Whole-House Approach Benefits
Builders, Buyers, and the Environment

The Program
The U.S. Department of Energy’s (DOE) Building America Program is reengineering the American home for energy efficiency and affordability. Building America works with the residential building industry to develop and implement innovative building processes and technologies — innovations that save builders and homeowners millions of dollars in construction and energy costs. This industry-led, cost-shared partnership program aims to:

- Reduce energy use by 50% and reduce construction time and waste
- Improve indoor air quality and comfort
- Encourage a systems engineering approach for design and construction of new homes
- Accelerate the development and adoption of high performance in production housing.

A multi-year goal of Building America is to reduce energy use by an average of 50% compared to typical local construction.

Typical Local Construction

Building America Goal

MORE EFFICIENT

Prefabricated wall panels await assembly at the Meadow View community in Longmont, Colorado. McStain Enterprises is the builder partner.
The Whole-House Approach

The teams design houses from the ground up, considering the interaction between the building envelope, mechanical systems, landscaping, neighboring houses, orientation, climate, and other factors. This approach enables the teams to incorporate energy-saving strategies at little or no extra cost. Examples of innovative design improvements that result from this systems-engineering approach include:

- **Advanced framing systems.** By using 2x6 studs on 24-inch spacing instead of the more common 2x4 studs on 16-inch spacing, the builder greatly improves the insulating value of the walls and reduces labor and lumber required to assemble the framing. Structural Insulated Panels (SIPs) and other innovative wall systems may also be used to create an airtight, highly insulating wall construction.

- **Integrated envelope sealing package.** Combinations of taped sheathing systems, air-tight caulking of drywall, and better workmanship lead to lower air infiltration rates and reduce heating and cooling loads on mechanical systems. Mechanical ventilation is often added to ensure adequate fresh air for building occupants.

- **Energy-efficient windows.** Low-emissivity coatings and vinyl frames provide much higher levels of thermal insulation than standard windows with clear glass and aluminum frames. In hot climates, an additional spectrally selective coating may be added to reduce the amount of solar heat entering the house. Exterior shading and house orientation can also be used to control solar gains.

**Examples of Building America Framing and Air Tightness Improvements in a Cold Climate**

**Standard Wall Construction**
- Possible air leakage at joint
- Continuous air barrier
- 16” on-center spacing
- Drywall
- Siding
- R-11 insulation
- 2” x 4” wall studs

**Advanced Wall Construction**
- Taped exterior R-4 insulating sheathing (first air barrier)
- Drywall clips
- 24” on-center spacing
- Air-tight caulking (second air barrier)
- Drywall
- Siding
- R-19 insulation
- 2” x 6” wall studs

The whole-house approach often uses advanced framing and a double air barrier to improve insulation and air tightness in cold climates.
Windows and air ducts are frequently major contributors to heat loss in a home. Energy-efficient windows allow the use of shorter ducts that are easier to seal and less expensive to install.

### One Example of Building America Cost Trade-offs in Hot-Dry Climate

<table>
<thead>
<tr>
<th>Standard Practice</th>
<th>Building America</th>
<th>Cost Impact*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roof vents</td>
<td>Unvented roof</td>
<td>- $250</td>
</tr>
<tr>
<td>Uninsulated roof deck</td>
<td>Insulated roof deck</td>
<td>+ $700</td>
</tr>
<tr>
<td>2x4 framing, 16-inch spacing</td>
<td>2x6 advanced framing, 24-inch spacing</td>
<td>- $250</td>
</tr>
<tr>
<td>Clear glass windows</td>
<td>Low-e, spectrally selective windows</td>
<td>+ $500</td>
</tr>
<tr>
<td>4-ton air conditioner</td>
<td>2-ton air conditioner</td>
<td>- $1000</td>
</tr>
<tr>
<td>Natural ventilation</td>
<td>Controlled ventilation</td>
<td>+ $100</td>
</tr>
</tbody>
</table>

Total cost of upgrades: - $200

*Estimated costs for production builders. Actual costs vary depending on specific features and supplier discounts. (Negative indicates cost savings, positive indicates additional costs.)

