IBACOS/PIX04791

Buildings for the 21st Century

By using a systems engineering approach, Building America teams have shown that energy-efficient homes need not cost more. This home, built by Building America's IBACOS Consortium team members in Rancho Santa Margarita, California, incorporates a tightened building shell with high-performance low-E windows and a centrally located HVAC system that uses 50% less duct work. The home is expected to be 30% more energy efficient but costs no more to build than comparable conventional homes in the area.

It's the first quarter of the 21st Century. We are living, working, and playing in buildings that are significantly more energy efficient—50 to even 70 percent or more efficient! Not only that, they are more affordable, brighter, and more comfortable. Indoor air quality is no longer a concern and construction wastes, no longer an issue. Some of us are using or living in buildings requiring us to buy very little energy. That's because major progress has been made toward constructing and renovating buildings that, later in the century, will be energy self-sufficient—or that may even generate excess energy that can be sold at a profit, for the owners and utilities.

To make these homes and buildings a reality, the U.S. Department of Energy's (DOE's) Office of Building Technologies, State and Community Programs (BTS), is taking a nontraditional, whole-building, systems integration approach. In the traditional approach, building industries work independently of one another. Such an approach slows development and adoption of new technologies and design know-how, and limits building efficiency, because decisions made in one area can reduce performance in another.

The "Buildings for the 21st Century" strategic planning process includes all stakeholders in the building process, including architects, engineers, builders, equipment manufacturers, material suppliers, community planners, mortgage lenders, contractors, and tradespeople to work together as a team. Teams make collective decisions to design, build, and test homes that incorporate energy-saving strategies, thus speeding the development and adoption of new technologies. Two interrelated programs that use the whole-building approach are Building America and Exemplary Buildings Programs. While Building America focuses on production housing, the Exemplary Buildings Program is working to develop the knowledge base and research required to achieve very low-energy buildings, know-how that will in time be replicated by Building America participants.

Systems Engineering

Four teams produce advanced homes using a whole-building, systems engineering approach. These teams, formed under BTS' Building America Program, are composed of more than 70 companies, including a number of Fortune 500 corporations (major building-product firms and several large U.S. homebuilders). At present, the teams have projects under construction, or are about to start projects in 12 states. The goal of Building America is to have major systems innovations used in 15,000 buildings within 5 years and 70% of new homes within 10 years.

The Building America teams design and build homes on a cost-shared basis and then evaluate the system-level benefits of advanced building energy technologies and design strategies. By using a systems engineering approach, the teams have shown that incorporating energy efficiency in buildings need not cost more. In fact, it can cost less. For example, Building America teams have shown that a whole-building approach can result in smaller, less costly heating, ventilating, and air-conditioning (HVAC) systems with smaller, shorter air ducts and reduced material waste.

Reducing Construction Costs

With this approach, one Building America team in Chicago found that by using materials efficiently it could reduce construction costs by

Warren Gretz, NREL/PIX04670

The wall assembly on the Building Science team's Illinois home includes the taped insulated sheathing that increases the home's air tightness. This home will use 50% less energy than many other new homes in the area.

an average of $1,500 per home. The team then reinvested these savings in a higher R-value wall assembly and high-performance windows. Combining these improvements to produce a tighter building reduced peak heating loads to levels that allowed these homes to be heated with hot water from the domestic water heater, eliminating the standard furnace. The net result is an extremely comfortable home that uses 50% of the energy of many other new homes in the area at no greater cost to the buyer.

wholebuilding

George James, DOE/PIX05510

Team members of Building America's Building Science Consortium constructed 12 test houses in Illinois, North Carolina, and Nevada in the last year. Twenty pre-production houses and one community-scale development are in the planning phase and will be constructed next year.

Hickory Consortium/PIX05499

In Massachusetts, Building America's Hickory Consortium team members used energy saving features such as increased insulation, state-of-the-art instrumented air sealing, high efficiency windows, and a ground source heat pump to reduce this building's energy load by about 50%.

energyefficient

George James, DOE/PIX05415

Building America's Consortium for Advanced Residential Buildings team members use modular construction to reduce costs and waste while increasing energy-efficiency. This roof, being lowered into place on a townhome in Maryland, is constructed of steel trusses, which are lighter weight but stronger than wood.

Increasing Comfort

In addition to improved efficiency, a common thread among the Building America projects is improved comfort. In hot, humid areas of the country, improving the building shell and distribution systems reduces costs, but the need for dehumidification remains. To control humidity, a Building America team worked with both a prominent homebuilder in Austin, Texas, and a major manufacturer of HVAC equipment to develop and test a variable-speed heat pump with innovative control strategies. The result is a home with a 35% reduction in the size of the air-conditioning equipment, satisfactory control of humidity levels, a 43% reduction in the operating cost of the cooling equipment, and the adoption of a new technology.

