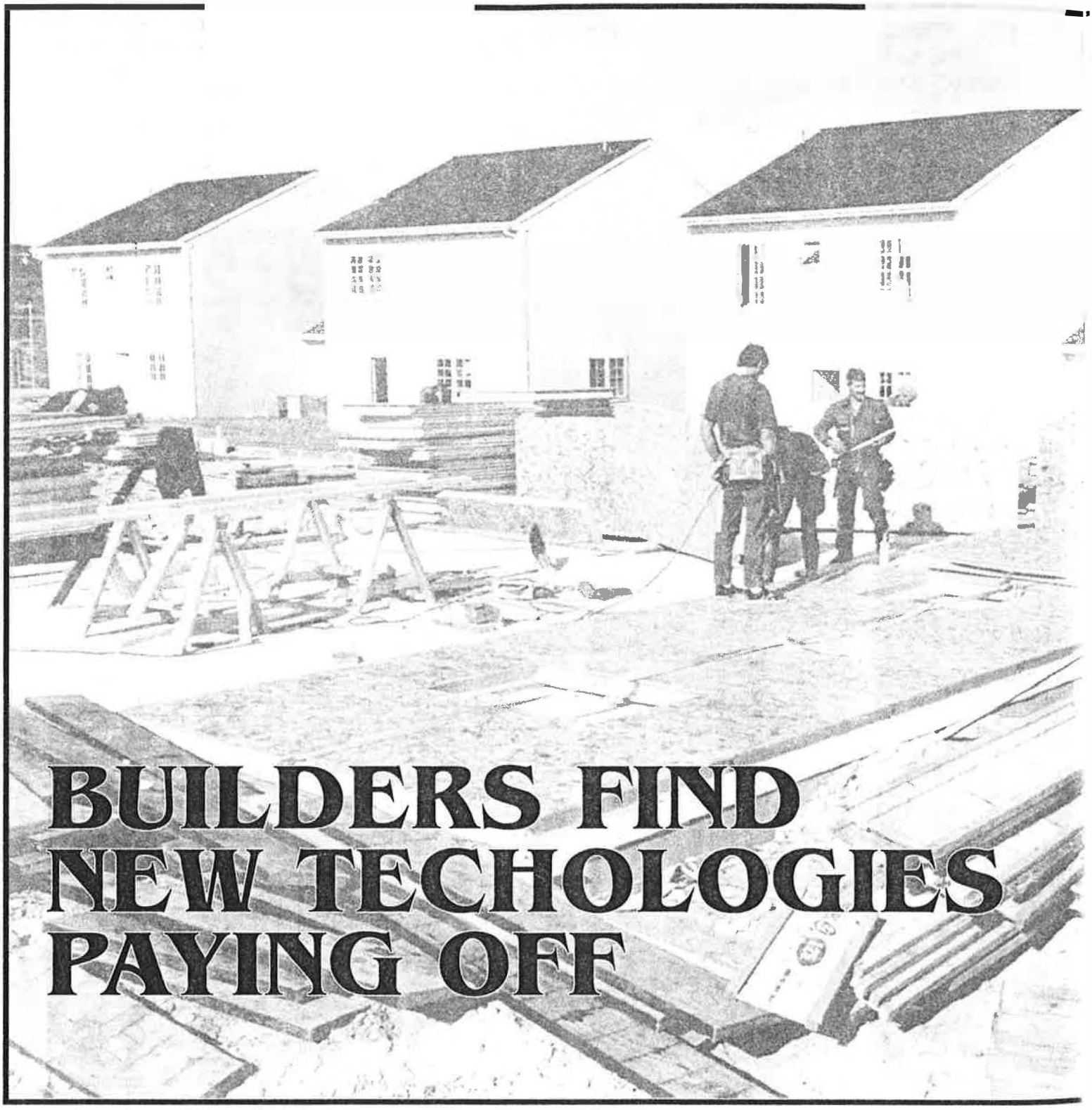


# BUILDERS FIND NEW TECHOLOGIES PAYING OFF

Builders across the United States are seeing strong sales of homes that can reduce heating and cooling bills by as much as 50% but cost about the same as conventional homes to build. In the process of designing, building, and analyzing these homes, they've learned lessons about systems engineering that all builders can put into practice.

