

Super Solar Homes Everyone can Afford

By Amanda Griscom Little

Super-efficient solar homes are now available that reduce monthly energy bills 50 percent to 70 percent compared to comparable conventional homes, thanks to the design innovations of private-sector pioneers and the U.S. government's energy gurus. But these trendsetters won't be satisfied until they've perfected "net-zero-energy" home designs.

Net-zero-energy means the homes are super-efficient, with much of their electricity produced by rooftop solar panels; they draw electricity from the grid at night or on cloudy days, but overall they generate at least as much energy as they consume each year. It's just a matter of time before such homes are truly affordable for the masses, according to Lew Pratsch, Zero Energy Homes project manager for the U.S. Department of Energy (DOE). Pratsch says that within the next decade, zero-energy homes could cost no more than comparable conventional homes. By 2020, he predicts, they could become the building-industry standard.

That's the exciting news emerging from the DOE-sponsored Building America program, which has built more than 26,000 homes as research projects. Zero-energy homes will incorporate the best energy-efficient strategies and renewable-energy systems, and home designs will be keyed to regional climates. Right now, more than a third of total U.S. electrical use goes to heat and cool our houses, and to power the appliances within. Through the groundbreaking work of the DOE and commercial innovators, we can move steadily toward "energy independence" one home at a time.

"My feeling is we — and the leaders in Washington — should put zero-energy living up there with putting a man on the moon," says Jeff Christian, director of the Buildings Technology Center, which participates in the Building America homes program through the DOE's Oak Ridge National Laboratory (ORNL) in Tennessee. "Let's make it the grand challenge."

(And Christian wants to recruit MOTHER EARTH NEWS readers to help with the next phase of his research; see "How You Can Help," Page 42. — MOTHER)

Today, anyone can have a zero-energy home by paying, upfront, roughly 10 percent to 20 percent more than the cost of a traditional home for renewable-energy technology, which generally has a payback in energy bill savings of about 20 to 30 years. But the grand challenge is making solar homes affordable enough on the front end to become the norm in U.S. neighborhoods, rather than the exception. The goal, Pratsch says, is to lower the cost of such homes across the nation to the point that the expense of the zero-energy technology will be no higher than the monthly energy bill savings — and therefore, the added initial costs will cancel out. Over the long term, there will be additional savings once the mortgage is paid and the lower energy bills keep coming.

VOLKSWAGENS & CADILLACS

Net-zero-energy test homes have been built in dozens of cities along the East and West Coasts, where air pollution and electricity demands are the most intense in the country, and many states offer incentives for green building and renewable energy.

Steven Winter Associates, an East Coast-based green-building consulting firm, is overseeing solar home developments in Connecticut, Illinois, Maryland, Massachusetts, New York and Texas.

In San Diego, more than 100 large homes in the city's San Angelo subdivision are rigged with solar panels and a wide ar-

Jeff Christian, director of the Oak Ridge National Laboratory's Buildings Technology Center, on the porch of a Tennessee solar test home that averages total energy bills of just \$25 a month.

greenhomes

ray of energy-efficient building technologies. Just up the coast on the shores of Clear Lake, Calif., a development known as Grand View Estates — composed of 90 solar homes — is under construction. At \$250,000 to \$330,000 each, the 1,400- to 1,900-square-foot homes are remarkably affordable considering that 10 years ago they would have cost at least 25 percent more to build in that location. Their affordability is largely due to the steady decline in the costs of energy-efficiency and solar technology.

The four homes Jeff Christian has built, on Bethel Drive in Lenoir City, Tenn., are much more modest in size — just 1,000 to 1,200 square feet — but they might offer the most convincing evidence to date that the dream of affordable net-zero-energy homes is on a fast track to reality. Collectively dubbed “Harmony Heights,” the homes were constructed by Habitat for Humanity volunteers for about \$100,000 each. That includes the cost of the photovoltaic solar system and factors in the labor provided by the Habitat volunteers.

At first glance, nothing about the homes, located just a few minutes from Christian’s office, seems out of the ordinary. The houses are pleasant colonials with porches and shutters, and the lawns are strewn with bikes and soccer balls. Christian reveals, though, what makes them extraordinary: Each of these homes’ total energy bills averages less than \$25 per month!



LEIGH T. JIMMIE/AP

Above: In Frisco, Texas, workers build a net-zero-energy home that will incorporate a photovoltaic system, an energy-recovery ventilation system and concrete walls.

Below: Modular homes in Atlantic City, N.J., that are being tested as part of the Zero Energy Homes program.

“What we’re trying to do is come up with the Volkswagen of net-zero-energy homes,” Christian says. “All too frequently, the typical solar home is something more akin to a customized Cadillac.” In other words, it features whiz-bang technologies; but simply isn’t affordable for most of us.

