

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

### The Program

The U.S. Department of Energy's (DOE) Building America Program is reengineering new and existing American homes for energy efficiency, energy security, and affordability. Building America works with the residential building industry to develop and implement innovative building energy systems—innovations that save builders and homeowners millions of dollars in construction and energy costs. This industry-led, cost-shared partnership program has the following goals:

- Reduce average whole-house energy use by 30%–90% and reduce construction time and waste
- Improve indoor air quality and comfort
- Integrate clean onsite power systems leading to Zero Energy Homes
- Increase the energy efficiency of existing homes by 20%–30%.



A multi-year goal of Building America is to **reduce energy use** by an average of 30%–90% compared to typical local construction. By 2010, production-ready systems will be developed that increase efficiency by 40% and that add an additional 10% in energy savings through the use of onsite power systems.

Warren Gretz, NREL/PIX08743



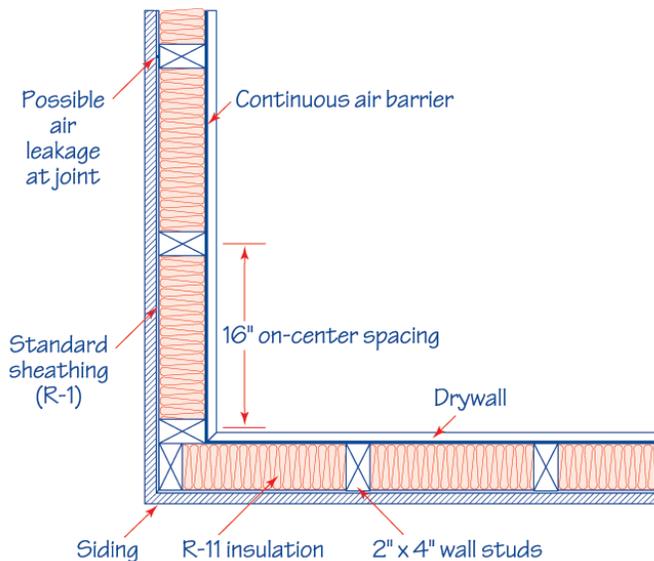
**Prefabricated wall panels** await assembly at the Meadow View community in Longmont, Colorado. McStain Enterprises is the builder partner (IBACOS).



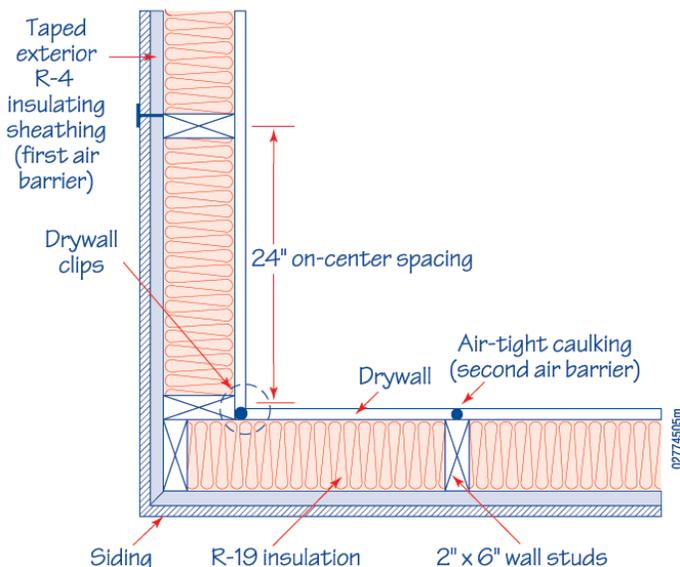
Warren Gretz, NREL/PIX08742

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

### Standard Wall Construction



### Advanced Wall Construction

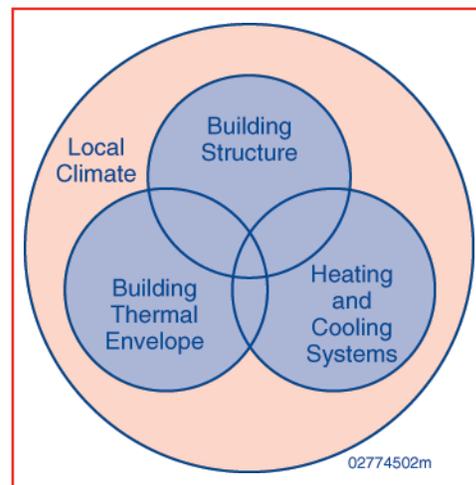


The whole-house approach often uses advanced framing and a double air barrier to improve insulation and air tightness in cold climates.

