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

Efficient Solutions for New Homes

Building America Case Study

The Impact of Thermostat Placement in Low-Load Homes in Sunny Climates

Denver, Colorado

MAIN HOUSE CHARACTERISTICS

Location: Denver, CO

Climate Zone: Cold (International Energy Conservation Code CZ 5)

Type: Two-story, single-family

Foundation: Conditioned basement

Size: 3,399 ft^2

Number of Bedrooms: 3

Wall Insulation: R-13 cavity; R-5 continuous

Basement Insulation: R-15 continuous

Ceiling Insulation: R-50; no radiant barrier

Windows: U-value 0.27; SHGC 0.27

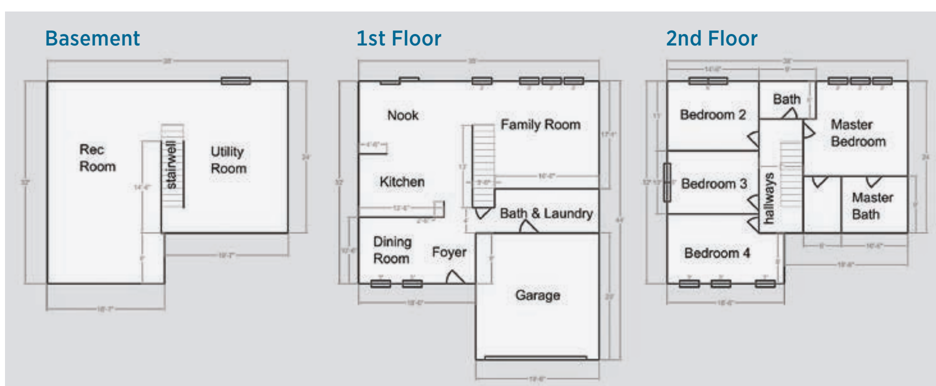
Heating Load: 35,883 Btu/h

Cooling Sensible Load: 12,566 Btu/h

Leakage: 0.10 ACHnat (2 ACH50)

The U.S. Department of Energy's Building America team IBACOS has found that low-load homes (zero energy ready homes) have differing room-to-room load densities and highly variable load densities throughout the day and year because of solar gains and internal gains. Traditional heating, ventilating, and air-conditioning systems in these homes with advanced thermal enclosures may not provide adequate thermal comfort. Thermostat placement is critical for optimum space-conditioning system performance and occupant comfort. Although thermostats often are centrally located for a single zone, this is not always the most effective approach for system performance and for maintaining individual room temperature variations.

IBACOS used 99 detailed TRNSYS models to determine the effect of different control strategies on three house geometries in three climate zones (CZs). By performing these simulations, IBACOS identified cases in which comfort standards were compromised and then determined improved space-conditioning strategies that builders can implement to reduce occupant discomfort. This case study focuses on one of those floor plans modeled in Denver, Colorado (International Energy Conservation Code CZ 5).



These floor plans show the basement and first and second floors of the house modeled in Denver. This floor plan is based on the Pittsburgh, Pennsylvania, unoccupied test house with both traditional ductwork and high velocity systems, which IBACOS has monitored extensively. IBACOS chose floor plans that correlate to houses monitored in the past to have the greatest impact and relevance to Building America goals and to make general comparisons.

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Simulation Combinations

IBACOS used 99 simulations, consisting of combinations of the following parameters, to analyze the conditions that resulted in the greatest risk of occupant comfort complaints and to determine which systems were the most effective.

THREE FLOOR PLANS:

- Single-story ranch (crawl space)
- Two-story on slab
- Two-story with basement.

THREE IECC CLIMATE ZONES:

- CZ 1: Hot (Orlando, Florida)
- CZ 3: Mixed (Fresno, California)
- CZ 5: Cold (Denver, Colorado).