### Optimally sized mechanical systems.
Significant reductions in heating and cooling loads allow the installation of smaller, more efficient heating and cooling systems. Mechanical systems with capacities more closely matched to actual loads also provide greater comfort.

### Ductwork improvements.
Heating and cooling ducts can be moved into conditioned space from the attic or basement, which reduces heat loss to or from the outside environment. Better duct sealing helps prevent the loss of conditioned air. Centrally located heating and cooling systems also lead to shorter supply and return duct runs, lowering construction cost and further reducing air leakage. The addition of return air transfers enhance comfort and minimize negative pressures that can cause moisture problems in humid climates.

### Factory construction.
Factory-made modules may reduce construction time and costs, and may also improve energy and resource efficiency. Better quality assurance and higher productivity may occur under factory conditions with a controlled environment, leading to tighter building envelopes and less wasted material.
Buildings for the 21st Century

Building America Industry Teams

The Participants

Building America’s systems engineering approach unites segments of the building industry that have traditionally worked independently of one another. It forms teams of architects, engineers, builders, equipment manufacturers, material suppliers, community planners, mortgage lenders, and contractor trades. There are five teams comprising more than 150 different companies.

**Building Science Consortium (BSC)**

**Team Leader:** Building Science Corporation

**Key Industry Partners:**
- Artistic Homes
- Ashland Construction
- Centex Homes
- DEC Therma-Stor
- Del Webb
- Dow Chemical
- Greenbuilt Homes
- Habitat for Humanity
- Hans Hagen Homes
- Ideal Homes
- Investec
- John Laing Homes
- Kaufman and Broad
- The Lee Group
- PPG
- Pulte Homes
- RPM Homes
- Southface Energy Institute
- Sturbridge Construction
- Town & Country Homes
- U.S. Green Fiber

**Consortium for Advanced Residential Buildings (CARB)**

**Team Leaders:** Steven Winter Associates

**Key Industry Partners:**
- Andersen Windows
- Beazer Homes
- Cambridge Homes
- Champion Home Builders
- Crosswinds Communities
- Del Webb
- Honeywell
- ITW
- McStain Enterprises
- Mercedes Homes
- Mitchell Homes
- Owens Corning
- Ryan Homes
- Simpson Strong-Tie
- US Steel
- Weyerhaeuser
- Whirlpool
- York

**Hickory Consortium**

**Team Leader:** Hickory Corporation

**Key Industry Partners:**
- Acorn Laboratories
- Building Science Engineering
- Cardinal Homes
- Center for Maximum Potential Building Systems
- Coachman Industries/All American Homes
- Epoch
- Excel Homes/Avis America
- Hampton Architect
- Oaktree Development
- Pella Windows
- Tamarack Technologies
- University of Central Florida

**Integrated Building and Construction Solutions (IBACOS)**

**Team Leader:** IBACOS, Inc.

**Key Industry Partners:**
- Burt Hill Kosar Rittelmann
- Carrier
- Civano Development Corporation
- The Estridge Companies
- Farm Homes
- Fortis Homes
- GE Appliances
- GE Plastics
- Hedgewood Properties
- John Wieland Homes
- Kohler
- Medallion Homes
- Montgomery & Rust
- Morrison Homes
- New Era
- Owens Corning
- Playa Vista
- Pulte Homes
- US Gypsum
- U.S. Army
- Venture Homes

**Industrialized Housing Partnership**

**Team Leader:** Florida Solar Energy Center

**Project Co-Funders:** Florida Energy Office and Northwest Energy Efficiency Alliance

**Key Partners:**
- American Energy Efficient Homes of Central Florida
- American Lung Association
- Atlantic Design & Construction
- Beck Builders
- Cavalier Homes
- Centex Homes
- Champion Enterprises
- D.R. Wastchek, LLC
- Energy Rated Homes of Nevada
- Fleetwood Homes
- Florida H.E.R.O.
- Florida Power Corporation
- Friedrich Air Conditioning Company
- Habitat for Humanity
- LaSalle Air Systems
- Nomaco, Inc.
- North Carolina A&T State University
- Oregon Office of Energy
- Pacific Northwest National Laboratory
- Palm Harbor Homes
- Southern Energy Homes
- Town & Country Homes of Texas
- Tyvek Weatherization Systems
- University of Central Florida
- Valley Manufactured Housing
- Washington State University Energy Program
- York International, Manufactured Housing Division
As of October 2000, the Building America approach has been used in the design of more than 2,000 houses in 24 states. This success is due to the efforts of more than 60 builders implementing projects in 48 different cities across the United States.

