

# Department of Energy laboratory shows new way to win the energy wars at home.



## Total annual heating and cooling cost for SIP research house is \$166

The Structural Insulated Panel Association (SIPA) built four "net-zero energy" research homes, in partnership with Oak Ridge National Laboratory, the Loudon County Habitat for Humanity affiliate in Lenoir City, TN, the Tennessee Valley Authority (TVA) and other project sponsors, which are expected to return nearly as much energy to the power grid as the homes use.

The homes, located in the Habitat for Humanity Harmony Heights subdivision of Lenoir City, Tennessee, have all been equipped with integrated heating, cooling, and appliance technologies to maximize energy savings. And fifty sensors have been measuring energy performance since November 2002. SIPA has provided building expertise and SIPs for the floors, walls, and roofs.

The first test home, completed in October 2002, achieved a 51% energy savings over the 2006 International Energy Conservation Code (IECC). During a colder-than-normal winter, sensors revealed that heating costs were only half as much as those for a comparable wood-framed house across the street. The total heating cost for one year was \$92. The total cooling cost was \$74, bringing the total heating and cooling costs to 45 cents a day.



Second and third zero-energy homes constructed with EPS core panels.



Jeff Christian, Director of Building Technology for ORNL, discusses the fourth zero-energy home constructed with polyisocyanurate core panels.



The first net-zero energy research home constructed with EPS core panels.

The third SIP near-zero energy house, with a geothermal heat pump instead of an air source heat pump, through the winter of 2003-2004 used almost 20% less than the first test house. The cost for a full year was only \$0.82 per day for all off-site energy needs in Lenoir City, TN which is serviced by the TVA.

By using SIPs in conjunction with other energy-efficient and affordable features, builders will be able to offer net-zero energy houses of all types to many more American homebuyers over the next few years. One important research objective is to demonstrate that homes built today with SIPs can achieve the Department of Energy's goal of achieving 70% energy savings by the year 2020.

A SIP-based system offers superior insulation, exceptional strength, and fast installation. Besides these benefits, the total construction costs are less with SIPs compared to wood-framed homes, especially when you consider speed of construction, less expensive HVAC equipment required, reduced

site waste, reduced construction financing costs, more favorable energy-efficient mortgages available, and the lower cost of owning a home built with SIPs. For greater structural integrity and immediate cost savings, a SIP home is a wise choice for builders and homeowners alike.

### SIPs save labor

A recent R.S. Means study shows building with SIPs saves 41% on labor (BASF Corporation Time and Motion Study, R.S. Means, 2006). That's because SIPs arrive at the construction site ready to set in place with speed and precision and there is no need to install sheathing or insulation.

### Where to find more information

To find a SIP manufacturer, dealer/distributor, builder, design professional or remodeler who is a member of the Structural Insulated Panel Association, search our member database on [www.sips.org](http://www.sips.org).



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### Special thanks to these research home sponsors and participants

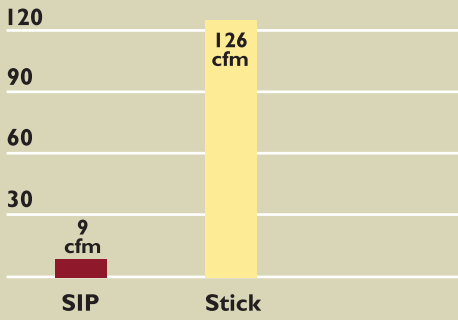
Oak Ridge National Laboratories, Pacemaker Building Systems, Insulspan, Incorporated, FischerSIPS, LLC, Winter Panel Corp., Andersen Windows, Metal Roofing Alliance, Rohm and Haas Company, Ashland, Design Basics, Weyerhaeuser, Falcon Foam, Archbold Container Corp., NOVA Chemicals, Inc., DOE Building America Program and Tennessee Valley Authority (TVA)

# Tests at Oak Ridge National Laboratory (ORNL) confirm that super airtight, energy-efficient homes can be built today with SIPs.

