



Building America Case Study

Northwest Energy Efficient Manufactured Housing Program High-Performance Test Homes

PROJECT INFORMATION

Construction: New Homes

Type: Single-family, affordable

Builders: Fleetwood Homes of Oregon,
Golden West Homes, Skyline Homes,
and Palm Harbor Homes

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

Size: 1,100–1,500 ft²

Price Range: Not available

Date Completed: 2014

Climate Zones: Marine and cold

PERFORMANCE DATA

HERS index: Data not available

Projected Annual Energy Cost Savings:
\$850–\$1,150

Incremental Cost of Energy-Efficiency
Measures: \$12,400 direct cost. Price
likely \$18,000 to \$24,000

Billing Data: Not available

High-Performance Manufactured Test Homes

The Northwest Energy Efficient Manufactured Housing Program teamed with the U.S. Department of Energy's research team Building America Partnership for Improved Residential Construction and Bonneville Power Administration to help four factory builders in the Pacific Northwest build prototype zero energy ready high-performance manufactured homes (HPMHs). The potential annual energy savings for this HPMH package ranges from about 8,000 to 10,000 kWh for each home, compared with those the factories typically build.

The HPMH package incorporates technologies that are not currently being used in manufactured homes and can be built in the factories with minimal changes to the current building process. The plants relied on their own suppliers and construction approaches to build each HPMH. Data about materials costs and additional installation labor costs (16 person-hours) were collected. If no cost reductions are realized in moving the HPMH into production (a worst-case scenario), the retail price of the package could be as high as \$24,000 for the homebuyer.

Modeling was performed in accordance with Building America House Simulation Protocols. The HPMH specification yielded a little less than 29% savings over the Building America Benchmark in a western Washington State marine climate location. The four homes are being monitored for energy and water use, temperatures, and humidity for 2 years in conjunction with the Northwest Energy Efficiency Alliance.

All the envelope improvements and energy-efficient mechanical technologies in the HPMH package are built with readily available equipment and materials. The HPMH uses a heat pump water heater (HPWH) that is fully ducted to extract heat from the tempered air in the crawlspace and exhaust it to outdoors. A ductless heat pump (DHP) with a single indoor head was installed in the main living area of each HPMH combined with electric resistance zonal heaters in secondary zones to meet the load at the heating design temperature. The floor

Key Energy-Efficiency Measures

HVAC

- Seasonal energy-efficiency ratio 19.2–25.5, heating seasonal performance factor 10.0–12.0, DHP with backup zonal heat units in each room (monitoring shows they almost never come on)
- Kitchen and bath fans vented to outside
- 22-watt exhaust-only whole-house ventilation fan.

ENVELOPE

- R-38 floor hybrid blown and/or batt/blanket insulation
- R-49 blown ceiling insulation in vented attic
- R-21 grade 1 fiberglass batts in 2 × 6 frame wall with R-5 foam sheathing
- Triple-pane, low-e/argon/krypton gas vinyl windows, U = 0.21–0.22, SHGC = 0.26–0.28, visible light transmittance = 0.45
- Blower door tests 2.75–3.57 ACH50 Pa.

LIGHTING, APPLIANCES, AND WATER HEATING

- 100% compact fluorescent lamps or light-emitting diodes or combination
- ENERGY STAR® dishwasher
- ENERGY STAR refrigerator
- Dual-ducted HPWH energy factor = 2.2
- Low-flow showerheads and faucets.

For more information, see the Building America technical report *Northwest Energy Efficient Manufactured Housing Program High-Performance Test Homes* at buildingamerica.gov.

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

has no duct system so up to 25% more insulation can be installed there. All four homes were built using 2 × 6 wall framing with R-21 insulation. House wrap was installed against the framing. R-5 foam sheathing was installed over the house wrap, which required longer fasteners for siding installation. All windows and doors were installed over a peel-and-stick flashing. The windows were all triple-pane, low-e, and filled with argon/krypton; they had a U-factor of 0.22/solar heat gain coefficient of 0.28 or lower. The attic insulation value of R-49 was achieved by packing the eave area.

In April 2014, Bonneville Power Administration utilities began offering a \$4,500 incentive for the HPMHs. Several HPMHs have been ordered from plants since the prototypes were built. Work continues to address building integration issues and seeks to further cost optimize the HPMH package. The goal is to make it affordable for many buyers of manufactured homes.

Lessons Learned

- The DHP hybrid zonal space-conditioning system provides most space heating and maintains even temperature distributions.
- The dual-vented HPWH installed in all four homes is efficient but expensive. Installing and insulating the 6-in. intake and exhaust metal ducting made it one of the more time-consuming measures to install. In the future, the General Electric Geospring 50-gal nonvented HPWH may be used.
- The ¾-in. foam installation appears to avoid problems with siding fasteners missing framing members and does not appear to contribute to transport racking issues.
- The added weight of the triple-pane windows (and other HPMH measures) often requires an additional axle under each home section. Extra labor is required to lift and install the windows. Lead time in ordering the window packages from new vendors delayed production schedules for all four homes.
- Nominal R-49 to R-60 attic values and nominal floor R-values of R-52 (belly)/R-32 (outrigger) were easily achieved using readily available materials.
- Preliminary analysis of energy use data from the monitored homes appears to agree well with predictions from Building Energy Optimization and SEEM modeling.
- U.S. Department of Housing and Urban Development code issues were few. Its labeling for egress windows was the only issue the window manufacturer quickly resolved.
- Costs to build an HPMH would likely decline with repetition, but its price will remain high enough to affect regional adoption. This could prevent some buyers from being able to secure a mortgage. The next phase will focus on cost optimization.