

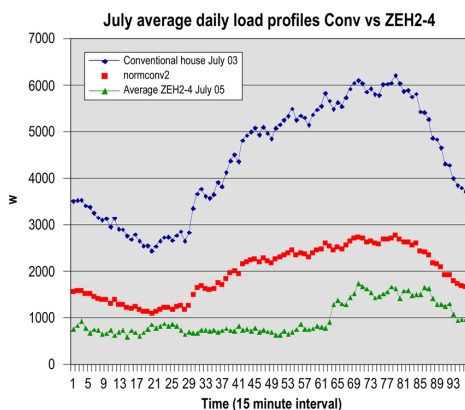


## TVA and DOE Team with Habitat for Humanity and ORNL to Design, Build and Monitor five Near-Zero Energy Homes in Lenoir City, Tennessee

Habitat for Humanity affiliates are able to offer families low or no interest loans and very moderate home prices thanks to volunteer labor, sweat equity, and donated materials, but affordability can still be an issue once the family moves in.

But what if the amount of energy needed to run these all-electric homes was cut in half and the electricity meter runs backwards at the same time the electric grid is calling for peak power, like on hot sunny afternoons? These very efficient houses with solar photovoltaic power production at times feed electricity to the grid when TVA's cost for traditional generation is the highest. This has benefits to TVA and as a result leads to crediting the home owner a premium rate of \$0.15/kWh for all the solar power these houses can produce. Under the Green Power Switch Program TVA makes this power available to customers willing to pay extra to run their houses from TVA's renewable energy sources. Everybody wins! The long term goal of this unique collaboration between Tennessee Valley Authority, the U.S. Department of Energy's Building America Program, DOE's Oak Ridge National Laboratory (ORNL), and the Habitat for Humanity Loudon County Affiliate is to develop affordable zero energy houses (houses that use as much energy as they produce over a one year period). TVA serves as a power broker improving the homeowner affordability of living in a near zero energy house.

As DOE was formulating the ZEH grand challenge for the U. S. Buildings Research, TVA was the first electric utility to commit to partner with DOE. In June 2002, Glenn McCullough at the time TVA Board Chairman committed TVA to collaborate with DOE to build, design, monitor and analyze 5 near zero energy research houses. The partnership hit a major milestone in 2006 with the fifth house going on line. These modest but pleasant 1,000 to 2,600 square foot all-electric bungalows generate energy bills that average around \$25 per month, 50%-70% less than their neighbors. The extraordinary savings are due to a combination of high-performance energy saving technologies, TVA Green Power Generation Partnership, and a design based on sound building principles, according to Jeff Christian, director of the Buildings Technology Center a DOE national user facility at the Oak Ridge National Laboratory (ORNL).



Average electric load profile in watts for ZEH2-4 compared to the actual labeled "Conventional house July 03" and normalized conventional house labeled "normconv2."

air using a heat transfer fluid pumped through pipes laid 5 feet underground where the temperatures stay about 55 degrees in winter and 70 degrees in summer. High-performance double-pane, low-emissivity windows are located on the homes' south facing walls under deep overhangs to increase day light while cutting unwanted summertime solar heat gain. Heat gain is also cut through infrared reflective paints on the exterior walls and reflective roofing materials. A year around mechanical ventilation system maintains much better than average indoor air quality. Energy Star appliances and compact fluorescent lighting adds to the energy savings.



Solar energy provided 2,260 kWh per year from this second house built in 2004. Solar system costs dropped from \$22K for the first house to \$15K for the second and third house one year later.

### Energy Saving Features

Features were varied among the five houses to test the effectiveness of each. Highlights included:

**Walls:** 4.5 or 6.5 inch SIP

**Roof:** 6.5, 8, or 10 inch SIP

**Roofing:** 24-gauge steel seam with 0.17 or 0.23 reflectivity

**Crawlspace:** unvented or mechanically vented

**Heating and Cooling:** 2-ton 17 SEER air-to-air heat pump or geothermal heat pump

**Ventilation:** mechanical ventilation to return side of coil, CO<sub>2</sub> sensor, bathroom exhaust

**Ducts:** inside conditioned space

**Water heater:** integrated heat pump water heater, solar water heater

**Solar system:** 12-165W multicrystal silicon PV modules-12.68% efficiency, 1.98 kWp or 20-110W polycrystalline 2.2 kWp



The fourth house, at 1,200 square feet with a walk-in lower level.

