When Wall Insulation Doesn't Save

Wall insulation clearly saves heating energy, but does it save cooling energy as well? Sometimes yes, sometimes no is the conclusion of a recent study in Florida, which clarifies the variables that determine wall insulation's usefulness in a warm climate.

The study, conducted by the Oak Ridge National Laboratory (ORNL) and the Florida Solar Energy Center (FSEC), focused on concrete block houses on slab foundations. Block construction is common in warm climates, especially where termites are a problem. As FSEC's Danny Parker points out, half of Florida's six million residences are built of concrete blocks and have little or no wall insulation.

Mark Ternes and his colleagues at ORNL had performed field tests on wall insulation for eight masonry homes in Phoenix, Arizona in 1993 (see "Cooling Benefits from Exterior Masonry Wall Insulation," *HE* Mar/Apr '94, p. 33). They found some energy savings, but wanted to test the insulation effects in the more humid Florida climate.

In the latest study, ORNL and FSEC tested two homes in Cocoa, Florida. The researchers retrofitted occupied single-family homes with exterior wall insulation. They hired contractors to install commercial exterior insulation and finish systems (EIFS) like those typically used on commercial buildings. In Arizona, they had fabricated the insulation systems on-site, using polystyrene foam board, wire lath, and stucco. In both studies, the insulation typically raised the thermal resistance of the walls from R-3 to R-13.

In Phoenix, where temperatures climb over 110°F in the summer and rarely drop below 80°F in July and August, the added insulation slowed the heat gain through the walls and reduced the measured air conditioning requirements. On average, energy consumption dropped 9%.

The houses studied in Florida had more complicated results. Summertime temperatures are less extreme there, especially in coastal areas. For a significant portion of the daily cycle, in the evening and overnight, the outside air can be cooler than the desired indoor temperature (see Figure 1).

These evening hours overlap with times that residents are typically home and active. Internal gains from people and appliances become a significant load for the cooling system. This heat generated inside the house can be passively transferred out into the environment, but only as fast as the walls and windows will allow. "During this period," Parker explains, "the most poorly insulated building possible will lower the required degree of air conditioning, because it will lose internally generated heat to the outside most quickly." Added insulation actually traps unwanted heat and impedes natural cooling.

The researchers determined that whether insulation saves cooling energy depends significantly on the interior thermostat setpoint. If residents set their thermostat at 73°F, rather than at the 79°F setpoint shown in Figure 1, the outside air would be warmer than the desired inside temperature virtually all the time. Heat would only flow inwardly through the wall under these conditions, and slowing it down with insulation would be helpful throughout the day.

The study found exactly this. The researchers monitored the two Florida houses, one with a setpoint of 73°F and another with a setpoint of 79°F. Although the cooler house used more air conditioning energy than the warmer house, the insulation saved 9%–14% of its pre-retrofit use. By contrast, the air conditioning energy use in the 79°F home actually increased by 5% after adding wall insulation!

Ventilation (by opening windows) could add to natural cooling at night. However, when the researchers mod-

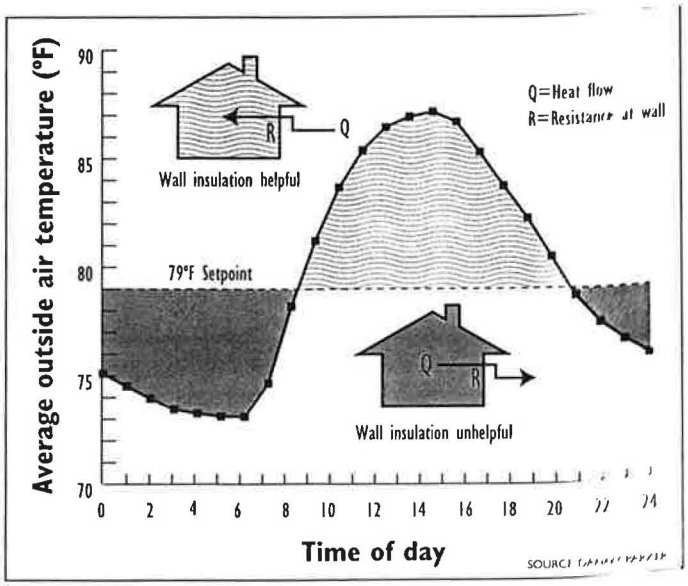

Figure 1. This graph shows the average daily June temperatures in Orlando, Florida. In this example, the residents kept their thermostat set to 79°F. Although wall insulation saved energy during the day (when outside temperatures were higher than inside temperatures) it prevented the heat from escaping during the evening and nighttime hours (when it was cooler outside than in).

eled the effects of open windows, they found that it would not completely overcome the negative impact of the wall insulation unless ventilation was forced, as with a whole-house fan. Also, according to Parker, "many people in humid regions air condition their homes around the clock and never ventilate. Ventilation is possible, but only if interior humidity of 80% or even higher is acceptable."