## The Systems-Engineering Approach

The Building America 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. The following are examples of innovative design improvements that result from this systems-engineering approach:

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**Advanced framing systems.** By using 2x6 studs on 24-in. spacing instead of the more common 2x4 studs on 16-in. 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.
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**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.
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**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.



Using a systems-engineering approach, Building America considers performance and interactions of all building systems.

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

Standard Practice	Building America	Cost Impact*
Roof vents	Unvented roof	-\$250
Uninsulated roof deck	Insulated roof deck	+\$700
2x4 framing, 16-in. spacing	2x6 advanced framing, 24-in. spacing	-\$250
Clear glass windows	Low-e, spectrally selective windows	+\$500
4-ton air conditioner	2-ton air conditioner	-\$1000
Natural ventilation	Controlled ventilation	+\$100
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.)

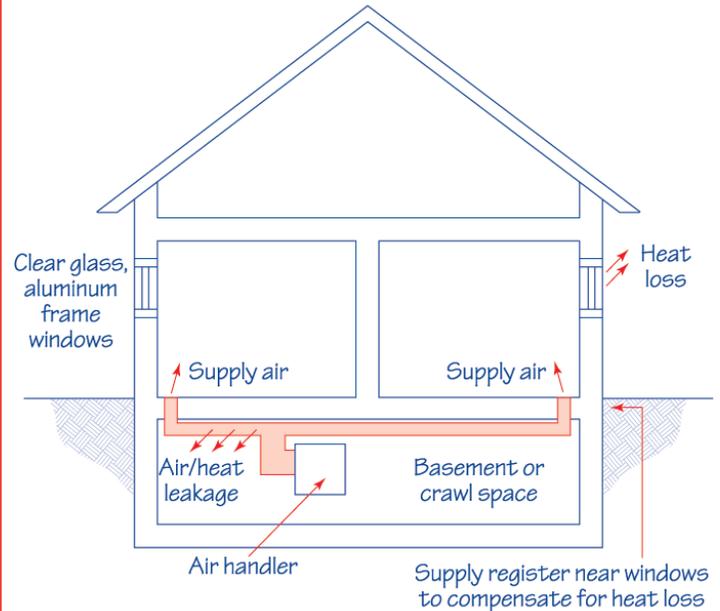
 **Optimally sized mechanical systems.** Significant reductions in heating and cooling loads allow the installation of smaller, more efficient heating and cooling systems. Mechanical systems with capacities more closely matched to actual loads also provide greater comfort.

 **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 enhances comfort and minimizes negative pressures that can cause moisture problems in humid climates.

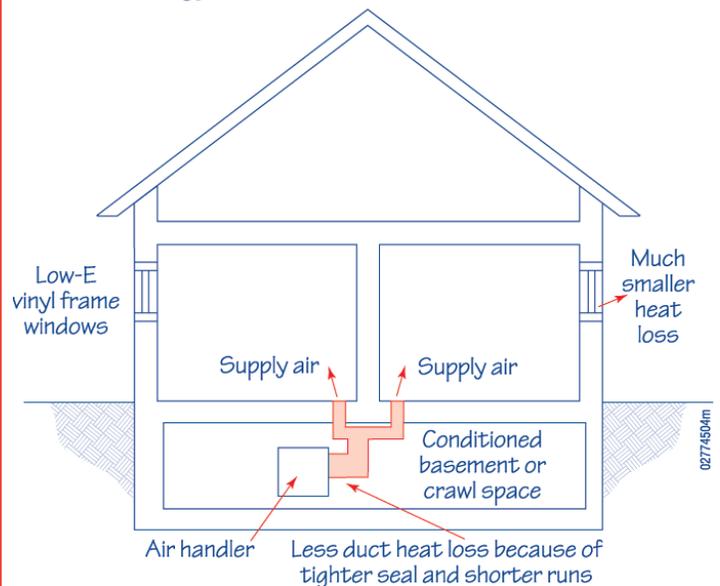
 **Factory construction.** Factory-made modules may reduce construction time and costs and may also improve energy and resource efficiency. Better quality assurance and higher productivity may occur under factory conditions with a controlled environment, leading to tighter building envelopes and less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

