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

Building America Case Study
Technology Solutions for New and Existing Homes

Multifamily Central Heat Pump Water Heaters

Davis, California

PROJECT INFORMATION

Project Name: West Village (UC Davis)

Location: Davis, California

Partners: Carmel Partners, UC Davis
ARBI, *arbi.davisenergy.com*

Building Component: Water Heating

Application: Multifamily, new construction

Year Tested: 2011–2013

Applicable Climate Zone: All, but Cold zones

PERFORMANCE DATA

Cost of Energy-Efficiency Measure: Costs vary based on application and whether comparing to central water heaters or individual water heaters. Based on project experience, current incremental costs estimated at ~$0 vs. individual gas water heaters, $10,000 vs. central gas water heating, and $20,000 vs. central electric.

Projected Energy Savings: 49–59% vs. central electric water heating

Simple Paybacks: 6–10 years vs. electric water heating; challenging economics vs. gas water heating.

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Heat pump water heaters (HPWHs) have gained high visibility in recent years as a high efficiency electric water heating solution for single-family homes. Central HPWHs for multifamily application are much less common with little available field performance data. HPWHs can be either ground-coupled or air source. Air source units are easier to install and less costly upfront, although performance is generally not as good as ground-coupled units.

In this project, the Alliance for Residential Building Innovation team monitored the performance of a central HPWH installed on a student apartment at the UC Davis West Village Zero Net Energy Community. Monitoring data were used to validate the TRNSYS building energy simulation model to project performance in different climates. Although natural gas was available at the West Village site, the project developer installed nominal 10.5-ton HPWHs as part of an overall all-electric solution for the project.

Performance was monitored in detail at one of the student apartment buildings for the period of October 2011 through January 2013. The monitoring was valuable in identifying initial installation problems and inadequate commissioning due partially to contractor infamiliarity with the technology. Over the next 12 months of monitoring, the HPWH operated reliably with the exception of a failed evaporator fan motor. The monitored HPWH operated with an annual coefficient of performance (COP) of 2.12, with minimal backup electric resistance heating (COP represents the HPWH hot water energy delivered divided by the electrical energy consumed).

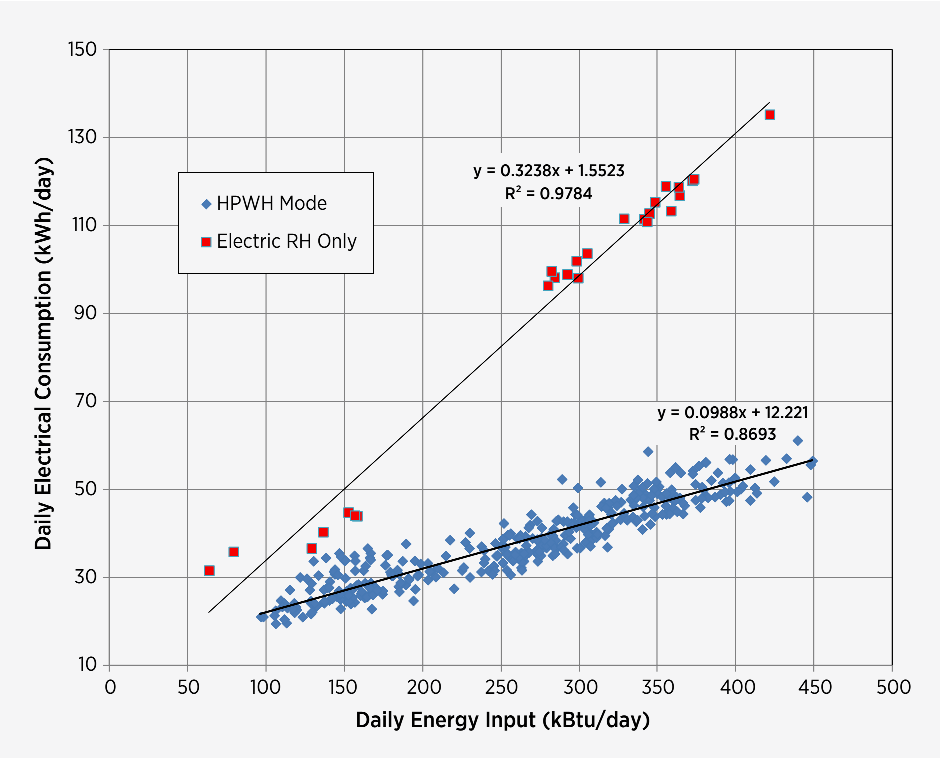
Looking Ahead

The HPWH technology is a valuable technology for replacing conventional electric resistance water heating. The technology will perform best in mild climates where electric rates are high and natural gas is unavailable (or expensive). States that currently have favorable rates and climates include Georgia, North Carolina, Alabama, Florida, and Hawaii.

Findings from the project suggest that more work needs to be undertaken so the technology's full potential can be realized. Key conclusions based on the monitored HPWH include:

- The standby electrical load due to pipe heaters, crankcase heaters, and controls was high, which significantly affected energy consumption, especially in the summer months when hot water loads were low.
- The monitored COP of the HPWH was consistent with the manufacturer's specification during steady-state operation. However, due to undersized storage, control impacts, and lack of a two-speed (or variable speed) compressor, the system rarely operated long enough to achieve steady-state performance.
- It is important that local installation and service personnel be familiar with the technology to facilitate proper operation from the beginning, which will result in more consistent unit maintenance over time.

For more Information, see the Building America measure guideline report: *https://www1.eere.energy.gov/buildings/publications/pdfs/building_america/measure_guide_hpwh.pdf*.



The graph plots measured daily kWh use as a function of increasing hot water load

Lessons Learned

- HPWHs perform best when outdoor temperatures are more moderate, inlet water temperatures to the unit are low, and operating cycle times are long enough to insure regular steady-state operation. If cycle times are short, performance suffers. This was evident in the summer monitoring, which showed the lowest average operating COPs during the year. Multistage compressors, oversized storage, or wider deadbands will serve to increase cycle times and improve performance.
- The installing contractor and service personnel should be familiar with the HPWH technology. Start-up issues in the initial construction phase contributed to early performance problems. These have been remedied in later project construction phases.
- Savings of 49%–59% are expected in typical applications relative to electric resistance water heating with paybacks in the range of six to 10 years (in lieu of any incentives). The comparison, relative to gas water heating, is more challenging due to current low gas rates in much of the country.
- Mechanical designers should carefully size the unit relative to the load and provide sufficient storage to allow the unit to operate extended run cycle to maximize efficiency.

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