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

Building America Case Study
Efficient Solutions for New and Existing Homes

Simplified Air Distribution, Desuperheaters, and Sub-Slab Geothermal Heat Exchangers

Pittsburgh, Pennsylvania

PROJECT INFORMATION

Construction: New Home

Type: Single-family

Location: Pittsburgh, Pennsylvania

Research Team: IBACOS

Builder: S&A Homes

Size: 2,772 ft²

Price Range: About $340,000

Date completed: 2010

Climate Zone: Cold

PERFORMANCE DATA

Home Energy Rating System index: 27

Builder standard practice: 84

Projected annual energy cost savings: $559

Incremental cost of energy-efficiency measures: $15,000

Incremental annual mortgage: $200

Annual cash flow: $359

In March 2010, IBACOS and S&A Homes broke ground on the Best Practices Research Alliance's Energy Efficiency Lab Home in Cobblestone, a community in the northern suburbs of Pittsburgh, Pennsylvania. Supported by the U.S. Department of Energy's Building America Program, in partnership with the Building America IBACOS research team, the Lab Home research explored approaches for pursuing near-zero energy consumption in the cold-climate zone, which equates roughly to the northern half of the United States. Construction was completed in October 2010; data collection began in February 2011. More than 40 project partners collaborated to evaluate the Lab Home and its energy-saving systems against three criteria:

1. **Performance:** The Lab Home's performance was monitored to see how it conserves energy and how it provides a healthful, safe, durable, and comfortable environment. Hundreds of sensors allowed for the testing and monitoring of key factors such as individual system energy use, moisture dynamics, air exchanges, indoor air quality, and water use.
2. **Constructability:** Highly energy-efficient homes need to be easier for homebuilders to produce on a large scale. An analysis was completed of the building material availability, the time and training required to implement the technologies used in the Lab Home, and how to overcome barriers that homebuilders might encounter when adding a low-energy home to their product lines.
3. **Cost:** Cost tracking is being done to see how to make low-energy homes more affordable to build and buy, as well as how much these homes can save homeowners on energy bills and the overall value of those homes.

In addition to serving as a research tool, the Lab Home provides an excellent educational venue and a valuable source of information about what needs to be done to build low-energy homes.

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Energy Efficiency Measures

HVAC

- Carrier geothermal multispeed heat pump with zoning controls and a desuperheater
- Energy recovery ventilator
- Sub-slab geothermal heat exchanger
- Three air distribution systems studied for comparison: conventional ACCA Manual D, twopoint, and PVC low-flow—all in conditioned space

ENVELOPE

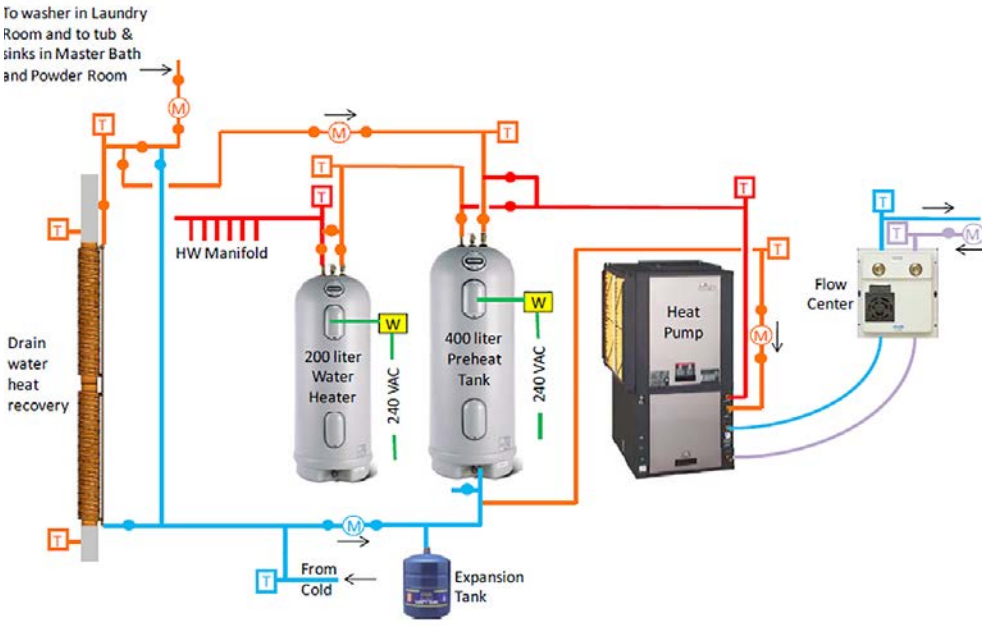
- Slab-insulated with R-10, 2-in.-thick XPS insulation
- R-60 ceiling blown fiberglass, 13-in. raised heel trusses, spray foam at roof-to-wall intersection
- R-40 blown-in insulation in 2 × 4 staggered stud exterior walls, 2-in. R-10 XPS exterior sheathing, housewrap
- Triple-glazed, single-hung, vinyl windows, U = 0.24 and SHGC = 0.22
- Tightly sealed house, <0.75 ACH50

LIGHTING, APPLIANCES, AND WATER HEATING

- 100% fluorescent lamps and light emitting diodes; controls
- Water heating supplemented by HVAC desuperheater
- ENERGY STAR® refrigerator, clothes washer, and dishwasher; gas, conventional cooking range

For more information see the Building America report Ground Source Heat Pump Sub-Slab Heat Exchange Loop Performance in a Cold Climate at *http://www1.eere.energy.gov/buildings/publications/pdfs/building_america/heat_exchange_loop_cold.pdf.*

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



Lab House HVAC/domestic hot water system schematic.

Lessons Learned

- **Simplified Air Distribution** – Significant reductions in distribution system complexity and conditioned airflow were found to have minimal thermal comfort effects in a well-insulated, tightly constructed home.
- **Desuperheater** – The overall performance of the geothermal heat pump can be improved, and "free" domestic hot water can be obtained with the use of a desuperheater. The single-tank was the best arrangement for cold climates such as Pittsburgh.
- **Geothermal Sub-Slab Heat Exchanger** – The sub-slab heat exchanger operated to successfully condition the house at lower-than-expected efficiencies. A detailed review of the modeling methods and software revealed areas that can be imporved to enhance future designs of similar geothermal heat exchangers. For example, the TRNSYS model could be used to accurately design future systems if the soil properties are well known and understood.

Looking Ahead

Initial research and analysis indicate valuable topics for future work. Much of this future work would be similar to the research and modeling that have been undertaken for vertical well systems, with the intent to understand the additional sensitivities of the sub-slab system.

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