STEVEN WINTER ASSOCIATES

# by Steven Bodzin

In 1993, the U.S. Department of Energy (DOE) invited building scientists, architects, and engineers to take part in a program, called Building America, that would bring highly efficient, super-comfortable homes into the mainstream market. According to the program manager, George James, Building America would aim to use a systems engineering approach to build appealing homes with reduced construction time and construction waste. Energy use in the homes would be cut by as much as 50%. Four consortia were formed to carry out this aim. As they began to work out in the field, they developed the joint goal of building 2,000 systems engineered homes by the year 2000.

Today, more than 600 of these homes have been built and are currently occupied (see Table 1). According to James, the program is on track for meeting its year-2000 goal, and expects to have trained 15,000 to 20,000 individual builders through direct experience and on-site workshops. The homes built so far include town houses, multifamily developments using modular construction, and single-family homes, and are found in locations ranging from upstate New York to Los Angeles. They appear in standard, mainstream production homes as well as in projects that focus on energy efficiency and cost savings.

Most importantly, Building America has provided the opportunity for building scientists to demonstrate how a systems engineering approach to building can make homes better in many ways—less expensive to operate, yet more comfortable. The monitoring and testing of Building America homes has shown positively that this approach can be successful on a large scale.

## Cooperation for Success

The success of the Building America program is the result of cooperation among the four winning consortia and a long list of partners (see "The Builder Partners," p. 21). Homes are designed by the consortia and are financed, built, and marketed by the individual builder members of each consortium. The consortia are led by building scientists, architects, and engineers, and their members include a range of manufacturers and consultants. The program works with large and medium-sized production builders across a variety of demographics and regions.

## Unique Approaches

One of the advantages of the Building America program is that, with the variety of groups involved, many different ideas have been explored and tested out. The four consortia have each taken different approaches to improving the homes they design and build.

Integrated Business and Construction Solutions (IBACOS), of Pittsburgh, Pennsylvania, was the first Building America consortium. According to Glenn Cotrell, an architect at IBACOS, it has made some major changes in its approach. When IBACOS first worked with Ryland Homes to build pilot houses in 1993, it was looking for new products that would make the difference in energy efficiency. However, IBACOS soon learned that inefficient homes weren't necessarily the result of poor products. It found that the real problems were poor design and quality control, and a widespread attitude that efficiency is too expensive. IBACOS's current approach is to reengineer the building. IBACOS engineers start by looking at the entire home, finding ways to economize on HVAC, framing, and other areas. While saving money on extra framing members and duct runs, they also try to improve the energy efficiency of all the houses' systems, from lighting, to heating, to windows.

Steven Winter, president of Steven Winter Associates (SWA) of Norwalk, Connecticut, explains that the Consortium for Advanced Residential Building (CARB)—an SWA project—initially tends to "pack pilot homes with as many improvements as possible," and then weeds out the improvements that don't work. CARB has experimented with a broad range of innovative materials, such as structural insulated panels, steel framing, and adhesive housewrap.

Betsy Pettit, architect at Building Science Consortium (BSC), of Westford, Massachussetts, says, "We believe you can make a lot of improvements, even to a wood stick-frame house." As pioneers of systems engineering, BSC has focussed on design. However, they also aim to teach tradespeople their goals and tech-

niques so the workers can offer improvements to materials and processes.

The fourth consortium—the Hickory Consortium, based in Cambridge, Massachusetts—has worked almost exclusively with modular construction. Hickory has facilitated the design, analysis, and construction of urban infill housing, including a duplex and an extremely efficient 41-unit cohousing condominium development.

**Table 1. Building America Homes, by State**

| | | | |
|---|---|---|---|
| Arizona | 3 | Nevada | 134 |
| California | 213 | New York | 2 |
| Colorado | 10 | North Carolina | 1 |
| Illinois | 130 | Pennsylvania | 52 |
| Maryland | 3 | Texas | 2 |
| Massachusetts | 43 | | |
| Minnesota | 10 | Total | 603 |

Homes are currently under way in Florida, Georgia, Idaho, Missouri, and Ohio, while 200 more are also under way in Colorado.