Designing the “people’s car” of solar homes, though, comes with challenges. “Because these are Habitat for Humanity houses, which are by definition no-frills, simple and affordable, we have to take minimum risks,” Christian says. “We’d love to use fancy controls and a lot more aggressive technologies, but we have to be disciplined and work within the realm of financial reason that makes sense for our occupants.”

To find out exactly how well each technology they incorporate functions, the houses are equipped with dozens of sensors that monitor electricity consumption, temperature, humidity, carbon dioxide and hot-water usage. Christian regularly visits with the owners to learn their experiences and perspectives on their homes, and daily updates his database with automatically collected data that chronicles the flow of electricity to appliances such as refrigerators, air handler units, water heaters, compressors and inverters.

HIGHER-QUALITY HOMES

The Harmony Heights homes gain their ultra-low \$25-a-month utility bills with the help of a long list of proven energy-saving features: airtight envelopes, Energy Star appliances, compact fluorescent light bulbs, HVAC distribution systems and low-emissivity windows, for starters. And Christian’s team designed all the homes with passive-solar principles in mind: Though they weren’t able to position the front or back of the homes to face south, they put at least 70 percent of the windows in each house on the south-facing side. They also included extended overhangs above the south-facing windows to block light during the hottest hours of the summer, when the sun is directly overhead.

All of the houses were built with structural insulated panels (SIPs), which are made of rigid foam that’s sandwiched be-



MARTIN PHOTOGRAPHY



Above: Bethel Drive in Lenoir City, Tenn., where four solar homes are paving the way for energy-independent living. At right, two residents, Cotton Duncan and Becky Clark, show off their lowest-ever monthly energy bill: \$11.90.



ALLAN B. HUNT (2)

tween two structural layers made of wood. SIPs are highly energy-efficient and cost-effective for walls and roofs, Christian says. He also is testing precast concrete walls that absorb and sequester heat to help keep the houses cool in the summer and warmer in the winter, cutting down on cooling and heating demands.

The prefabricated SIPs have superior insulation value and are tightly joined, to form an airtight building envelope (for maximum energy efficiency). The houses all have a relatively simple ventilation system that maintains indoor air-quality to the high standards recently mandated by the American Society of Heating,

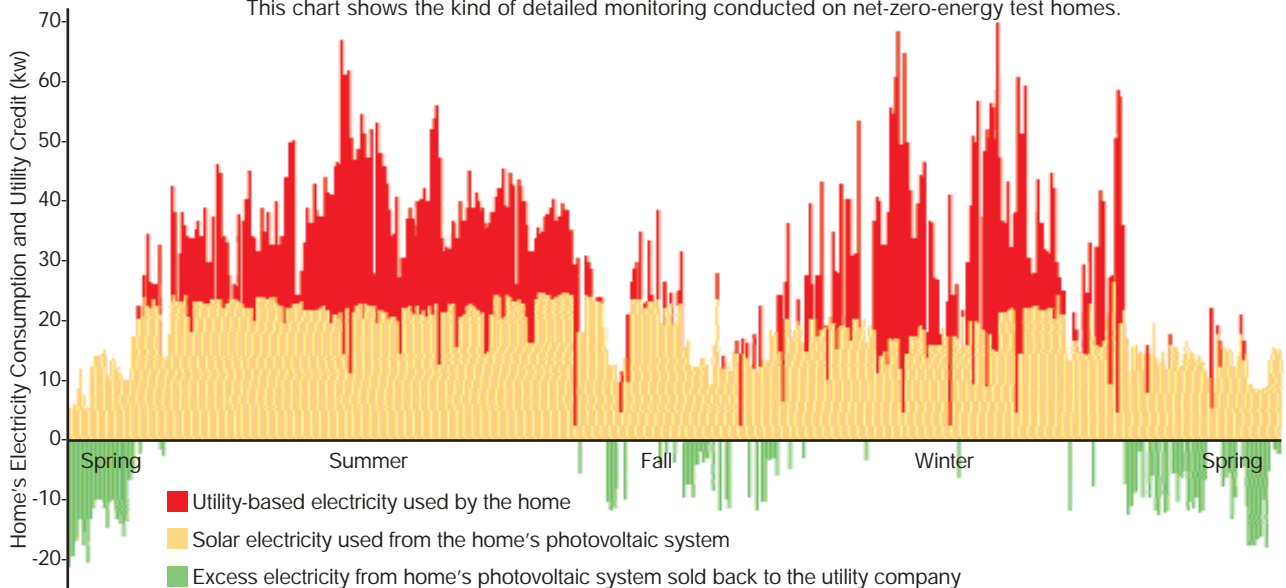
Refrigerating and Air-Conditioning Engineers. These ventilation systems filter outside air into the houses throughout the day and condition it in response to interior carbon dioxide, humidity and temperature measurements.

