Building America Case Study

High-Performance Ducts in Hot-Dry Climates

PROJECT INFORMATION

Project Name: High-Performance Ducts in Hot-Dry Climates

Partners:

Alliance for Residential Building Innovation, *arbi.davisenergy.com*

Pacific Gas and Electric Company, *pge.com*

Building Component: Heating, ventilating, and air conditioning

Application: New; single- and/or multifamily

Year Tested: 2013–2014

Climate Zones: Hot-dry and mixed-dry

PERFORMANCE DATA

In early stages of HPD implementation, costs averaged about $1–$2/ft^2 of conditioned floor area, but are highly variable and expected to fall.

Projected energy savings: 4%–12% source heating and cooling savings versus low-leakage R-8 ducts in attic, depending on HPD, house type, and climate

Projected cost savings: $18–$80/year versus low-leakage R-8 ducts in attic (climate, system, and house dependent)

Building America SM U.S. Department of Energy

High-performance duct (HPD) systems are a key component of any high-performance home. Ducts must be installed within conditioned space in order to meet both the U.S. Department of Energy (DOE) Zero Energy Ready Home program and California's adopted 2016 Title 24 Residential Energy Efficiency code. In hot-dry climates, the impacts of duct losses on air conditioner sizing are significant and contribute to high peak air-conditioning demands and increased electricity grid instability. Efficient duct systems with lower losses under peak design conditions can lead to smaller heating and cooling systems, which help keep builder costs low and reduce complaints from residents about comfort and high utility bills.

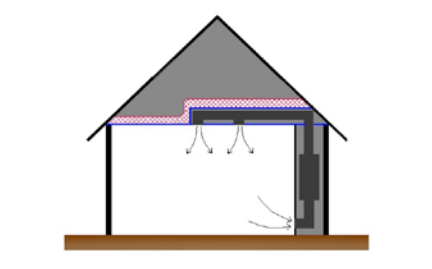
The DOE Building America team Alliance for Residential Building Innovation (ARBI) worked with Pacific Gas & Electric Company to secure participation from five builders in northern California to implement various HPD strategies. These strategies included ducts located fully within conditioned space, ducts in nonvented (sealed) attics, and a "high-performance attic" strategy that adds insulation to the roof deck of a normally vented attic. The ARBI team observed and documented construction methods, completed field testing of duct delivery effectiveness (DE), surveyed builders about construction costs and implementation issues, and developed energy-savings projections using Building Energy Optimization (BEopt™) in northern California, Arizona, and New Mexico. Developed by the National Renewable Energy Laboratory, BEopt is used to evaluate residential building designs and identify cost-optimal efficiency packages at various levels of whole-house energy savings.

Field test results for the different strategies showed significant improvement in DE, even compared to well-insulated, tightly sealed ducts. BEopt projections showed annual source energy savings of 11% for heating and cooling for ducts in conditioned space in the four climates evaluated. Other HPD strategies demonstrated somewhat lower projected savings.

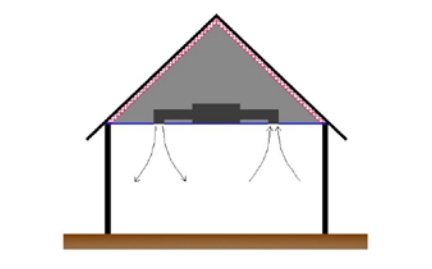
Other benefits of HPD systems include longer lifetimes for ducting, because its exposure to temperature extremes is reduced, and easier access to attic spaces by insulation contractors, which results in higher quality thermal enclosures.

DESCRIPTION

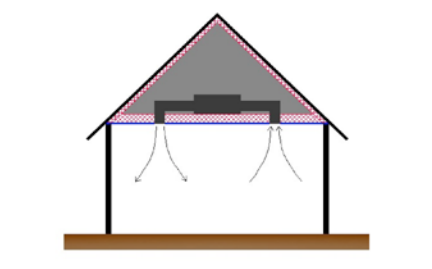
The ARBI team evaluated three HPD systems in California production homes: (1) ducts in sealed and attic duct chases, (2) ducts in a nonvented attic with R-20 spray foam applied to the roof underside, and (3) ducts and equipment in a "high-performance attic" that is insulated at the attic floor (R-30) and at the underside of the roof deck (R-13). BEopt analysis was completed for each of these cases in the Sacramento, Fresno, Phoenix, and Albuquerque climates.



1. Ducts in conditioned space (attic chase)



2. Nonvented attic



3. High-performance attic

For more information see the Building America technical report *High-Performance Ducts in Hot-Dry Climates* at *buildingamerica.gov*

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

Lessons Learned

Though the team recommended creating duct chases by lowering ceilings, three of the participating builders chose to construct chases through the attics to house the ducts. All three builders cited concerns about market acceptance of lowered ceilings in hallways and other small spaces. The attic chases effectively increased the area of the homes' thermal barrier and proved to be costly to build, seal, and insulate. Measured seasonal design and DE ranged from 95%–99%, which was slightly lower than the 100% DE that is assumed for ducts in dropped ceilings.

Attic chase and infrared image taken during a winter heating cycle

Testing of the nonvented attic used by the fourth builder showed almost 99% DE when it was evaluated using ASHRAE Standard 152, but about 15% of the energy supplied by the system went to the attic. Code changes that require at least R-30 insulation at the roof deck as well as the increased surface area of the thermal enclosure would make this approach more costly than others.

The fifth builder applied the lower-cost "high-performance attic" strategy (shown at right) that has been approved as a code-compliance option under 2016 California Title 24. The measured DE was about 93%, or 3–7 percentage points better than low-leakage R-6 or R-8 ducts in a standard vented attic.

While the attic chase and nonvented attic strategies were thermally successful, they were more costly than the dropped ceiling approach. More research is needed to find a solution that is less costly and more acceptable to builders.

Looking Ahead

HPD strategies are gaining traction throughout the country because interest in zero energy homes is increasing. California's 2016 Title 24 energy code is also driving the adoption of HPD. Improved coordination between architects, builders, and trades is needed to achieve cost-effective solutions—such as compact duct designs that can reduce equipment costs. Builders will benefit from this research and will find solutions that are both cost-effective and market-acceptable as early adopters test different strategies.

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

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