## Pilots Lessons

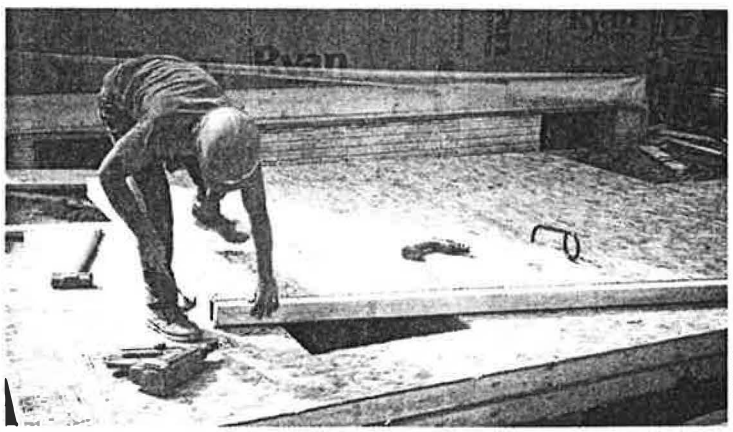
Although the specific changes they make to their buildings can vary, all of the consortia follow the same protocol in making those changes. They start out by creating pilot homes through reengineering one or two houses, while monitoring and testing one of the builder's standard houses as a reference. Once the pilots are built, the consortia collect feedback. The houses are subjected to a week of Short-Term Energy Monitoring (STEM) testing, an evaluation procedure developed by National Renewable Energy Laboratories (NREL). Other feedback can come from interviews with tradespeople and focus groups with potential home buyers, to find out what can be improved. They repeat the process at least once, this time building five improved houses. They typically consider a particular approach to be production-ready after about ten reengineered houses are built. Even then, the consortia sometimes monitor energy use for as much as a year in the production-scale homes in order to verify the predictions of the energy monitoring.

The result of these extensive efforts is one or two pilot houses that are built with supervision and training from each consortium. The consortia also determine how comfortable the houses are, and how well the tradespeople working with the builder members adapt to the new techniques and designs. Finally, each consortium asks the crucial question: Does the new design cost more, or less, to build?

All the consortium members involved in building the pilot home report on their experiences and discuss options for how to build the home more quickly and smoothly, and at less cost. For example, a mechanical contractor with Town & Country homes developed a better return duct method for the HVAC system, while framers at the same project came up with a better header framing detail. Tradespeople also find that they benefit from sharing information (see "Creating New Techniques," p. 22).

The dozens of Building America pilot homes brought to light many insights about such issues as attic venting, advanced framing, and using water heaters to heat homes. For example, Building Science Consortium showed that unvented roofs perform better than vented roots in hot-dry and hot-humid climates (see "Conditioned Attics Save Energy in Hot Climates," *HE* May/June '97, p. 6). They also showed that in many cases, houses don't need a fully distributed return duct system, that supply ventilation works better than exhaust ventilation, that supply ventilation with dehumidification is necessary for controlled ventilation in hot-humid climates, that polyethylene vapor barriers are generally a bad idea, and that batt insulation in basements is always a bad idea because it causes mold problems. (For more information on ventilation, see "Mechanical Ventilation for the Home," *HE* March/April '96, p. 13).

Despite these results in the pilot homes, however, the fact remains that some builders are legitimately skeptical of results from pilot homes that are built with the extra supervision from the consortium. The real proof of systems engi-



STEVEN WINTER ASSOCIATES

Structured insulated panels (SIPs) were used in CARB's Building America homes whenever appropriate because of the speed and ease of construction, because they contain renewable resources, and because of their high R-values.

BACOS

For this house at the Village at Washington's Landing, in Pittsburg, Pennsylvania, builder Montgomery & Rust specified Werzalit composite wood and resin siding, which features excellent moisture resistance. Rigid foam joints were taped to minimize air infiltration.

STELLA TARNEY/CAMBRIDGE COHOUSING

Modular units by EPOCH being placed at the Hickory Consortium's Cambridge Cohousing site in Cambridge, Massachusetts. The units are completed up to 90% on the factory floor, reducing waste and allowing for factory quality control.

neering comes when many production homes are built, sold, and lived in. The great success of Building America is that it has shown unequivically that systems engineering works in the real world, on large scales (see "Building America: Real World Results," p. 24).

## The Question of Cash

All of the Building America consortia have had great success in reducing energy use, increasing comfort, and reducing callbacks (see Table 2). However, one goal of the program has not always been met. The building costs have sometimes been slightly higher—rather than the same as—the costs for standard construction.