Even in the hotter Phoenix climate, adding wall insulation may not be cost-effective. ORNL had modeled a prototypical house in Phoenix with a central gas, forced-air furnace and air conditioner to estimate the combined heating and cooling savings attained through additional insulation. For an average retrofit cost of $3,900, the simple payback was calculated to be 32 years at 9.4¢/kWh. Ternes explains, though, that "the simple payback is reduced to 12 years if the homeowners were planning to restucco the house anyway and only the insulation cost of $1,500–$1,900 is considered."

Parker cautions that "what is true of walls is not true of ceilings. Ceiling insulation in cooling climates is often exposed to very hot temperatures due to attic heat collection, often up to 130°F in the height of summer." Thus it is more universally desirable than wall insulation.

On the other hand, the retrofits all slowed daytime heat gain through walls, reducing peak cooling demand. This can be a major benefit, primarily to electric utilities but also to customers with time-of-day rates or those who have an opportunity to downsize their cooling equipment. The 15% demand reduction found by both studies is comparable to reductions achieved by replacing old air conditioners with high-efficiency units, which is often supported with utility subsidies.

Another benefit not captured in the analyses is the improved comfort resulting from lower interior wall temperatures after adding insulation. Lower radiant wall temperatures may allow residents to raise their setpoints comfortably, thereby saving energy. Ternes reports that "several occupants observed marked improvement in the comfort of rooms on the south and west sides of the house that once overheated unbearably."

Optimally, says Parker, we would have "dynamic walls where thermal resistance is adjustable throughout the daily cycle during the cooling season." Though some energy researchers have experimented with creative ideas, such as movable insulation and vacuum insulation, no practical system has as yet been developed.

In the absence of such a breakthrough, people who design and retrofit homes in hot climates will do well to examine the specifics of their situation in light of these studies.

—Doug Johnson

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Conditioned Attics Save Energy in Hot Climates

Do homes with vented attics use less cooling energy than homes with unvented, conditioned attics in hot climates? With little formal research available to answer the question, common wisdom and most building codes have favored venting. But a recent field study in Las Vegas challenges existing assumptions about the virtues of venting in hot, humid climates. The study shows that moving the thermal and air barrier from the plane of the ceiling to the sloped roof plane improves airtightness and can save cooling energy by eliminating heat gain to ducts located in the attic.

Curbing Condensation

Joseph Lstiburek of the Building Science Corporation (BSC) in Chestnut Hill, Massachusetts was the primary researcher for the Las Vegas study. He said that one goal of the study was to validate observations of energy savings at homes and schools that BSC had retrofitted in Florida and Hawaii to eliminate moisture problems. The buildings had leaky ducts and air handlers in vented attics that caused the buildings to be depressurized. In hot climates, negative pressures in the house cause infiltration of warm, moist air from outside. This led to mold growth throughout the house. Having given up on getting large builders to install tight ducts, Lstiburek decided to do the next best thing—put the ducts inside the conditioned space.

The retrofits (sealing the attic vents and insulating at the roof deck) solved the moisture problems because, with the ducts leaking only to the inside, the houses were no longer depressurized. They also showed reduced energy use. According to Lstiburek, having the duct system within the conditioned space saved more energy than was used to condition the attic.

To confirm these results, Lstiburek and Armin Rudd of the Florida Solar Energy Center designed a computer model to describe what was happening, which they then tested with real data from the Las Vegas study.

The Las Vegas Study

The field study was performed on three houses in a Las Vegas subdivision. Two of the houses had attics with roof air barriers of sheathing, along with R-30 fiberglass batt insulation under the plywood roof deck. The third house (the study control) had a conventional vented attic with insulation above the ceiling gypsum board. The three houses had the same floor plan, elevations, and orientation.

The researchers installed temperature sensors at several locations and elevations—from the roof tile top to the inside air space—to record temperatures throughout the day. They measured air conditioner energy use at the compressor units, and performed air leakage tests for each home. Lstiburek and Rudd then analyzed the monitoring data for two weekend days on which the outside temperature peaked at 92°F. The days also had similar solar radiation peaks.

Even though the maximum temperatures recorded at the bottom of the plywood roof deck were higher in some instances for the conditioned attics than for the vented attic, air leakage rates and energy consumption were significantly less in the conditioned attic homes. The duct systems for the sealed attic houses had no measurable air leakage via the attic to the outdoors. There was also reduced heat gain to the ducts, since the attic was now cooled along with the