

## Cost Saving System Trade-Offs for Hot Climates

**Unvented Roofs, High Performance Windows,  
Combo Domestic Hot Water and Air-Conditioning System**  
vs.  
**Vented Roofs, Conventional Double Glazed Windows,  
Furnace and Air Conditioning System**

Building America is an industry-driven program sponsored by the U.S. Department of Energy (DOE) for applying system engineering approaches that accelerate the development and adoption of innovative building processes and technologies. The goal of the program is to produce energy efficient, environmentally sensitive, affordable, and adaptable residences on a community scale. Field support is provided by the National Renewable Energy Laboratory (NREL).

Building America (BA) homes use state-of-the-art building materials and building systems including spectrally selective glass (lets the visible light through but keeps the solar gain out) and an innovative unvented roofing system that encloses the home's thermal barrier. Ductwork and air conditioners are "inside" surrounded by room temperature air at 75°F rather than the 140°F air in a typically vented attic.

Six BA houses are models in the Pulte Home Corporation's Retreat at the Bluffs housing development in Tucson, Arizona. All six houses exceed Energy Star building requirements. In fact, they are predicted to use between 46% and 50% less energy (in Btus) for heating, cooling, and hot water, than a similar house built to meet the 1995 Model Energy Code in the southwest. In addition, the six houses have controlled mechanical ventilation to insure air exchange required for good indoor air quality.

The houses range in size from 1,332 square feet to 1,618 square feet and sell for \$73 to \$78 per square foot. Utility bills for heating and cooling are guaranteed through the "Engineered for Life" (EFL) program to cost between \$20 and \$30 per month. EFL is a Building

Science Corporation consortium member and a spin off of the U.S. Department of Energy's Building America program, in partnership with GreenStone Industries and Louisiana Pacific.

In the cooling mode, the energy efficient spectrally selective windows and unvented roof construction of the BA homes means



air-conditioning units can be 30% smaller than units in typically built homes. The BA homes in Tucson are superior in performance and have lower operating costs (i.e., utility bills and maintenance) than typical homes. They benefit the home owner because of lower electrical air-conditioning costs and lower gas heating costs. The homes also benefit utilities by reducing peak demand loads and installed cooling capacities.

Possibly most important, the BA homes are safer than typical homes. They have controlled mechanical ventilation that eliminates negative pressures that can cause soil gas, radon, and pesticide ingress plus spillage, back drafting of combustion appliances, and dust marking on carpets.

The BA design approach addresses the effect of air leakage in ductwork and air handlers in vented attics. By moving the thermal and airtightness plane to the roof deck, all of the ductwork and air handlers are within the conditioned envelope making leakage no longer critical to the safe and efficient operation of HVAC equipment. Although thermal gains may increase by as much as 5%, the penalty is offset by the thermal benefit associated with the 25% to 35% elimination of pressure differentials that drive uncontrolled air exchange. The net positive effect is a 20% to 30% reduction in energy use in a much safer building enclosure.

*The key problem addressed by the Building America approach is the effect of air leakage of ductwork and air handlers locate in vented attics. By moving the thermal and airtightness plane to the roof deck (right), all of the ductwork and air handlers are now located within the conditioned envelope (below).*



# Comparison of Energy Performance of Vented Roofs vs. Unvented Roofs in Tucson



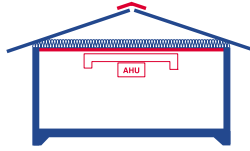
## BUILDINGS FOR THE 21ST CENTURY

Buildings that are more energy-efficient, comfortable, and affordable ... that's the goal of DOE's Office of Building Technology, State and Community Programs (BTS). To accelerate the development and wide application of energy efficiency measures, BTS:

- Conducts R&D on technologies and concepts for energy efficiency, working closely with the building industry and with manufacturers of materials, equipment, and appliances
- Promotes energy/money saving opportunities to both builders and buyers of homes and commercial buildings
- Works with State and local regulatory groups to improve building codes, appliance standards, and guidelines for efficient energy use
- Provides support and grants to States and communities for deployment of energy-efficient technologies and practices

### House 1 (Base Case)

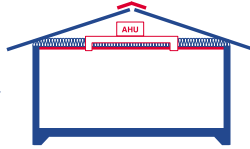
Fully Ventilated Attic, No Ductwork in Attic, Perfect Air Barrier at Ceiling



AHU and ductwork completely inside the conditioned space.

### House 2

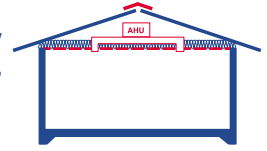
Fully Ventilated Attic, Perfectly Sealed Ductwork and AHU in Attic, Perfect Air Barrier at Ceiling



Energy performance -3% to -5% penalty compared with base case due to conductive losses across the ductwork and AHU.

### House 3

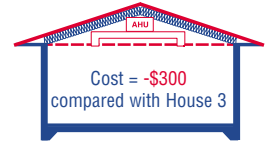
Fully Ventilated Attic, Leaky Ductwork and AHU in Attic, Imperfect Air Barrier at Ceiling



Energy performance -15% to -30% penalty compared with base case due to air change induced by leaky ductwork. House 3 is the true "Base Case" for typical residential construction.

### House 4

Non-Ventilated Attic, Insulation Tight to Underside of Roof Deck, Leaky Ductwork and AHU completely inside the Conditioned Attic, Typical Ceiling Construction



Cost = **-\$300** compared with House 3

Energy performance -3% to -5% penalty compared with base case (House 1). However, it allows for 15% to 25% savings over the true base case (House 3).

*\*Actual costs vary depending upon features selected by the builder/developer team.*

## INCREMENTAL COST SUMMARY TO ACHIEVE BUILDING AMERICA METRICS FOR TYPICAL HOUSE LAYOUT IN TUSCON\*

Not installing roof vents	\$ -250
Unvented roof, increased cost of moving insulation	+500
Advanced framing (2x6's with R-20 in place of 2x4's with R-11)	-250
High performance windows	+400
Insulated tank water heater (0.62 EF)	+75
Controlled ventilation system	+125
Downsizing A/C by 2.0 tons	-750
Increase furnace efficiency from 82% to 92%	+150
<b>Total Incremental Cost</b>	<b>\$ 0</b>

## Monetary Benefits to Owner

- Lower utility bills

## Other Benefits to Owner

- Healthier home due to controlled ventilation system
- Safer home due to aerodynamically uncoupled combustion appliances
- More comfortable home due to improved energy efficiency of building envelope
- More durable home with lower maintenance due to superior moisture control characteristics of building envelope

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July 1999 NREL/FS-550-26884