For example, BSC's analysis of its pilot homes in both Chicago and Las Vegas found cost increases for the builder. With the Town & Country homes in Vernon Hills, the price increases were minimal. However, the early Prairie Crossing houses cost about $2,000 more to build than standard code-compliant homes. About $1,000 of this increase came with a relatively long payback period, but it raised the average savings in heating season energy use to about 60%. BSC has since dropped this $1,000 worth of measures, bringing costs closer to parity with conventional homes, but the heating season energy savings are now predicted to average about 40%. To put this savings into perspective, it is greater than homes in the U.S. Energy Star program, which must reduce heating season energy use by 30%.

Other Building America builders have had the same experience. David Kipnis, a consultant for Civano, says, "I can get you 30% savings at no cost. But with the next 20%, you start getting diminishing returns. I find there has to be a premium."

An untapped marketing angle of the Building America program is the issue of "payback," or "return on investment." The homes built under this pro-

## The Builder Partners

**Building Science Consortium, Westford, MA**

Braemer Homes, Agoura Hills, CA
Del Webb, Georgetown, TX
Domega Homes, Pueblo, CO
Hidden Springs Community, Boise, ID
Investec, Santa Barbara, CA
The Lee Group, Marina Del Rey, CA
M/I Homes, Raleigh, NC
Pulte Home Corporation, Las Vegas, NV
Pulte Home Corporation, Tucson, AZ
Pulte Homes Corporation, Maitland, FL
Pulte Homes Corporation, Bloomfield Hills, MI
Pulte Homes of Minnesota, Mendota Heights, MN
Randal Homes, Waverly, OH
Sturbridge Construction (formerly Shaw), Grayslake, IL
Town & Country Homes, Minneapolis, MN
Town & Country Homes, Westchester, IL
Watt Homes, Denver, CO
Watt Homes, Las Vegas, NV

**Consortium for Advanced Residential Building (CARB), Norwalk, CT**

Beazer Homes, Orange, CA
Crosswinds Communities, Novi, MI
Del Webb, Phoenix, AZ
Michael Homes, Pensacola, FL
Ryan Homes, Thurmont, MD
Wonderland Custom Builders, Boulder, CO

**Hickory Consortium, West Wareham, MA**

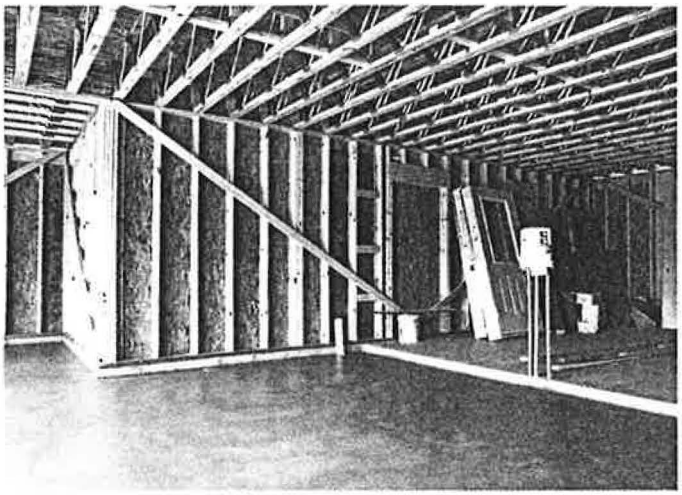
Codman Square Community Development Corp., Dorchester, MA
Epoch Corporation, Pembroke, NH
Green Village, Cambridge, MA
Oaktree Development, Cambridge, MA
Suffolk Construction, Boston, MA

**IBACOS Consortium, Pittsburgh, PA**

Brookfield Homes, Costa Mesa, CA
Case Enterprises, Tucson, AZ
Classic Homes, Colorado Springs, CO
EPAC Development, Costa Mesa, CA
Estridge Homes, Indianapolis, IN
Ferree Development, Pittsburgh, PA
The Forecast Group, Corona, CA
Medallion Homes, San Antonio, TX
Montgomery & Rust, Pittsburgh, PA
New ERA Building Systems, Strattanville, PA
Pulte Homes Corporation, Silver Spring, MD
Pulte Homes Corporation, Chicago, IL
Pulte Homes Corporation, Phoenix, AZ
Pulte Homes Corporation, Las Vegas, NV
RecreActions Group of Companies (RGC), Newport Beach, CA
Ryland Homes, Columbia, MD
Sundance Homes, Chicago, IL
John Weiland Homes, Atlanta, GA
West Homes, Allison Park, PA
Doyle Wilson Homebuilder, Austin, TX