The homes also have "cool roofs" made of light-colored reflective materials or infrared reflecting pigments that allow darker colors to reflect heat like lighter colors. That keeps heat from being absorbed by the roof and conducted into the house, and can provide a 30-percent reduction in peak heat gain into the building during summer afternoons. Exterior wall panels also have special coatings to reflect heat.

"The result is not just energy-efficient homes, but higher-quality homes," Christian says. "They are healthier and more durable, with fresher air and more stable thermal comfort. They also have more natural lighting than you find in conventional homes today."

One of the biggest energy-saving features is the geothermal heating and cooling system. "It's hard to find much better energy savings than those from geothermal," Christian says. Over a roughly 20-year life span, a geothermal system would save a homeowner about 25 percent annually compared to fuel costs for a typical gas furnace. That estimate is based on current nat-

This chart shows the kind of detailed monitoring conducted on net-zero-energy test homes.



COURTESY NAEHB RESEARCH CENTER, 2004

ural gas prices; as prices increase, the benefits of geothermal will be even greater.

Geothermal systems include a heat pump that taps the energy stored in the Earth, where the soil temperature is roughly 55 degrees in the winter and 70 degrees in the summer. In the winter, using a heat-transfer fluid pumped through a labyrinth of pipes buried about 5 feet underground, the system warms the house. In the summer, the earth is colder than the air, and the system helps cool the house.

Geothermal technology is relatively new, and right now systems cost more up front than a gas furnace and air conditioner. So builders tend to install minimum-efficient furnaces, air conditioners and heat pumps to keep the initial costs of new homes down. But those systems will use more energy for the next couple of decades than geothermal would. In fact, the energy savings from geothermal systems are so substantial that even now the cost of the technology can be recouped in less than 10 years through lower energy bills.

According to Pratsch, geothermal markets are developing in more than a dozen states, including Kentucky, Missouri, New Jersey, Ohio, Oklahoma, Pennsylvania and Texas. In good markets, a basic geothermal system for a standard four-person home can be purchased for roughly \$8,000. Communities can help create markets for geothermal by organizing bulk purchases. "Once you have schools, office buildings or groups of homes making large-scale purchases — you have competitive bids, which lowers the [upfront] cost," Pratsch says.

Eventually, he adds, the economies of scale will kick in and the time it takes to recoup the initial cost of geothermal systems will become shorter and shorter — Pratsch predicts that by the end of the decade, geothermal will be much more affordable and common in markets nationwide. (We'll have an article about geothermal systems in our April/May 2005 issue. — MOTHER)

ZERO-ENERGY SOLAR HOME KITS

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envelope of the newest house was built in just two days. The bottom floor, a walkout basement, took only six hours and was assembled with premanufactured insulated concrete panels. The walls on the main floor are made of SIPs and were installed in five hours, and the insulated roof was up in just three hours. The solar system was installed in just one day. The final product totals 1,100 square feet with three bedrooms.

Christian's vision is a market-ready solar home kit, customized for each region: "We want to package the best-tested features and appliances, and make the whole home package available commercially to contractors and owner-builders."

He says these kits could be adapted to any style of home, be it a Cape Cod, ranch or colonial: "We're basically talking about bundling the concepts — air-

tight construction, panelization, mechanical ventilation, dehumidification and so on. These are all generic ideas that can fit into any style of home." These bundled concepts could even be applied to straw bale homes, he says, though it would require extra effort to assure durable airtight construction.

Different kits will be needed for different climate zones, Christian says. You can't put a home designed for Tennessee humidity levels and air conditioning demands in northern Maine, for instance. And different climates justify different expenses — in northern climates, it is more reasonable to invest in a high-tech geothermal heat pump because it will yield more savings in heat bills; likewise in southern climates, it is more practical to invest in state-of-the-art central air for the savings in cooling and dehumidifying expenses.

LEARNING TO CONSERVE

Before Kim Charles moved into her net-zero-energy home at the end of the Bethel Drive cul-de-sac, she had seen solar panels only once — at Dollywood, Dolly Parton's theme park in Pigeon Ford, Tenn. They were mounted on the parking lot canopy to power its lights.

"I felt totally clueless going into this," Charles says. "At first, when we were getting all this attention with the media, I'm going, 'What is the big deal? What is so great about all this?' I didn't get the big picture. It took me a couple weeks to realize, wow, it's the first one of its kind."

Another fantastic first for Charles was studying her utility meter. As gratifying as it was to see it spin backwards on sunny days when her son and daughter weren't home and there was little energy demand on the house, Charles says it was even more riveting when she saw it hurtle forwards, making her think about her family's energy usage. "I'll never forget, I was on the back porch one evening and I heard the clothes washer and dryer start," she says. "I looked at the utility meter and all the sudden it started flying, but not backwards." It made her realize that laundry is one of her most energy-intensive chores.

