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

Building America Case Study
Efficient Solutions for New and Existing Homes

High-Velocity Small-Diameter Duct System

Pittsburgh, Pennsylvania

PROJECT INFORMATION

Construction: New

Type: Single-family, two-story with basement

Partners:
Builder: S&A Homes, *sahomebuilder.com*
IBACOS, *ibacos.com*

Size: 2,772 ft^2

Price Range: About $400,000

Date Completed: 2010

Climate Zone: Cold

PERFORMANCE DATA

Home Energy Rating System Index: 27

Builder standard practice: 84

Case study house: 2,772 ft^2

With renewables: 81%

Without renewables: 67%

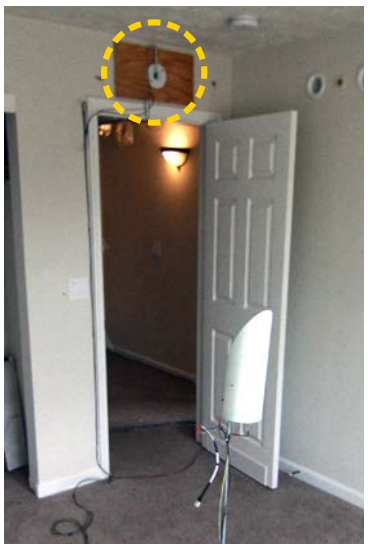
Projected annual energy cost savings: $559

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

Building AMERICA U.S. Department of Energy

Current engineering guidelines for forced-air space-conditioning systems use methodologies that were developed more than 50 years ago and based on the concept that buildings are dominated by externally driven shell loads. Significant advances in thermal enclosure performance suggest that traditional spaceconditioning systems should be rethought to better handle loads that are more strongly influenced by internal gains.

In a new unoccupied test house in Pittsburgh, Pennsylvania, the U.S. Department of Energy's Building America team IBACOS assessed the performance of a commercial high-velocity small-diameter air distribution system. The purpose was to test how the system handled the room-to-room cooling and heating loads with respect to Air Conditioning Contractors of America (ACCA) Manual RS criteria for thermal uniformity and ASHRAE Standard 55-2010 criteria for temperature variation with time. The main goal for using the small-diameter (2-in.) duct system was to simplify the installation of ductwork inside conditioned space.



Register location

Results showed that the ASHRAE criteria were not met during heating defrost cycles when auxiliary heat was not energized during defrost. More importantly, the ACCA criteria for room-to-thermostat temperature uniformity were not met in some rooms because of insufficient airflow and because the centrally located thermostat did not sense the solar gains. During typical heating mode days the master bedroom was consistently 3°–5°F lower than the thermostat. This bedroom was at the end of the longest duct run. During typical sunny days in cooling mode, the south-facing and west-facing bedrooms overheated by more than 3°F up to 40% of the time because of solar heat gains.

Key Energy-Efficiency Measures

HVAC

- Whole-house loads of 18,115 Btu/h (heating) and 11,424 Btu/h (cooling)
- High-velocity, small-diameter duct system (2-in.-diameter branch)
- Supply register air velocity greater than 1,000 fpm
- System design airflow of 250 cfm/ton
- Whole-house energy recovery ventilator exhausting from the kitchen, laundry, and baths and supplying an air handler unit return plenum.

ENVELOPE

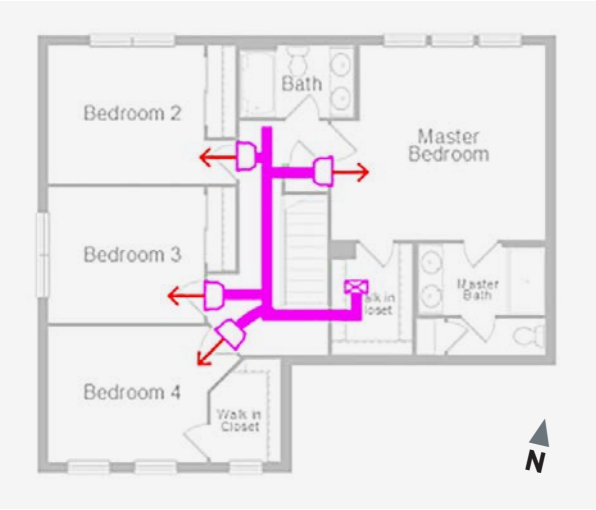
- Reflective shingle roof
- R-60 blown ceiling insulation in a vented attic
- R-30 blown cellulose insulation in 2 × 8 wall thickness with 2 × 4 staggered studs, plus R-10 continuous exterior sheathing
- Triple-pane, low-e, vinyl windows; U = 0.24, solar heat gain coefficient = 0.22
- Tightly sealed house, ACH50 = 0.54.

LIGHTING, APPLIANCES, AND WATER HEATING

Not applicable—unoccupied test facility.

For more information see the Building America report Measured Performance of a Varied Airflow Small-Diameter Duct System at *https://www1.eere.energy.gov/buildings/publications/pdfs/building_america/64161.pdf.*

Image credit: All images were created by IBACOS.



The small-diameter system allows for a simplified duct layout. Each room is supplied by one 2-in.-diameter branch. A single return is located on the first floor of the home.

Lessons Learned

The following lessons were learned from this project:

Pros

- Material and installation costs of small-diameter ductwork are lower for builders who wish to realize the energy savings of bringing ductwork into conditioned space compared to the cost.
- The relatively shallow bulkhead (dropped ceiling) height necessary for bringing small-diameter ductwork into conditioned space is more attractive to builders than traditional bulkheads.

Cons

- Register placement is more critical for reducing draft-related comfort concerns.
- The small-diameter system did not maintain room-to-thermostat temperature uniformity in all rooms because of insufficient airflow and lack of response to varying solar gains.
- Running the small-diameter duct system at high airflow rates significantly reduces fan efficacy. System control should maximize lower speed fan operation and minimize high-speed fan operation.

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DOE/GO-102017-4665 • April 2017