Building AMERICA SM
U.S. Department of Energy

Research that Works

# Moving toward Zero Energy Homes in California

## "Green" House Effect Makes Sense in the Golden State

David Springer, Davis Energy Group/PIX13628

*Southwest view of the Centex 21st Century Performance Home in Livermore shows 3.6-kW photovoltaic panels on the south-facing roof.*

Most homeowners would enjoy a house that pays its own energy bills. Many are willing to pay more for the features that can make it happen, if the home meets their standards of comfort, convenience, and indoor environmental quality. In California, where residents have experienced severe droughts, natural disasters, and energy shortages, energy-efficient homes that are friendlier to the environment will appeal to many.

The U.S. Department of Energy's Building America Zero Energy Homes initiative has collaborated with the National Renewable Energy Laboratory (NREL), Centex Homes, Davis Energy Group, and the Florida Solar Energy Center (FSEC) to build three innovative, energy-efficient homes in northern California: one "first-generation" demonstration home in Livermore and two "second-generation" model homes in San Ramon. These high-performance homes were built to meet the criteria for homeowner satisfaction and environmental friendliness.

### The 21st Century Performance Home in Livermore

In 2002, Centex Homes built the 3,080-ft$^2$, one-story 21st Century Performance Home in the Los Olivos development of Livermore, California. The house is a demonstration model for energy efficiency and renewable energy technologies. For the past two years, its owners have been strong advocates for these complementary technologies. A large part of that advocacy stems from the utility bills they have submitted to Davis Energy Group for the past two years. They have yet to pay for electricity—the roof-mounted solar panels generate 100% of the home's annual net electrical energy. And the home uses about 45% less natural gas for space and water heating than comparable homes in the area.

The owners have also become "meter watchers." When they first moved into the home, they wanted to cover the electrical meter, which is located in the hallway, with a picture. Now

### Key Features of the 21st Century Performance Home

**Energy Efficiency**

*Building Enclosure*

Roof—Tile roof with TechShield radiant barrier sheathing and R-38 attic insulation

Walls—R-13 cellulose insulation; 5/8-in. gypsum wallboard for increased interior thermal mass

Windows—Low-E$^2$ Milgard Suncoat with vinyl frames U = 0.35, SHGC = 0.28, VisTrans = 0.50; south, east, and west windows are shaded by generous overhangs

Foundation—1.5-in. slab edge insulation of extruded polystyrene with termite barrier

Floor—Large areas of flooring tile and hardwood to improve summer thermal comfort

Appliances—ENERGY STAR®

*Heating/Cooling*

Two, 2-ton Carrier A/C condensers with Puron refrigerant

NightBreeze system for nighttime ventilation

Smart controls integrate all mechanical system components

Variable-speed air handler for space heating (obtains its heat from Rinnai instantaneous gas water heater, which is also the backup for the solar hot water system)

**Renewable Energy**

Photovoltaics—3.6-kW PV array composed of 36 Astropower AP-100 modules

Solar Hot Water—Solahart CollectaPak-K solar water heater

David Springer, Davis Energy Group/PIX13623

*The edge of the slab is insulated with 1.5 inches of extruded polystyrene board. A steel flashing embedded in the concrete protects the top of the insulation and prevents termites from entering the wall.*

David Springer/PIX13629

*The NightBreeze system delivers conditioned air and brings cool nighttime air into the house.*

David Springer, Davis Energy Group/PIX13624

*The NightBreeze system draws in outside air through the lower louvers (the upper are for attic ventilation). The device above the roof to the left measures outside air temperature, relative humidity, and solar radiation.*

they like to check it periodically to see what they're using. If the use seems a bit high, they find something they can turn off to save energy. And they can also see how the photovoltaic system works: on a sunny day the solar cells can generate power; on a cloudy day or at night the house draws current from the electrical grid. From October 2002 through September 2003, the photovoltaic system generated 104% of the electrical energy the house needed.

The home's architectural and energy features—from walls to windows to appliances—work together to use energy efficiently and to maintain a high level of comfort and satisfaction. A shining example of energy savings is the home's air conditioning. During the summer of 2003, when the area experienced record temperatures of 100°F or higher, the home's two air conditioners operated for a total of only 8.9 hours. Several features made this possible:

- The tile roof and attic insulation help keep the upper part of the house cool.
- Generous overhangs on the south, east, and west windows reduce the solar gains during the summer.
- The insulated concrete foundation—rimmed with polystyrene—and the tile and hardwood floors help keep surfaces cool.
- The cellulose insulation in the building envelope helps prevent thermal leaks.
- The high-efficiency windows help with insulation and reduce solar glare.
- The NightBreeze ventilation system automatically monitors the outside air and distributes it via ductwork to cool the house at night. This minimizes the need for air conditioning during the day. It runs quietly and is controlled by a thermostat.
- A weather sensor on the outside of the house allows the prediction of the next day's weather to the computer-controlled variable-speed fan, which provides cooling airflow accordingly.

The house has a solar water heater, which produces about 50% of the energy required for the domestic hot water. There is also an instantaneous tankless gas water heater that serves as a backup when the solar heat is unavailable. It uses about 70% less gas than a typical storage water heater. In addition, motion sensors in the kitchen and bathrooms activate a pump when someone enters the room so hot water is available whenever it's needed. Performance data on this home are available on the Web site at www.fsec.ucf.edu/bldg/active/zeh/livermore/data.htm.