Accelerating Adoption of Innovative Technologies

In Las Vegas, high-performance windows were adopted after a Building America team demonstrated their energy and performance benefits. A partnership between a major window manufacturer and a builder resulted, allowing the team to arrange a bulk purchase of the windows, normally a special-order item, for an entire subdivision. The bulk purchase reduced handling costs, and the high-performance windows reduced the homes' energy use, enabling the builder to use smaller air-conditioning systems. The combined reduction in handling costs and equipment size led to a net reduction in the builder's cost.

In addition to the accelerated adoption of advanced technologies, the Building America teams have found that their combined expertise and creditability can make changes in building codes to support the use of innovative energy designs. For example, new energy codes have been developed in Illinois and Nevada as a result of test house demonstrations provided by Building America teams.

Paul Torcellini, NREL/PIX04805

Paul Torcellini, NREL/PIX05412

The Emergency Services Building in Valmeyer, Illinois, uses whole-building design to reduce mechanical system and electric lighting requirements. By incorporating daylighting, direct gain and natural ventilation systems, and high-efficiency HVAC equipment, lights, and energy management system, the building is expected to use 60% less energy and save over $8000 per year.

Advanced, Very-Low-Energy Buildings

The Exemplary Buildings Program works with the building industry to develop both residential and nonresidential buildings for the 21st century. By using passive solar heating, cooling, and lighting strategies in combination with energy efficiency measures, the Exemplary Buildings Program has built experimental buildings that use passive solar design to provide at least 75% of their heating, cooling, and lighting needs. These buildings perform at least 70% better than those meeting consensus standards. By integrating other renewable energy technologies, the buildings become more energy self-sufficient. Many of the program's design recommendations will be implemented by Building America. Because the most critical decisions affecting energy use are made during predesign, the Exemplary Buildings Program encourages teams of builders, developers, and designers to focus on reducing energy from the start of the design process to its completion, as well as throughout construction, commissioning, and operation.

improvedcomfort

Exemplary Buildings take advantage of, and manage, the use of many environmental resources, including solar radiation, natural airflows, differences in day/night sky temperatures, and/or the ground temperatures. The buildings' walls, floors, and windows, for example, are used to collect, store, and distribute solar radiation for heating and natural fresh air for cooling; additional building elements are used to shade, distribute daylight, and reject unwanted solar radiation or heat. Active solar and photovoltaic systems may also be integrated where appropriate, backed up by traditional heating and cooling equipment.

Exemplary Buildings Program design teams also examine use of landscaping that requires no irrigation (i.e., xeriscaping), wind energy conversion systems, solid waste management systems, recycled building materials, and the potential for recycling building components. The teams pay equal attention to heating, cooling, and

NREL/PIX05507

The 10,550 sq.ft. design for the St. Benedict Child Care Center in Louisville, Kentucky, takes advantage of the sun's heat and light with its atrium and its large, south facing and clerestory windows. The air core flooring system captures and stores energy from solar and internal gains, creating a radiant heating effect. Overhangs avoid unwanted solar gain during summer months.

Paul Torcellini, NREL/PIX04810

This home for park service employees, located on the south rim of the Grand Canyon, is expected to use 75% less energy than other contemporary homes in the area. Its design incorporates a Trombe wall, structural insulating panels, high-performance glazing, an integrated mechanical system, and efficient appliances to reduce the annual heating need by over 90%.

designbuildtest

daylighting in all climates. They also carefully integrate controls for electric lighting with daylighting systems, and properly size, select, control, and integrate auxiliary heating, cooling, and ventilation systems with the appropriate passive solar systems. In the Exemplary Buildings Program, the building owner is responsible for his/her own design team, construction, and commissioning. The program supports the research staff involved in the design process, guiding the commissioning and monitoring activities.

Low-Energy Home

In Pueblo, Colorado, the Exemplary Buildings Program staff helped design, and is currently monitoring the performance of, a Tierra Concrete Home that preliminary data indicate to be about 70% more energy efficient than the reference building. It cost the same as conventional homes in the area. The home's thermal mass—precast concrete walls—absorbs the sun's energy for heat in the winter and helps keep the home cool in the summer, eliminating the need for a central heating and cooling system. Low-e windows have overhangs that provide shade in the summer, allow daylighting and, in winter, solar gains for heat. If needed, auxiliary heating is provided by gas units in the main living area, fireplaces, and electric radiant panels in bathroom ceilings. The result is a bright, comfortable, pleasant living environment that led some people who visited during a recent Parade of Homes showing to have similar homes built. As the design and construction of these concrete homes continue to be refined, it is projected that they could eventually become more than 90% more energy efficient than traditional buildings.

Paul Torcellini, NREL
PIX05144 and PIX05142

The integrated passive solar/energy-efficient design strategies incorporated by this award-winning Tierra Concrete Home in Pueblo, Colorado, eliminate the need for central heating and cooling and create a comfortable home that costs the same to build as comparable ones in Pueblo.