<table>
<thead>
<tr>
<th>State</th>
<th>City</th>
<th>Builder Partner</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arizona</td>
<td>Grand Canyon</td>
<td>National Park Service</td>
</tr>
<tr>
<td></td>
<td>Phoenix</td>
<td>VIP Homes</td>
</tr>
<tr>
<td></td>
<td>Phoenix</td>
<td>Pulte Homes</td>
</tr>
<tr>
<td></td>
<td>Phoenix</td>
<td>Del Webb Corp.</td>
</tr>
<tr>
<td></td>
<td>Phoenix</td>
<td>Palm Harbor Homes</td>
</tr>
<tr>
<td></td>
<td>Tucson</td>
<td>Pulte Homes</td>
</tr>
<tr>
<td></td>
<td>Tucson</td>
<td>Civano</td>
</tr>
<tr>
<td>California</td>
<td>Southern California</td>
<td>RGC</td>
</tr>
<tr>
<td></td>
<td>Simi Valley</td>
<td>Beazer Homes</td>
</tr>
<tr>
<td></td>
<td>Sylmar</td>
<td>Lee Homes</td>
</tr>
<tr>
<td>Colorado</td>
<td>Clear Creek County</td>
<td>Van Geet</td>
</tr>
<tr>
<td></td>
<td>Denver</td>
<td>Wonderland Builders</td>
</tr>
<tr>
<td></td>
<td>Denver</td>
<td>Habitat for Humanity</td>
</tr>
<tr>
<td></td>
<td>Longmont</td>
<td>McStain Homes</td>
</tr>
<tr>
<td></td>
<td>Pueblo</td>
<td>Domega Homes</td>
</tr>
<tr>
<td></td>
<td>Pueblo</td>
<td>Tierra Concrete Homes</td>
</tr>
<tr>
<td></td>
<td>Ft. Myers</td>
<td>Pulte Homes</td>
</tr>
<tr>
<td></td>
<td>Gainesville</td>
<td>Florida H.E.R.O.</td>
</tr>
<tr>
<td></td>
<td>Jacksonville</td>
<td>Pulte Homes</td>
</tr>
<tr>
<td></td>
<td>Melbourne</td>
<td>Mercedes Homes</td>
</tr>
<tr>
<td></td>
<td>Pensacola</td>
<td>Mitchell Homes</td>
</tr>
<tr>
<td></td>
<td>Plant City</td>
<td>Palm Harbor Homes</td>
</tr>
<tr>
<td>Florida</td>
<td>Atlanta</td>
<td>Venture Homes</td>
</tr>
<tr>
<td></td>
<td>Atlanta</td>
<td>Hedgewood Properties</td>
</tr>
<tr>
<td></td>
<td>Cobb County</td>
<td>Habitat for Humanity</td>
</tr>
<tr>
<td></td>
<td>Fairburn</td>
<td>Ashland Homes</td>
</tr>
<tr>
<td></td>
<td>Boise</td>
<td>Hidden Springs</td>
</tr>
<tr>
<td></td>
<td>Boise</td>
<td>Super Good Cents/Natural Choice</td>
</tr>
<tr>
<td></td>
<td>Grayslake</td>
<td>Sturbridge</td>
</tr>
<tr>
<td></td>
<td>Vernon Hills</td>
<td>Town &amp; Country</td>
</tr>
<tr>
<td></td>
<td>Indianapolis</td>
