# Highly insulating windows are very energy efficient, though expensive

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This image shows the installation of triple-pane windows in one of the Lab Homes on the campus of Pacific Northwest National Laboratory. Credit: Graham Parker/PNNL

Highly insulating triple-pane windows keep a house snug and cozy, but it takes two decades or more for the windows to pay off financially based on utility-bill savings, according to a report by energy efficiency experts

at the Department of Energy's Pacific Northwest National Laboratory.

The findings are being presented Dec. 4, 2013 by PNNL research engineer Sarah Widder at the Buildings XII Conference in Clearwater Beach, Fla. The meeting is sponsored by ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers).

The report by Widder and senior staff engineer Graham Parker is based on a study at PNNL's Lab Homes, a pair of identical manufactured homes used to study energy efficiency. Researchers replace one item at a time in one home, such as the windows or the water heater, then compare the performance of the homes.

For this study, the PNNL team studied the effect of replacing aluminum-frame double-pane windows, which are common in homes across the country, with newer, triple-pane windows, also known as highly insulating windows. The team found that the newer windows slash energy use in the home by 12.2 percent. But because of the cost of the highly insulating windows, it would take anywhere from 23 to 55 years for the reduced energy cost to make up for the increased expense.

"A savings of 12 percent on whole-house energy consumption is substantial, especially when you're talking about changing a relatively small percentage of a home's envelope," said Parker, a founder of the Lab Homes project. "But the windows are expensive."

The team notes that there are many other factors to consider in addition to money when deciding whether to install highly insulating windows.

"Comfort is also important," said Parker. "The windows cut down dramatically on cold air radiating from the windows and they reduce temperature variations in the home, where some areas will be much warmer or cooler than others. They also nearly eliminate the formation

of condensation on the inside of the window which can lead to mold growth and unhealthy indoor air. It's hard to put a dollar value on comfort and health."

The PNNL team found an added value during summer months: The newer windows, which have low-emissivity (low-e) coatings that reduce internal solar heat gain, slashed energy consumption by almost 25 percent during peak cooling times on hot summer afternoons. That benefit is passed along to utilities as less demand on the overall electricity grid at times when demand and price are highest, Widder said.

## Lab homes – an energy laboratory in a home environment

Each of the lab homes is about 1,500 square feet and is equipped with more than three dozen sensors which hang from the ceiling or are attached to windows, walls, and other areas throughout the home. The sensors record information on temperature, humidity, and the amount of sunlight entering through windows. Instruments outside the homes record temperature, humidity, wind speed, rainfall, barometric pressure, and wind direction.

The house has 196 square feet of windows, including two large sliding glass patio doors and eight other windows.

For this experiment, in one home the team installed triple-pane vinyl-frame Jeld-Wen windows with a U-factor of 0.20. That's equivalent to an R-value of 5. (R-value is a well-known metric typically used for rating building insulation – the higher, the better). The triple-pane windows are filled with an inert gas, an argon/krypton mix, in the two spaces between the panes, to further reduce thermal transmission.

The other home's double-pane windows had a U-factor of 0.68, which is the equivalent of a 1.47 R-value. In addition the triple-pane windows block approximately 80 percent of solar heat gain, compared to 30 percent for the double-pane windows. (The triple-pane windows had a solar heat gain coefficient of 0.19 compared to the double-pane windows' 0.70.)

The team ran its experiments for two periods, during a 10-week heating season from February to April 2012 and during a six-week cooling season in July and August 2012. The thermostat was kept at 75 degrees during the winter and 70 degrees during the summer. No window coverings were used during the experiment.

The team found that the windows saved about 5.8 kilowatt hours per day during the winter and about 6.5 kilowatt hours per day during the summer. When the team extrapolated the weather data across a typical year of heating and cooling, they found an overall savings of 12.2 percent, with higher savings of 18.4 percent during the cooling season and a savings of 11.6 percent during the winter season.

In their report, the researchers note that prices for the windows vary widely depending on location, shipping cost, installation, and other factors. For their experiment, the PNNL team paid about $32 per square foot, or a total of $6,243 for the windows.

## Added benefits

In their experiments, the researchers found that temperatures sometimes varied in the house with the double-pane windows, as the cooling system struggled to keep up during hot sunny days. Areas of the home, primarily on the south side, were too hot in the summer. That was not true in the house with the triple-pane windows, where less thermal transmittance and less solar heat gain reduced the demand on the cooling system.

Widder and Parker also found an unanticipated benefit of the windows which they say deserves further study. It's possible that the amount of duct work in a home and even the size of the heating and cooling unit could be reduced with the highly insulating windows. That's because duct work typically extends to the edges of a room, where vents are located near windows to help lessen the 'drafty' feel near the window surface and to help reduce condensation. With more energy-efficient glass in the windows, it's possible that the ducts could be located closer to the center of a room.

"The money that you save with less duct work and a smaller heating and cooling system could help pay the additional cost of triple-pane windows," said Parker.

Another benefit of triple-pane windows is less chance of condensation and mold. The temperature of the inner-facing window pane of the triple-pane windows was much closer to the thermostat set point. On the inside portion of the windows themselves, during the winter with the thermostat set to 75 degrees in both homes, the average inside surface window temperature was 75.7 degrees in the home with highly insulating windows and 68.7 degrees in the home with double-pane windows. The window surface temperatures never dipped below 60 degrees on the highly insulating windows but sometimes fell as low as 50 degrees with the double-pane windows. That temperature difference in the home with double-pane windows makes window condensation and potential mold formation more likely.

And there are other benefits, Widder notes.

"We shouldn't forget that triple-pane windows reduce energy usage, which helps the environment and reduces the impact of our energy use on the climate," she added.

**More information:** Sarah Widder and Graham Parker, Demonstration of the Performance of Highly Insulating (R-5) Windows in a Matched Pair of Homes, to be published as part of the Proceedings of the Thermal Performance of the Exterior Envelope of Whole Buildings XII International Conference.

Provided by Pacific Northwest National Laboratory