Building America Case Study

Performance and Costs of Ductless Heat Pumps in Marine Climate High-Performance Homes: Habitat for Humanity—The Woods

Tacoma, Washington

PROJECT INFORMATION

Construction: New home

Type: Single-family, affordable

Partners:

Tacoma Public Utilities, *mytpu.org*

Habitat for Humanity of Tacoma/Pierce County, WA, *tpc-habitat.org*

Building America Partnership for Improved Residential Construction, *ba-pirc.org*

Size: 1,133–1,391 ft^2 (monitored) 950–2,500 ft^2 (all homes)

Dates Completed: 2013–2015

Climate Zone: Marine

PERFORMANCE DATA

DHP testing of the first seven homes suggests a DHP can offset 33%–58% of ER zonal space heating while maintaining thermal comfort and humidity control.

DHP typically adds $6.81/month to Habitat 30-year zero-interest fixed mortgage payments and saves roughly $16 to $30/month ($0.0853/kWh) in energy bills (electricity) in the first year.

Life-cycle cost analysis suggests that hybrid DHPs are more cost-effective than all-ER heaters in high-performance homes, and they provide air conditioning.

Building America SM U.S. Department of Energy

The Washington State University (WSU) Extension Energy Program—a member of the U.S. Department of Energy Building America research team Partnership for Improved Residential Construction (BA-PIRC)—works with builders in the cold and marine climates of the Pacific Northwest to develop exceptionally efficient residential construction practices. Many of these practices have been adopted in utility, state, and federal energy-efficiency programs, codes, and standards.

The Woods is a sustainable community built by Habitat for Humanity (Habitat) in 2013. This community comprises 30 homes that are high-performance and energy-efficient. With support from Tacoma Public Utilities (TPU) and the Bonneville Power Administration, WSU is researching the energy performance of these homes and the ductless heat pumps (DHPs) they employ. This project provides Building America with an opportunity to:

- Field-test heating, ventilating, and air-conditioning (HVAC) equipment; ventilation system airflows; building envelope tightness; and lighting appliances and collect other input data required for preliminary Building Energy Optimization (BEopt™) modeling and ENERGY STAR® field verification.
- Evaluate cost data from Habitat and other sources related to building efficiency measures that focus on the DHP/hybrid heating system and heat recovery ventilation (HRV) system.
- Evaluate the thermal performance and cost benefit of DHP/hybrid heating systems in these homes from the perspective of homeowners.
- Compare the space-heating energy consumption of a DHP/electric resistance (ER) hybrid heating system to that of a traditional zonal ER heating system. Conduct weekly "flip-flop tests" to compare space heating, temperature, and relative humidity in the ER zonal heating mode to DHP/ER mode.

Key Energy-Efficiency Measures

HVAC

- DHP with ER baseboards as backup
- Heating seasonal performance factor/seasonal energy efficiency ratio = 12/25
- Ventilation: HRV
  - HRV supplies fresh air to bed room zones
  - Kitchen range fans and bathroom exhaust fans provide intermittent local exhaust ventilation

ENVELOPE

- Wall R-value = 27 (R-21 + 1-in. XPS)
- Slab-on-grade R-value = 15
- Ceiling R-value = 49
- Windows U-value = 0.30
- Doors U-value = 0.19
- Air sealing, ACH50 = 3.2–4.7 (tested)

LIGHTING, APPLIANCES, AND WATER HEATING

- 100% compact fluorescent lamps and light-emitting diode bulbs
- ENERGY STAR® appliances
- DHP with ER backup
- Future test bed for other Building America research

For more information see the Building America report *Performance and Costs of Ductless Heat Pumps in Marine Climate High-Performance Homes—Habitat for Humanity The Woods* at *buildingamerica.gov*.

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

The Woods incorporates all the requirements for certification under ENERGY STAR Northwest Version 3.0. BEopt modeling indicates that these designs achieve the goal of the Building America program to reduce home energy use 30% to 50% (compared to 2009 energy codes for new homes).

The BA-PIRC team conducted one-year monitoring to verify whole-house energy use, HVAC performance, and occupant behavior related to interior conditions that affect comfort. The study helped to demonstrate, evaluate, and optimize the use of DHP/ER systems in low-load affordable housing communities. Also, the team educated occupants to encourage using the DHP as the primary heating source in lieu of the ER bedroom heaters.

With assistance from WSU, TPU will continue to research community-scale energy-savings assessments of annual and peak load profiles and occupant behavioral impacts associated with DHP.

"The Cottage," a 3-bedroom, 1,267-ft^2 home.

The Community Connections board shares general information and fosters interaction between residents at The Woods.

Lessons Learned

- DHP/hybrid heating systems provide Habitat homeowners with positive monthly cash flows from energy savings that are large enough to offset the higher mortgage payments.
- Higher R-value walls were achieved with 2 × 6-in. advanced framing, R-21 high-density batt insulation, and 1-in. extruded polystyrene (XPS) foam sheathing.
- Implementing a "built tight, ventilate right" approach requires specific design details and performance testing. This is done with Habitat crews and an ENERGY STAR verifier using infrared-guided air leakage testing and HRV flow-measurement equipment for commissioning to American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., Standard 62.2.

U.S. DEPARTMENT OF ENERGY
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For more information visit
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The U.S. Department of Energy's Building America program is engineering the American home for energy performance, durability, quality, affordability, and comfort.

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