PIX05509

The design of this 2320 sq.ft. Pittsboro, North Carolina, home captures and manages solar gain and natural breezes to heat and cool the home, resulting in a building 66% more efficient than conventional homes in the area. The overhangs shade it from unwanted summer solar gains.

Decreasing Energy Costs

One nonresidential building currently being monitored is the Thermal Test Facility (TTF) at the National Renewable Energy Laboratory (NREL) in Golden, Colorado (pictured on the back cover). Completed in 1996, this 10,000-square-foot facility incorporates passive solar design with high-efficiency lighting and mechanical systems. Daylighting strategies, using clerestories, allow the building to operate during the day without artificial lighting. Even during construction temporary lighting was

reducecost

not required. Other passive solar and energy efficiency features are a direct/indirect evaporative system for auxiliary cooling, ceiling fans to improve air distribution, water conservation devices, a heat recovery system, an active solar hot water and space-heating system, and an electronic ballast lighting system controlled by daylighting and motion sensors. Initial studies indicate that the TTF will have an annual HVAC energy cost that is 65% lower than that of a comparable building using traditional energy sources for heating and cooling.

Both the Thermal Test Facility and the Tierra Concrete Home show that careful, integrated design based on thorough, innovative energy analysis is crucial to the development of high-performance, cost-saving buildings.

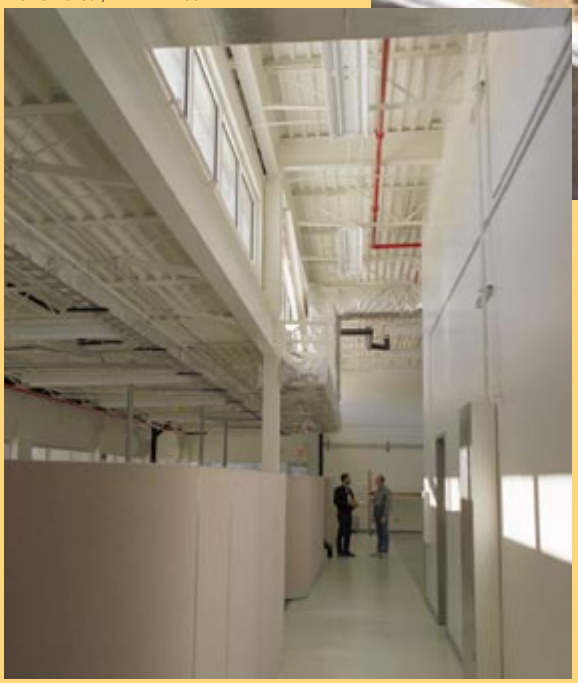
Meeting Tomorrow's Energy Challenges Today

From advanced system design to community-scale production, the Exemplary Buildings and Building America Programs are working together to meet tomorrow's energy and environmental challenges. By testing and improving the initial designs with their partners, these two interrelated programs identify and resolve technical and market barriers to advanced energy systems in production housing and other buildings. These strategic partnerships allow the private and public sectors to work together with DOE to construct more comfortable, energy-efficient homes and buildings at lower cost. They identify and clarify issues requiring near- and longer-term attention. By working with industry partners and each other, the Building America and Exemplary Buildings Programs will assist in producing Buildings for the 21st Century.

From advanced system design to community-scale production, the Exemplary Buildings and Building America Programs are working together to meet tomorrow's energy and environmental challenges.

Warren Gretz, NREL/PIX04117

Warren Gretz, NREL/PIX05172



The Thermal Test Facility at NREL in Golden, Colorado, incorporates daylighting, passive solar heating, ventilation, evaporative cooling, high performance lighting, and mechanical systems into its design. The building is expected to use at least 70% less energy than one meeting existing energy standards and to save 65% in HVAC energy costs.

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For more information:

Building America Program

George James
U.S. Department of Energy
Room 5E-098
Forrestal Building
1000 Independence Avenue, SW
Washington, DC 20585
Phone: 202-586-9472
Internet: GEORGE.JAMES@hq.doe.gov

Sara Farrar
National Renewable Energy Laboratory
Mail Stop 2723
1617 Cole Boulevard
Golden, Colorado 80401

Building America Website:
www.eren.doe.gov/buildings/building_america

Exemplary Buildings Program

Mary-Margaret Jenior
U.S. Department of Energy
Room 5E-098
Forrestal Building
1000 Independence Avenue, SW
Washington, DC 20585
Phone: (202)586-2998
Internet: Mary-Margaret.Jenior@hq.doe.gov

Paul Torcellini
National Renewable Energy Laboratory
1617 Cole Boulevard
Golden, Colorado 80401

Exemplary Buildings Website:
www.nrel.gov/buildings/exemplary