## Examples of Building America Window and Ductwork Improvements in a Cold Climate

### Inefficient Windows and High-Loss Ductwork



### Energy-Efficient Windows and Ductwork



**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.

## Building America Industry Teams

Visit the Building America Web site for detailed information on Building America teams, partners, builders, and suppliers: [www.buildingamerica.gov](http://www.buildingamerica.gov).

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.

### Consortium for Advanced Residential Buildings (CARB) [www.carb-swa.com](http://www.carb-swa.com)

**CARB**, led by Steven Winter Associates, Inc., works with scores of professionals throughout the homebuilding industry to design, engineer, and test energy-efficient homes. CARB projects start with a thorough analysis of current standard building practices and local climate conditions. The systems-engineering strategies used to build the houses assure the highest level of performance, while maintaining market appeal. Results range from a 40% improvement in energy efficiency with little or no cost to the builder, to truly "zero-net-electric" homes that produce as much energy as they use.

### Integrated Building and Construction Solutions (IBACOS) [www.ibacos.com](http://www.ibacos.com)

**IBACOS** has conducted many successful design and construction partnerships to deliver energy-efficient, high-quality, and affordable single-family homes since helping to launch DOE's Building America Program in 1991. IBACOS partners with innovative builders and developers with a commitment to continually challenge and evolve current building practices to deliver quality homes and communities. Past performance achievements include 40% to 60% utility savings to the homeowner annually with no additional cost to the builder, in addition to increased home durability, comfort, safety, and health aspects of the home.

### Building Industry Research Alliance (BIRA) [www.bira.ws/](http://www.bira.ws/)

**BIRA**, the Building Industry Research Alliance, is a diverse coalition of industry professionals working to research better, more cost-effective ways to meet Building America goals. Our partners include builders, architects, community planners, building scientist, lenders, utilities, retrofit specialists, state energy offices, public interest groups, building product and appliance manufacturers. The BIRA partners' common goal is to make homes more resource efficient and more affordable. The BIRA team, lead by ConSol, has been successful in meeting and exceeding the 2005 Building America goal of 40% improvement in whole-house efficiency, including more than 10% renewable, onsite energy.

### Davis Energy Group (DEG) [www.davisenergy.com/index.html](http://www.davisenergy.com/index.html)

Davis Energy Group complements the Building America collaborative with its 20+ years of technology development, building energy analysis, and field-monitoring experience. In addition to working with builders, DEG identifies needs and opportunities for new technologies, conducts funded R&D to develop them and to evaluate their potential, and facilitates production by teaming with manufacturers. DEG also works with ACEEE to identify other promising technologies and participates in California's appliance standards proceedings to help to raise the performance bar. These activities produce more efficient choices for the building industry and facilitate progress toward Building America's efficiency and renewables goals.

### NAHB Research Center [www.nahbrc.org](http://www.nahbrc.org)

Created in 1964 as a subsidiary of the National Association of Home Builders (NAHB), the NAHB Research Center has become the source for reliable, objective information and research on housing construction and development issues. The center's mission is to promote innovation in housing technology, thus improving the durability, affordability, and environmental performance of homes and home-building products. The Research Center has a unique relationship with the housing industry and a breadth of technical expertise, resulting in an unrivaled depth of understanding of the housing industry and access to its business leaders in fulfilling clients' research needs.