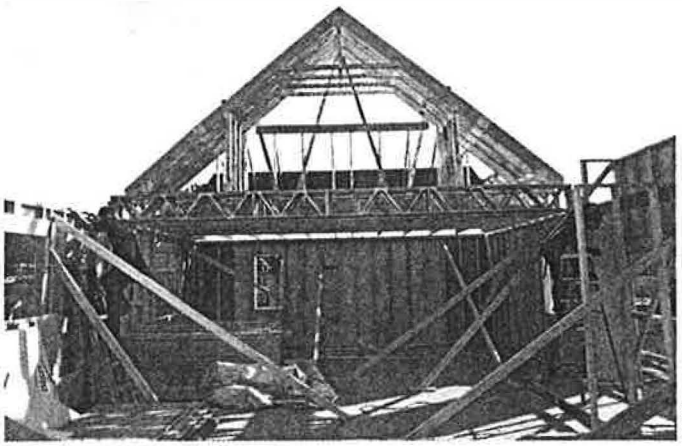
**Table 2. Comparison of Callback Rates for BSC Homes**

| Callbacks | Typical Homes | BSC Homes |
|---|---|---|
| related to comfort | 3%–5% | 0 |
| related to paint and trim | 5% | 1% |
| related to drywall cracking | 50% | 10% |



IBACOS

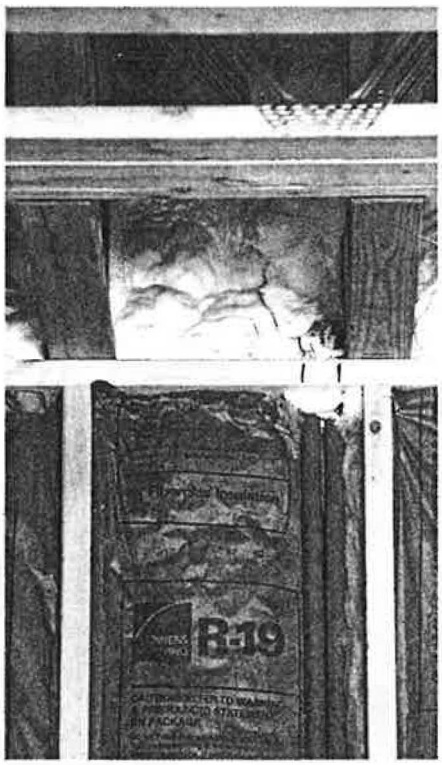
Open-web trusses at this Washington's Landing home use recyclable steel for webs for clear spans, providing design flexibility and open floor plan.



IBACOS

Combined roof and floor trusses in the Washington's Landing home allow additional ceiling height on the top floor. With structural components directly transferring loads from the roof to the foundation, less framing material was needed, increasing the effective insulation value of the shell.

gram are selling for the same price as other homes with similar amenities built by the same builder (the builder absorbs the excess costs), but people who buy Building America homes see an instant advantage in reduced energy costs. The energy savings start paying off right away, since there's no extra first cost for the buyer.




IBACOS

Icynene spray-in flexible foam insulation was used at Washington's Landing in areas where insulating with more traditional materials was difficult. Here, the foam is sprayed into the band joist area, with fiberglass batt insulation used in the wall cavity below.

## Market Transformation?

While individual energy-saving houses are important, the real goal of Building America is to transform the market, which means getting enough companies to offer high-performance homes that performance becomes part of what consumers ask for. It could be that Las Vegas is closer to this goal than any other city. There, two large production builders—Pulte and Watt—have been vying for consumer attention as the high-performance home builder in the area.

Both are Building America partners. Watt, which builds more than 300 homes per year, now only builds homes that meet Building America standards. Pulte is not yet following Building America designs for all its homes, but the company is incorporating techniques learned from its Building America experiences in all of the 1,100 or so homes it builds this year in the city. For example, in one new project, it included unvented attic air space and hydronic heating systems.

