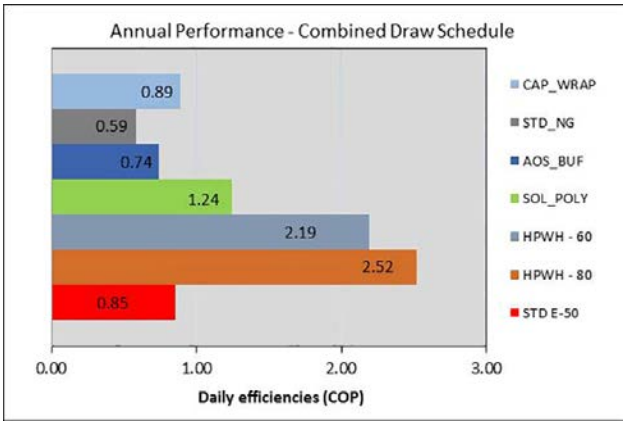

Figure 2. Averaged daily COP obtained from seven hot water heating systems at the HWS Laboratory. Average annual COP efficiencies of 0.82 and 0.56 were measured from the baseline electric 50-gallon and 40-gallon NG water heaters.

Lessons Learned

- Laboratory measurements revealed the performance efficiency of larger capacity HPWHs of 60 and 80 gallons, respectively, (COP of 2.2 and 2.5) under both standard (64.3 gpd) and typical family draw (52 gpd average) schedules. The 60-gallon HPWH on its highest-efficiency compressor mode operated at an annual average electric consumption of 2.7 kWh/day. This represents a 61.5% energy savings over the standard electric water heater baseline.
- A 60-gallon or larger HPWH is recommended for large family homes (bedrooms >4) due to larger capacity and temperature regulation over seasonal variations. On high-efficiency compressor mode, HPWHs operate around 800 watts compared to a 4,500-watt resistance heating element, although they require longer run cycles to satisfy the setpoint.
- The large capacity unit evaluated (80-gallon) has the ability to program turn-on heating (deadband). Higher energy savings may be achieved using the default factory set deadband (20°F), but comfort may be compromised. The centrifugal blower fan used may be perceived as quieter if installed indoors.
- A standard 40-gallon upright vented NG water heater with one-inch increased wall insulation (18-inch outside jacket diameter) improved efficiencies in the order of 5.0% (COP of 0.59) compared to previous-generation gas heaters tested in 2012. Similar performance efficiency gains are expected for NG water heaters complying with revised minimum energy factor ratings in 2015.
- Energy savings of 84 kWh/year on average were measured by installing a jacket and insulation cap with one-half inch air space on a standard electric water heater. Higher savings were measured from a high-performance argon-filled blanket (FiFoil) where it outperformed the bubble-type wrap in warmer ambient conditions. A payback of 3 years is achieved assuming a $0.12/kWh rate.

Looking Ahead

The HWS Laboratory at FSEC (Cocoa, Florida) completed a fourth and final round of water heater evaluations with thermostat setting of 120°F. Heat pump water heaters continue to demonstrate outstanding efficiencies compared to standard heaters. Further evaluations on hot water heaters will be performed by raising thermostat levels to 125°F.

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