FIGURE 1

## WHOLE-ROOM AIR INFILTRATION, ORNL TESTING

Lower cfm = higher comfort + lower energy cost

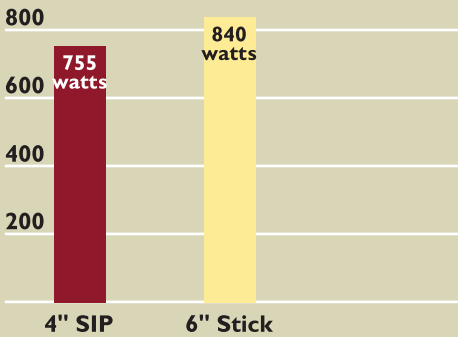


Source: ORNL

FIGURE 2

## WHOLE-ROOM ENERGY USE, ORNL TESTING

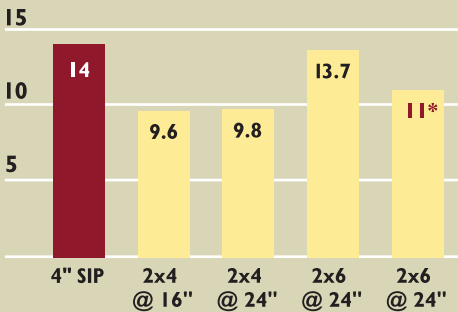
Lower watts = lower energy cost



Source: ORNL

FIGURE 3

## WHOLE-WALL R-VALUE



Source: ORNL

### APPLES TO APPLES: REALISTIC COMPARISONS

This chart shows a realistic comparison between SIP wall and stud wall thermal performance. Superior design enables even a 4-inch SIP wall to outperform the fatter 2x6 stud wall, despite the stud wall's nominally higher rated insulation. The 4-inch SIP wall beats the 2x4 stud wall by R-4, providing 40% more thermal resistance.

Whole Wall R-value comparisons between 3.5 inch EPS core SIP wall and conventional 2 x 4 and 2 x 6 wood frame walls with fiberglass batt insulation.

Source: Jan Košny, André Desjarlais, and Jeff Christian, ORNL. From Figure 9, Whole Wall Rating/Label for Structural Insulated Panel: Steady-State Thermal Analysis, June 4, 1999.

\* Test shows that in the "worst case commonly found of procedures for installing batt insulation" the performance drops to R-11. This is a result of common installation imperfections such as "rounded shoulders, 2% cavity voids, compression around wiring, and paper facers stapled to the inside of studs."

From Table 4, How Imperfections Affect the Whole Wall R-value of 2 x 6 Batt-Insulated Wall, ORNL.

### What are SIPs?

The basic definition of a structural insulated panel (SIP) is "A structural sandwich panel which consists of a foam plastic insulation core securely bonded between two structural facings (such as oriented strand board)." Other structural facings can be used for specific applications. The foam core in a SIP performs a structural, insulating and air-sealing function in wall, roof, floor and foundation systems.

### ORNL test results

A SIP test room has significantly outperformed a 2x6 wood-framed and fiberglass-insulated wall in controlled testing under identical laboratory conditions at the government's Oak Ridge National Laboratories (ORNL). Results from a carefully monitored and instrumented study in ORNL's large-scale, climate simulator showed that SIP construction can be almost 15 times more airtight than wood-frame construction.

Under blower door testing, a room with SIP walls, a SIP ceiling, a window, a door, pre-routed wiring chases, and electrical outlets showed 90% less air leakage than an otherwise

identical room built with 2x6 studs, OSB sheathing, fiberglass insulation, and drywall.

At 50 pascals of negative pressure, the wood-framed room leaked 126 cubic feet of air per minute (cfm), while the SIP room was calculated to leak 9 cfm (Figure 1).