<td>Estridge</td>
</tr>
<tr>
<td></td>
<td>Frederick</td>
<td>Ryan Homes</td>
</tr>
<tr>
<td>Massachusetts</td>
<td>Boston</td>
<td>CWC/Thomas Construction</td>
</tr>
<tr>
<td></td>
<td>Cambridge</td>
<td>Epoch Corporation</td>
</tr>
<tr>
<td></td>
<td>Detroit</td>
<td>Crosswinds</td>
</tr>
<tr>
<td></td>
<td>Grand Rapids</td>
<td>Pulte Homes</td>
</tr>
<tr>
<td></td>
<td>Minneapolis</td>
<td>Centex Homes</td>
</tr>
<tr>
<td></td>
<td>Minneapolis</td>
<td>Hans Hagen Homes</td>
</tr>
<tr>
<td></td>
<td>Minneapolis</td>
<td>Pulte Homes</td>
</tr>
<tr>
<td></td>
<td>Minneapolis</td>
<td>Town &amp; Country</td>
</tr>
<tr>
<td></td>
<td>Las Vegas</td>
<td>Pulte Homes</td>
</tr>
<tr>
<td></td>
<td>Las Vegas</td>
<td>Watt Homes</td>
</tr>
<tr>
<td></td>
<td>Albuquerque</td>
<td>Artistic Homes</td>
</tr>
<tr>
<td></td>
<td>Rochester</td>
<td>Ryan Homes</td>
</tr>
<tr>
<td>North Carolina</td>
<td>Charlotte</td>
<td>Pulte Homes</td>
</tr>
<tr>
<td></td>
<td>Raleigh</td>
<td>Carolina Country Builders</td>
</tr>
<tr>
<td></td>
<td>Cleveland</td>
<td>Greenbuilt</td>
</tr>
<tr>
<td></td>
<td>Cleveland</td>
<td>Tesco Builders</td>
</tr>
<tr>
<td></td>
<td>Toledo</td>
<td>Randal Homes</td>
</tr>
<tr>
<td></td>
<td>Norman</td>
<td>Ideal Homes</td>
</tr>
<tr>
<td></td>
<td>Salem</td>
<td>Super Good Cents/Natural Choice</td>
</tr>
<tr>
<td></td>
<td>Chambersburgh</td>
<td>New Era Building Systems</td>
</tr>
<tr>
<td></td>
<td>Pittsburgh</td>
<td>Kacin Builders</td>
</tr>
<tr>
<td></td>
<td>Pittsburgh</td>
<td>Montgomery &amp; Rust</td>
</tr>
<tr>
<td></td>
<td>Charleston</td>
<td>McIntire</td>
</tr>
<tr>
<td>South Carolina</td>
<td>Charleston</td>
<td>CMPBS</td>
</tr>
<tr>
<td></td>
<td>Austin</td>
<td>Doyle Wilson</td>
</tr>
<tr>
<td></td>
<td>Austin</td>
<td>Del Webb Corp.</td>
</tr>
<tr>
<td></td>
<td>Georgetown</td>
<td>Beazer Homes</td>
</tr>
<tr>
<td></td>
<td>Houston</td>
<td>Medallion Homes</td>
</tr>
<tr>
<td></td>
<td>San Antonio</td>
<td>Pulte Homes</td>
</tr>
<tr>
<td></td>
<td>Fairfax</td>
<td>Super Good Cents/Natural Choice</td>
</tr>
</tbody>
</table>
The Results