### Building Science Consortium (BSC) [www.buildingscience.com](http://www.buildingscience.com)

**BSC** works to design cost-effective, energy-efficient single-family homes for each of the U.S. climate regions. BSC builder partners have adopted Building America concepts to construct thousands of energy-efficient homes. Re-engineering and design is underway in additional locations. Results from homes tested for a year at Prairie Crossing in Grayslake, Illinois, confirm that their techniques allow for 50% to 60% energy savings over the regional standard construction practice at a small incremental cost over the builder's standard practice.

### Industrialized Housing Partnership (IHP) [www.fsec.ucf.edu/bldg/baihp/](http://www.fsec.ucf.edu/bldg/baihp/)

**BAIHP** brings decades of application-oriented energy research and industry consulting together with researchers from around the country. IHP focuses on effectively balancing cost, design, construction, and energy decisions to develop customized solutions for their residential housing industry partners. BAIHP project goals include the following:

- Cost effectively reducing the energy cost of industrialized housing by up to 50%, while enhancing indoor air quality, durability and productivity
- Improving the energy efficiency of thousands of homes produced annually with industrialized methods.



BIRA/PX13539

*The Schingler residence in Stockton, California, is a Building America prototype house built by BIRA that will have a 42% energy savings, as determined by computer simulation.*

## The Projects

As of August 2004, the Building America approach has been used in the design of more than 26,000 houses in 34 states. This success is a result of the efforts of more than 250 builders implementing projects in many cities across the United States.

Visit the Building America Web site at [www.buildingamerica.gov](http://www.buildingamerica.gov) to learn more about Building America and for a full listing of Building America house projects with detailed specification.

## Research that Works

Building America's systems-engineering approach unites segments of the building industry that have traditionally worked independently of one another. Building America forms teams of architects, engineers, builders, equipment manufacturers, material suppliers, community planners, mortgage lenders, and contractor trades.

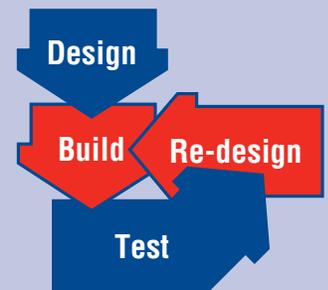
The concept is simple: systems engineering can make America's new homes cost effective to build and energy efficient to live in. Energy consumption of new houses can be reduced by as much as 40% with little or no impact on the cost of construction.

In order to reach this goal, Building America teams work to produce houses that incorporate energy- and material-saving strategies from design through construction.

First, teams analyze and select cost-effective strategies for improving home performance. Next, teams evaluate design, business, and construction practices within individual builder partnerships to identify cost savings.

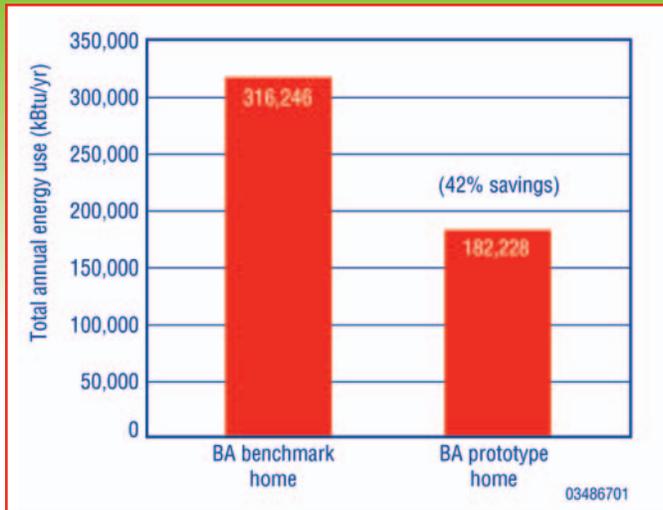
Cost savings can then be reinvested to improve energy performance and product quality. For example, a design incorporating new techniques for tightening the building envelope may enable builders to install smaller, less expensive heating and cooling systems. The savings generated in this process can then be reinvested in high-performance windows to further reduce energy use and costs.