Airtightness relates directly to durability. An integral part of the SIP building system is properly sealed joints. One reason for the high performance of the SIP test room is that the joints were properly sealed. When panel joints are sealed properly to prevent air infiltration and exfiltration, moisture is prevented from entering the building envelope and long-term durability is ensured.

### Surprising energy savings

SIPs have consistently proven to be up to 50% more energy efficient than required by the model energy code. Perhaps more significantly, this same study shows that under identical conditions (an indoor temperature of 70°F and an outdoor temperature of 0°F), the room with 4-inch nominal SIP walls (4 1/2-inch overall thickness, 3 5/8-inch expanded polystyrene (EPS) core) used 9% less heating energy than the wood-framed room with 2x6 walls and R-19 fiberglass insulation (Figure 2).

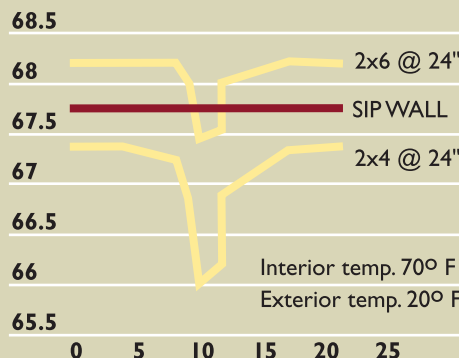
### SIP walls trounce conventional fiberglass methods in "Whole-Wall R-Value" comparisons

When it comes to R-values, sometimes less can be more. That's the lesson from a careful comparison of wall systems carried out by energy experts at ORNL.

"The comparison shows that a SIP wall system is thermally very well designed. The 4-inch SIP wall outperforms the 2x4 wood-frame

FIGURE 4

## INTERIOR WALL SURFACE TEMPERATURE



Interior temp. 70° F  
Exterior temp. 20° F



walls by more than R-4 and even the 2x6 wood stud walls by R-0.3 for best practice details,” says Jeff Christian, ORNL director of the laboratory’s Buildings Technology Center. Even though the SIP wall’s rigid insulation is rated at only R-15, lower than the fiberglass insulation labeled R-19 used to insulate the conventional wall, the superior design of SIPs achieved a realistic whole-wall R-value of 14 in the ORNL tests. The 2x6 frame wall stuffed with fiberglass labeled R-19 only achieved a whole-wall R-value rating of less than 14, even with studs spaced at 24 inches on center (**Figure 3**).

The comparison demonstrates the fact that a wall’s real performance is not the same as the rating of its insulation alone. Approximately 15-25% of a stick wall’s area consists of framing lumber — studs, headers, corner posts, and plates. That lumber transmits heat at a much higher rate than the insulated cavities do. Wood members in the wall

create cold zones on wall interiors and warm zones on the outside skin. Add to that the effect of thermal short-cuts at corners and at joints where wall plates meet the floor or roof framing, and actual insulating value can be cut by close to a third.

ORNL tests further show that in the “worst case commonly found of procedures for installing batt insulation” the performance drops to R-11. This is a result of installation imperfections such as “rounded shoulders, 2% cavity voids, compression around wiring, paper facers stapled to the inside of studs.”

## **SIPs provide a more comfortable living environment**

The inherent airtightness of SIP construction means fewer drafts, warmer walls and ceilings, and a more comfortable home. That means your home will maintain a more even temperature throughout the day and night. Your furnace and air conditioning system won’t have to work overtime to keep you comfortable. And you won’t be annoyed by drafts (**Figure 4**).

It also means saving money on HVAC systems. Typically, heating and cooling loss can be 30% or more due to air leakage in wood-frame construction. Since SIP construction is inherently more airtight, the size of heating and air conditioning systems required and equipment cost is reduced significantly.

## **Structural insulated panels make solar energy feasible**

Solar energy has long been looked to as a source of endless energy. Combined with construction using structural insulated panels (SIPs), it not only works, but can be affordable. And now science proves it.