Each Building America team is constructing test homes and developing community-scale projects that incorporate its systems innovations. DOE’s National Renewable Energy Laboratory (NREL) provides feedback on the systems-level benefits of energy technologies and design strategies implemented by the teams. Results to date demonstrate that Building America homes use 30% to 70% less energy than conventional homes and are more comfortable. These results are documented in Building America project summaries, case studies, and on the Building America Web site at www.eren.doe.gov/buildings/building_america/.

Benefits for Builders

Building America helps builders to develop a competitive advantage by reducing construction costs and improving the quality of the houses they build:

- Reduced callbacks and warranty claims
- Lower material and labor costs during construction
- Reduced purchase cost of mechanical equipment
- Less construction waste
- More options for the same sales price
- New product opportunities for manufacturers and suppliers
- Learning from other builders
- Prominence in the marketplace
- Advanced energy system integration, including photovoltaics and solar hot water.

A worker installs high efficiency, argon-filled windows with low-emissivity glass on this Building American home in the Prairie Crossing community in Grayslake, Illinois. Sturbridge Construction is the builder partner.
Benefits for Homeowners

Building America’s partnership with builders also provides important benefits to homeowners by improving the quality and affordability of the product they buy:

- Lower utility bills
- Greater comfort
- Better indoor air quality
- Energy-efficient mortgages
- Higher resale prices.

Benefits for the Nation

The energy-efficient, healthy, and environmentally friendly houses created under Building America contribute to a better quality of life for all citizens:

- Less reliance on fossil fuels
- Reduced greenhouse gas emissions
- More affordable homes for first-time homebuyers
- Lower medical costs resulting from unhealthy or unsafe living conditions
- Job creation in the energy-efficient building materials and equipment industry

Homes of the Future

The research conducted by Building America teams improves the quality and performance of today’s homes and provides valuable information for homes of the future. By supporting the development of innovative building methods and technologies that achieve significant energy and cost savings, the Building America Program is helping to shape the future of American homes.

Heating and cooling ducts are routed through open-web floor joists in a sealed crawl space for this Building America house in the Civano Community in Tucson, Arizona.

A third-story module is lifted into place on a prototype Building America duplex in a Cambridge, Massachusetts infill project. Epoch Corporation is the modular builder partner.
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- and 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.

Visit our Web sites at:
www.eren.doe.gov/buildings/building_america
www.pathnet.org/home.html
www.energystar.gov

Building America Program
George James • Building America Program • Office of Building Systems, EE-41 • U.S. Department of Energy
1000 Independence Avenue, S.W. • Washington, DC 20585-0121 • (202) 586-9472 • fax: (202) 586-8134
e-mail: George.James@ee.doe.gov • www.eren.doe.gov/buildings/building_america

Building Science Consortium
Betsy Pettit • Building Science Consortium • 70 Main Street • Westford, MA 01886 • (978) 589-5100 • fax: (978) 589-5103
e-mail: Betsy@buildingscience.com • www.eren.doe.gov/buildings/building_america/bsc.shtml

Consortium for Advanced Residential Buildings
Steven Winter • Steven Winter Associates, Inc. • 50 Washington Street • Norwalk, CT 06854
(203) 857-0200 • fax: (203) 852-0741 • e-mail: swinter@snet.net • www.carb-swa.com

Hickory Consortium
Mark Kelley • Hickory Consortium • 85 Depot Road • Harvard, MA 01451 • (617) 491-1888 • fax: (617) 491-6004
e-mail: dragon@world.std.com • www.eren.doe.gov/buildings/building_america/hickory.shtml

IBACOS Consortium
Brad Oberg • IBACOS Consortium • 2214 Liberty Avenue • Pittsburgh, PA 15222 • (412) 765-3664 • fax: (412) 765-3738
e-mail: boberg@ibacos.com • www.eren.doe.gov/buildings/building_america/ibacos.shtml

Industrialized Housing Partnership
Subrato Chandra • Florida Solar Energy Center • 1679 Clearlake Road • Cocoa, FL 32922 • (321) 638-1412 • fax: (321) 638-1439
e-mail: subrato@ucf.edu • www.baihp.org

National Renewable Energy Laboratory
Ren Anderson • 1617 Cole Boulevard, MS4111 • Golden, Colorado 80401 • (303) 384-6191 • fax: (303) 384-6226
e-mail: ren_anderson@nrel.gov • www.nrel.gov

Printed with a renewable-source ink on paper containing at least 50% wastepaper, including 20% postconsumer waste

May 2001 NREL/BR-550-27745

Two showcase manufactured homes being monitored side-by-side on the North Carolina A&T State University campus. A section of another manufactured home (below) is produced by Palm Harbor Homes in Plant City, Florida.