The only feature that suggests these houses are special from the outside comes from the 2-kiloWatt power solar photovoltaic (PV) modules and solar hot water heater collectors mounted on the roofs. The PV systems are connected to Lenoir City Utility Board, the local distributor, grid and TVA credits the home owners 15 cents per kWh for all the solar power generated. That's twice the rate TVA customers pay for traditionally generated electricity, but less than it costs the utility to install new, renewable generating capacity. The solar credit from TVA reduces the total annual electricity cost to the homeowner by 50%. Habitat home owner Becky Clark was thrilled to receive her first electricity bill showing a credit of \$35 in one month. "We got paid!" she said. "It's like we're our own little power plant." Clark had been paying \$200 per month for utilities in her apartment.

ORNL is doing extensive tracking of the thermal comfort and energy use on the five homes. According to Christian, the first year's worth of data, on the first home completed in 2002, showed that while the home used \$644 worth of electricity over the year, its solar panels generated 2,006 kWh, earning \$301 from TVA. Christian said they are seeing improvements with every house. The average energy cost to operate the homes stands at \$1 per day for the first house, \$0.88 for the second, \$0.79 for the third, and \$0.75 for the fourth, with a preliminary measured performance of \$0.60 per day for the fifth. National average energy costs for a conventional house are \$5 per day. The cost to construct the first four houses was under \$100,000. The fifth house, built on a walkout basement, came in at around \$60/ft<sup>2</sup>. This includes the market value for all the energy efficiency and solar features.

The goal, according to Lew Pratsch, Zero Energy Homes project manager for the U.S. Department of Energy (DOE), is to make zero energy homes truly affordable for the average consumer. Pratsch predicts that within the next decade, zero energy homes could cost no more to construct than comparable conventional homes.

In the meantime the project has made believers at the Loudon County Habitat for Humanity. Loudon County's Habitat Construction Supervisor Todd Helton, union carpenter, and trainer, was so impressed with SIP construction he is building his own house with SIP panels. The affiliate has committed to building all of its houses to the Energy Star level, which is a 30% more efficient building envelope than standard construction, and a big step on the road to zero energy construction.

TVA is continuing to work with DOE and ORNL to carry these houses to the market. Several projects are under way to make these homes broadly available in the Tennessee Valley as well as establish the manufacturing capabilities in the TVA service territory for global distribution.

**Why is TVA interested in ZEH**

- Promote the "wise and efficient use of electricity" (houses use 40-50% less energy than new code compliant units in same development)
- Peak load reduction (energy efficiency features and 2 kWpeak solar Photovoltaic system reduce winter and summer peak load by 1-2 kW, ~30%)
- Increase source for renewable energy to satisfy growing number of participants in TVA Green Power Switch program (In January, 2006, 7,040 residential participants and 351 non-residential customers purchasing 3,166,050 kWh/month)
- Test bed for "Generation Partners" connectivity (1<sup>st</sup> four TVA Green Generation Partners)

**Future Direction of TVA and ORNL Collaboration**

- Package/kit concept for builders
- Economic development potential with factory housing industry
- Zero peak communities; Transmission and Distribution benefits

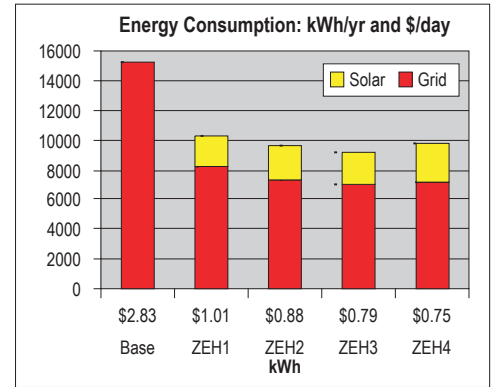
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Comparison of the energy consumption of the base house and the four test houses.

**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, utility 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.



All five houses use structural insulated panels (SIP) for super efficient wall and roof construction.

**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.