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

Building America Case Study
Efficient Solutions for New Homes

Occupant Comfort from a Mini-Split Heat Pump

San Antonio, Texas

PROJECT INFORMATION

Construction: New home

Type: Single-family, production

Builder: Imagine Homes, *imaginehomessa.com*

Size: 3,663 ft^2

Price Range: About $450,000

Date Completed: 2013

Climate Zone: Hot-humid

PERFORMANCE DATA

HERS Index: 39

Builder's standard practice = 55

With renewables = 39

Without renewables = 41

Projected annual energy cost savings—no photovoltaics (PV): $513

Incremental cost of energy-efficiency measures—no PV: $9,196

Incremental annual mortgage—no PV: $559

Annual cash flow—no PV: –$46

Billing data: Not available

IBACOS, a U.S. Department of Energy Building America research team, performed long-term monitoring of an occupied test house built by Imagine Homes in San Antonio, Texas. The research monitoring equipment measured the performance of key subsystems in the house including the effectiveness of the multihead mini-split heat pump (MSHP) system to provide adequate thermal comfort throughout the rooms in the house. Data were collected for 18 months, and the house was occupied for 9 of those months. This test house is projected to achieve 36% source energy savings relative to the Building America House Simulation Protocols (Hendron and Engebrecht 2010).

The ductwork was brought inside the house, but floor-plan design changes were minimized using an MSHP space-conditioning strategy. The photo on the left shows the ductless unit on the first floor, and the photo on the right shows the ducted unit on the second floor.

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Key Energy-Efficiency Measures

HVAC

- MSHP system (ducted and ductless units) with a seasonal energy efficiency ratio of 16.5 and heating seasonal performance factor of 9.2)
- All ductwork and indoor air handling units in conditioned space
- Energy recovery ventilator whole-house ventilation system (continuous operation)
- Kitchen and bath fans vented to the outside.

ENVELOPE

- R-5 extruded polystyrene insulation of exposed edge of monolithic slab foundation
- R-38 blown-in cellulose in vented attic
- R-20 Grade-1 cellulose insulation in 2×6, 24-in. on-center frame wall with R-5 extruded polystyrene foam continuous sheathing
- Double-pane, low-emissivity, vinyl windows; U-value = 0.36, solar heat gain coefficient = 0.25
- Tightly sealed house, air changes per hour at 50 Pa = 3.

LIGHTING, APPLIANCES, AND WATER HEATING

- 100% compact fluorescent lamps and light-emitting diodes
- ENERGY STAR® ceiling fans and appliances
- Solar thermal water heater
- 2-kW PV roof shingle system.

For more information, see the report *Mini-Split Heat Pump Evaluation and Zero Energy Ready Home Support* at *buildingamerica.gov*.

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

Hendron, R., and C. Engebrecht. 2010. *Building America House Simulation Protocols.* Golden, CO: National Renewable Energy Laboratory.

(Left) The first floor of the test house. (Right) The second floor of the test house.

Unit A of the MSHP system is associated with a ductless unit placed in the loft area, one ducted unit in the master suite, and another ducted unit between the other two bedrooms upstairs. Unit B refers to three ductless units: one in the study, one supplying the living room/kitchen/entry/dining room area, and one for the guest suite.

In heating mode, the temperature and relative humidity profiles for the rooms associated with Unit B were primarily controlled by the fireplace, which caused room temperature differentials exceeding 6°F. However, this difference would not be considered a comfort issue because the occupants used the fireplace as they felt necessary and did not note any complaints when surveyed. During cooling mode, the ductless unit in the living room area appears to adequately condition its adjoining spaces. The temperature differences among rooms serviced by Unit B rarely exceeded 1°F except when cooking was presumed to occur in the kitchen. The temperatures in the bedrooms were slightly less consistent. The temperatures in bedroom 3 and bedroom 4 tended to deviate from those of the guest suite—sometimes beyond the typical 3°F standard. This deviation could be considered uncomfortable, but the occupants did not indicate any level of discomfort because of this deviation. When the system is off, the temperatures tend to converge to within 1°F of each other, which suggests the difference is not the result of an additional load on the room.

Lessons Learned

The builder says using the MSHP system increases the marketing challenge. The builder is accustomed to building an insulated, sealed cathedralized attic assembly to enclose a traditional space-conditioning system. Customers respond well to the builder's unique marketing strategy that shows how a chocolate candy bunny will not melt in a semiconditioned attic. In an attempt to balance costs, the builder would pair a vented attic space and horizontal attic insulation with the MSHP system. In that case, the builder would lose the impactful marketing strategy. For buyers who prefer to eliminate ducts for health reasons or who like the ability to separately control space temperatures throughout the home, the MSHP system has greater appeal.

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The U.S. Department of Energy Building America Program is engineering the American home for energy performance, durability, quality, affordability, and comfort.

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