Zero-sum Details

For more info on the Building America program's net-zero-energy homes, including building partners, contact:

ORNL Buildings Technology Center
www.ornl.gov/btc

Building America
www.buildingamerica.gov

For more info on the products and technologies discussed in this article, contact:

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Charles admits she wasn't exactly mindful of energy efficiency before moving to Harmony Heights. "I used to think that electricity is like air — it's a given," Charles says. "I never really spent much time thinking about it."

Christian says there are advantages to working with people like Charles, who are previously unfamiliar with green building — it gives a realistic picture of mainstream habits — but no matter how technologically savvy a person becomes, mindfulness will always have to be a part of energy-independent living.

"To really get to net-zero, a certain amount of prudent practice in everyday habits is going to have to be a part of it," Christian says. "Lights being left on when nobody is home during daylight hours is sacrilege. This has to be about the best utilization of resources."

And, he says, living in these homes will instinctively teach families to become more mindful. "It's just like when we garden — you're more in tune with what the sun is giving today."

THE UTILITY COMPANY PAYS YOU

In the case of Harmony Heights, the sun translates not into flowers or food, but into direct financial return: The homes have rooftop solar electric panels that create electricity whenever the sun is shining. When Charles' neighbor Becky Clark received her first electricity bill there, it showed a credit of \$35 in one month. "We got paid!" she says, beaming. "It's like we're our own little power plant." At her old apartment, Clark paid nearly \$200 per month for her combined utilities.

Price signals, Pratsch says, are a good way to change consumer behavior: "We're working with utilities on ways to give consumers good indications of time-of-use-pricing." It's much more expensive for consumers to use electricity at peak load times which occur during the work day when businesses are buzzing, air conditioners are humming and energy demand is at its highest.

"We're trying to come up with user-friendly meters that could go in every home

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so consumers could have a real-time read-out of the cost of their electricity use," Pratsch says. "I can't imagine a better reminder to conserve." Even better, he adds, appliances and heating and cooling systems should be computerized, with "smart economizers," so that they automatically run at optimum times of the day to keep electricity costs down.

THE ZERO-ENERGY REVOLUTION

Why, you may wonder, would utility companies have any interest in cooperating with zero-energy home programs, thereby encouraging consumers to use less of their product? Because the demand for electricity over the past decade has grown faster than the utilities' capacity to produce it. That situation was dramatically illustrated by the August 2003 blackout: The largest ever in North America, it affected 50 million people in eight states and southeastern Canada.

"It's very expensive for utilities to invest in greater transmission line capacity to carry the growing electricity loads," Christian says. "And it's becoming increasingly difficult, especially in condensed urban areas, to find sites for new substations and transformers to generate extra capacity. So, investing in on-site generation that goes directly into the home without all that infrastructure makes good economic sense." Rooftop solar panels produce power during the afternoon and along with other features of these homes, such as continuous fresh-air ventilation and thermal mass, help reduce the utilities' peak demand.

That's one of the main reasons why the Tennessee Valley Authority (TVA), the local utility in the Tennessee Valley (which includes Lenoir City), agreed to help fund the ORNL project and offered to pay a premium price for the solar energy from the Harmony Heights homeowners. In the last two years, TVA has initiated its own "Green Power Switch" program, which offers customers the option of paying a monthly premium for solar- and wind-generated electricity; more than 7,000 residential customers are now enrolled. The strong response encouraged TVA to launch another

program called "Generation Partners," which offers homeowners the option of installing their own rooftop solar system or windmill, and selling the electricity generated back to TVA for 15 cents per kWh, more than twice the rate that TVA customers pay for traditionally generated electricity, but less than it costs the utility to install new, renewable generating capacity.

The more interest TVA detects among consumers, the more large-scale projects it — and other utilities — will want to finance, Christian says. This means if all goes well, we won't be moving toward energy independence just one home at a time — it will be one subdivision, one community, maybe even entire cities at a time. ☺

How You Can Help

Jeff Christian, director of the Oak Ridge National Laboratory's Buildings Technology Center, has been studying energy efficiency in homes for more than 30 years, and he wants to make zero-energy homes affordable for everyone. To do so, he needs real-life data from homeowners so his team can refine and improve the homes' engineering and cost efficiencies. To that end, he hopes to organize a mass purchase of these types of houses: "If we can get a few thousand people who will all order houses at the same time — not all with the same size and floor plan, but the same efficiency principles and materials applied to each, it would add some economies of scale and help us bring the unit cost down," Christian says. "From a research standpoint, it would be immensely valuable to get the feedback about what works and what doesn't work from homeowners who really care about these issues."

Sounds like a perfect assignment for MOTHER'S readers who want to build a new home. If you would like to learn more, send an e-mail to Jeff Christian at christianje@ornl.gov.