*The solar storage tank is shown on the left. It is connected to solar collectors on the south-facing roof of the house. The white box is an instantaneous gas water heater that also supplies heat to the NightBreeze air handler for winter space heating; the two brown pumps circulate water to the two air handlers. The red pump circulates hot water to the kitchen and bathroom fixtures and is activated by motion sensors.*

David Springer, Davis Energy Group/PIX13627

The experience in Livermore taught the builder how to integrate these energy efficiency systems into production buildings. According to Jeff Jacobs, project manager at Centex, "The Livermore house gave us the opportunity to learn how to integrate these systems into a mainstream options package for a production home. We are now ready to offer that package, which we call PowerSave, to the general public at Lunaria and Aventura in San Ramon."

## PowerSave Plus Homes in San Ramon

Centex Homes is moving forward with its zero energy homes program, and has now built two model homes in San Ramon, California. The homes, which were unveiled during the summer of 2004 under the PowerSave brand, were value-engineered to incorporate a second-generation design that is intended to provide the homeowners with a positive cash flow. At the same time, it reduces energy use by more than 70% (see graph on next page). They were built in the Aventura and Lunaria community developments, where the energy efficiency systems are being offered as packages to homebuyers. Each PowerSave Plus home has a corresponding standard model home for comparison, and both will be monitored for about one year while they are unoccupied. They will then be put up for sale.

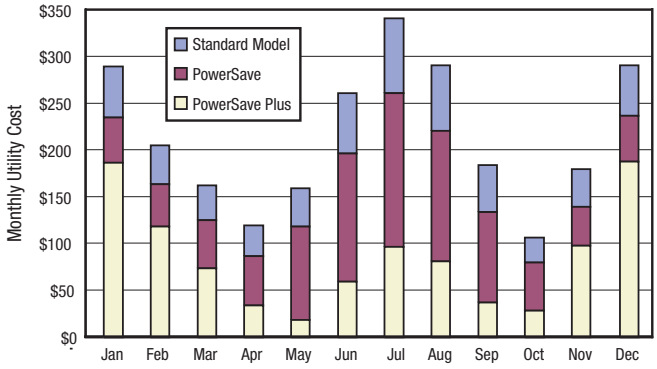
During this period, the homes will be compared side by side and will provide data that can be used to verify and improve computer

David Springer, Davis Energy Group/PIX13636

*The PowerSave Plus model home in the Aventura development of San Ramon, California.*

David Springer, Davis Energy Group/PIX13638

*The PowerSave Plus model home in the Lunaria development of San Ramon, California.*




*Projected electrical energy cost savings*

simulations of the zero energy design. A monitoring system, which includes a computer connected to a datalogger system, was installed at each home. Each computer stores data and communicates with the Davis Energy Group offices. A touch-screen display is also connected to each computer so potential buyers can view PowerSave cash flow analyses and see information on the energy savings of the home compared to conventional models.

According to computer simulations, the optimized zero energy design will save the homeowner about 71% ($1900) in energy costs during the course of a year*:

- 8940 kWh (76%) of electrical energy use
- 232 therms (30%) of gas energy use
- $1,650 in electricity costs (based on Pacific Gas & Electric's net metered time-of-use rate)
- $250 in natural gas costs

Assuming that the total cost of the zero energy package is included in the mortgage and amortized at 6% for 30 years, the incremental annual cost is $1,440. This is $480 less than what the annual utility bills would have been. **This will obviously create a positive cash flow for the homeowners.**

## What's Next for the Market?

For consumers in some markets, renewable energy and energy efficiency systems are attractive new home features. They help reduce costs, and homeowners can do their part to help clean the environment while they save money. In growing, upscale markets where houses cost $600,000–$800,000, an extra $20,000 or so tacked on to the selling price of a house may not be significant, especially when there's a positive cash flow from the beginning. And with these packages, the savings from the energy bills compensate for the increased cost of the home—the homeowners save money from the time they move in.

The bottom line is that Centex and several other builders (Pardee Homes and Morrison Homes, for example) think it's the right thing to do, and are building some homes to near zero energy home standards. And if buyers are satisfied, the word-of-mouth advertising could increase this trend even further. Given all this, an increase in volume could translate into decreased prices. Dave Springer, president of Davis Energy Group, admits, "There is no one silver bullet, but . . . we need to encourage builders to purchase and integrate sustainable materials and energy efficiency measures in their projects and find ways to make these features cost-competitive with conventional products and construction methods."

*All savings values are relative to the Centex standard models, which meet ENERGY STAR standards.

## Key Features of the San Ramon PowerSave Plus Homes

### Energy Efficiency

*Building Enclosure*

Roof—R-49 attic insulation, radiant barrier roof sheathing

Walls—Light-colored exterior walls, zero-defect blown fiberglass wall insulation, 5/8-in. drywall

Windows—Low-$E^2$ Milgard Suncoat with vinyl frames U = 0.35, SHGC = 0.28, VisTrans = 0.50

Lighting—90% fluorescent

Floor—50% tiled floor slab

Ducts—R-14 (buried)

Appliances—ENERGY STAR® (recommended options)

*Heating/Cooling*

NightBreeze ventilation and cooling system

High-efficiency air conditioner (SEER 13.5)

High-efficiency variable-speed furnace (AFUE 94)

### Renewable Energy

Photovoltaics—2.4-kW G.E. Energy building integrated PV array

Solar Hot Water— SunEarth CopperHeart integral collector storage (ICS) solar water heater (tankless on-demand gas water heater as backup)

## 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

**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**

## Partners in These Zero Energy Home Projects

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Davis Energy Group • www.davisenergy.com

Florida Solar Energy Center • www.fsec.ucf.edu/

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