For these companies, efficiency

## Creating New Techniques

Building America tradespeople have found that they benefit from sharing information on the job. For example, CARB project manager Don Clem worked with the local HVAC installer that was chosen by the team for a project in Syracuse, New York. Clem noticed that the HVAC contractor learned a lot about computer aided design. Meanwhile, Clem learned about tools and materials. "There's a give and take with any craft," he explains. "Especially in a mechanical area." Clem learned, for example, the proper way to join round metal pipe to flex duct. Once he had worked with the experienced HVAC installer, he had knowledge he could apply to future designs.

Building Science Corporation (BSC) recently released a report on its work. In this report, BSC says that the tradespeople chosen by the teams were very interested in learning about innovative techniques—although they were not always quick to change their habits. The tradespeople did not initially want to change how they did their work, the report said, but they became very enthusiastic about new ways of doing things once they had finished a home and could see how they had contributed to the functioning product. "Plumbers were interested in the innovative framing techniques, and electricians were fascinated by the need for ventilation systems," the report said. "Many ... wanted to apply the most current building science thinking to their own [home renovation] projects." This interest can turn into valuable research assistance, BSC found, as the framers kept coming up with better details such as headers at windows, roof truss geometry, and sealing rim joists. Also, the HVAC contractors came up with simpler duct layouts—especially for return systems.

IBACOS

Field commissioning tests prior to wallboard installation at the Washington's Landing home identified thermal shell and duct system weaknesses at a time when modifications were most cost-effective. Pre-drywall tests demonstrated 0.13 ACH.

IBACOS

The HVAC equipment in the 3200 ft², four-story house is located on the second floor, reducing the amount of duct-work needed.

seems to be paying off. According to Angel Moran, construction manager at Watt Homes in Las Vegas, one surprise was that the company's own workers bought several of its first Building America development homes. She adds that the Energy Star certification from the joint DOE and Environmental Protection Agency program helps to show consumers that the improvements are not just hype.

To spread the word, the local building association just started an energy committee, with Dave Beck, Pulte's construction director, as chair. Now several more builders are jumping on the home performance bandwagon and plan to join the BSC team. According to Beck, Pardee Homes and Lewis Homes are both learning systems engineering techniques.

## Home Performance Goes Mainstream

Gradually, Building America techniques are becoming more widely accepted. They have moved in two directions: around the market, and to different units of large companies. Within the Las Vegas market, for example, more and more tradespeople and builders are understanding how to use unvented roofs to increase HVAC efficiency.

Glenn Cotrell, of the IBACOS consortium, points to the RecreActions Group of Companies (RGC) as an example of this success. IBACOS worked with RGC on a pilot home, and then helped it to design three home models based on lessons learned from the prototype. RGC recently built 183 homes in Southern California using designs developed from this Building America pilot house.

Domega Homes in Pueblo, Colorado, built 10 homes under Building America and has continued building to that level of efficiency outside of the program. It is now building 230 systems-engineered, high-performance houses using the knowledge it gained through its participation with BSC.

Within companies, the knowledge spreads slowly but surely. For example, Angel Moran says that other branches of Watt—in Denver and Utah—are starting to pick up on the techniques learned in Las Vegas. Pulte's Beck sees his techniques spreading to Phoenix and Tucson.

Beazer Homes, a member of CARB, is unusual in that it pays David Root, its vice president of operations, to spread the systems engineering concepts learned through their Building America participation across its various units around the country. Beazer is currently building CARB system-engineered houses in Houston.

And knowledge of these techniques is spreading among tradespeople as well. Once construction supervisors have learned the new energy efficiency techniques, they sometimes implement them on other homes right away. BSC reports that supervisors who learned that stopping drafts around fireplaces and bathtubs could reduce backdrafting and pipe freezing immediately began to apply that knowledge on other projects.

Beyond its goal of building 2,000 homes by the year 2000, the Building America consortia intends to facilitate the adoption of a systems engineering approach to design and construction in 70 percent of the new housing market within 10 years.

*Steven Bodzin is a freelance writer in San Francisco and a former managing editor of* ***Home Energy.***

### Building America Contacts

For more information on Building America projects and research results, contact George James; EE-41, U.S. Department of Energy, 1000 Independence Ave. SW, Washington, DC 20585-0121. Tel:(202)586-9472; E-mail: george.james@hq.doe.gov; Web site: www.eren.doe.gov/buildings/building_america.

*Funding for Building America is provided by the Department of Energy. Analysis support came from the Florida Solar Energy Center, and testing support came from the National Renewable Energy Laboratory.*