THREE HVAC SYSTEMS:

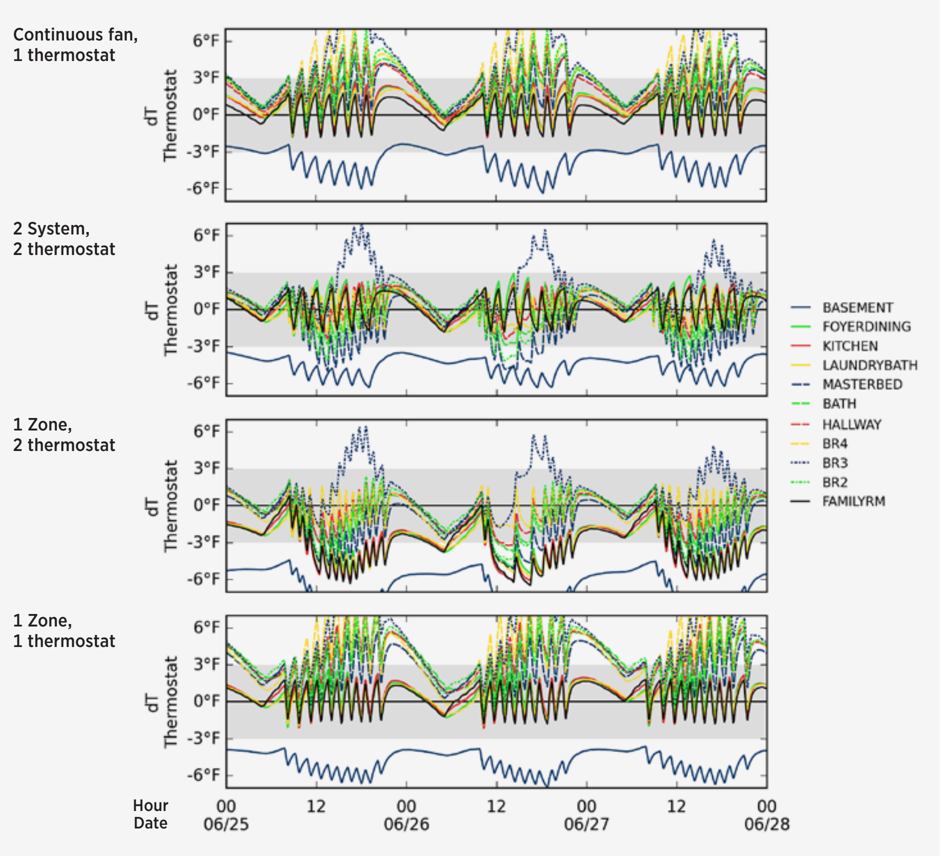
- Mini-split heat pump (combination of ducted and ductless)
- Traditional, centrally ducted system (gas furnace; direct expansion air conditioner)
- High velocity, small-diameter system (gas furnace, direct expansion air conditioner).

FIVE CONTROL STRATEGIES:

- Single zone; single thermostat
- Single zone; two thermostats
- Two zone; two thermostats
- Single zone; single thermostat; constant fan operation
- Responsive thermostat.

For more Information see the Building America technical report *Risk Assessment of Heating, Ventilating, and Air-Conditioning Strategies in Low-Load Homes* at *buildingamerica.gov*.

Image credit: All images were created by IBACOS.



These plots show the simulation temperature data in the summer for a two-story house with a basement in Denver, Colorado (CZ 5). The two-system, two-thermostat scenario provides the most uniform temperature.

Denver has significant diurnal temperature swings and a trend toward sunny days, making it challenging to condition this home with a single zone or thermostat. Also, the two-story home with a basement was the most difficult house type to condition because of its high window-to-wall area ratio and strong stack effect. For this case, the team determined that the best results occur when two zones and two thermostats are used; continuously running the air handling fan was insufficient to keep the house air mixed. The other strategies created undesired stratification, overcooling, or overheating in some rooms.

Lessons Learned

- The ideal control stategy, system type, and thermostat location vary with house geometry, climate, and latitude. Homebuilders should consider all of these parameters for proper system design.
- Typically, only one or two rooms pose comfort problems in low-load homes. Such rooms can be made somewhat more comfortable by changing the thermostat location for a particular house.
- Modeling exercises can give homebuilders valuable insight into the best tradeoff between occupant comfort and energy efficiency.

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