The initial "test" home is the field application of proposed solutions. The team builds this prototype home according to their strategic design, tests each system for efficiency, and makes any necessary changes to increase efficiency and cost effectiveness. Before additional houses are built, these



changes are incorporated into the design. This process of analysis, field implementation, re-analysis, and design alteration facilitates ultimate home performance once a design is ready for use in production or community-scale housing.

Understanding the interaction between each component in the home is paramount to the systems-engineering process. Throughout design and construction, the relationship between building site, envelope, mechanical systems, and other factors is carefully considered. Recognizing that features of one component can dramatically affect the performance of others enables Building America teams to engineer energy-saving strategies at little or no extra cost.



Computer simulation shows that the Schingler prototype house in Stockton, California, will provide a 42% savings on its annual energy bill. The house was a BIRA project.

High efficiency, argon-filled windows with low-emissivity glass were installed on this Building America home in the Prairie Crossing community in Grayslake, Illinois. Prairie Holdings Corporation was the builder partner (BSC).



Warren Gretz, NREL/PIX04670



Warren Gretz, NREL/PIX04671

## 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%–40% 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.buildingamerica.gov](http://www.buildingamerica.gov).

## 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 onsite power system integration, including photovoltaics and solar hot water
- ✓ Improved air quality and comfort
- ✓ Accelerated development of high-performance housing options.

## 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 energy efficiency strategies and integrating onsite power systems, the Building America program will ultimately develop homes that produce as much energy as they use.



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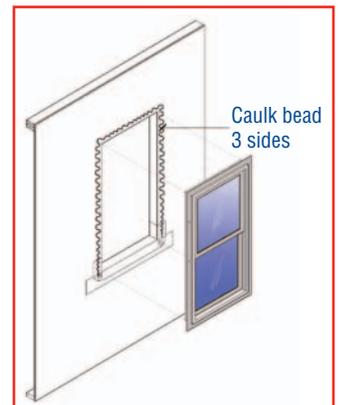
Heating and cooling ducts are routed through open-web floor joists in a sealed crawl space for this Building America house in the Civano Community in Tucson, Arizona.



CARBPIX13538

Mercedes Homes, with the assistance of CARB, created a "Mold Response Team" to address incidents of moisture and mold damage and to remediate those problems. The information gained will be used to further refine and improve house performance and how the mold problem is addressed.

Mercedes Homes uses a quality control and feedback loop to improve window installation. The flashing techniques are based on a CARB recommendation to standardize practices regionally and to create a field "check-off" list to be used by a supervisor who views, and approves, each installation.



## A Strong Energy Portfolio for a Strong America

Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and greater energy independence for America. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a diverse portfolio of energy technologies.

## Research and Development of Buildings

Our nation's buildings consume more energy than any other sector of the U.S. economy, including transportation and industry. Fortunately, the opportunities to reduce building energy use—and the associated environmental impacts—are significant.

DOE's Building Technologies Program works to improve the energy efficiency of our nation's buildings through innovative new technologies and better building practices. The program focuses on two key areas:

- **Emerging Technologies**  
Research and development of the next generation of energy-efficient components, materials, and equipment
- **Technology Integration**  
Integration of new technologies with innovative building methods to optimize building performance and savings

For more information contact:  
EERE Information Center  
1-877-EERE-INF (1-877-337-3463)  
[www.eere.energy.gov](http://www.eere.energy.gov)



U.S. Department of Energy  
**Energy Efficiency  
and Renewable Energy**

An electronic copy of this factsheet is available on the Building America Web site at [www.buildingamerica.gov](http://www.buildingamerica.gov)

*The Industrialized Housing Partnership monitored the performance of the two side-by-side showcase homes on the campus of North Carolina A&T State University, demonstrating a savings of more than 50% in the heating, cooling, and hot-water energy bills in this Building America prototype. The performance of the Zero Energy Manufactured Home (inset at right) is currently being monitored in Lewiston, Idaho, in partnership with the Bonneville Power Administration.*



David Beal, FSEC/PIX09705

IHP/PIX13537

## Visit our Web sites at:

[www.buildingamerica.gov](http://www.buildingamerica.gov)

[www.pathnet.org](http://www.pathnet.org)

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