Roofs Reflect BETTER SAVINGS

by Danny Parker and Jeff Sonne

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Reflective roofing represents one of the most significant energy-saving options available to homeowners and builders.

Dramatic savings in cooling energy are possible with highly reflective roof systems. But, exactly how dramatic? That's the question we, at the Florida Solar Energy Center, sought to answer when we measured the cooling performance of different materials during realistic weather conditions.

Heat gain through the roof and attic exerts a powerful influence on cooling energy use in Florida homes. Unshaded residential roofs are heated by solar radiation, causing high afternoon attic air temperatures. This effect is due to increased ceiling heat transfer as well as heat gains to the duct systems, which are typically located in the attic space (see Figure 1).

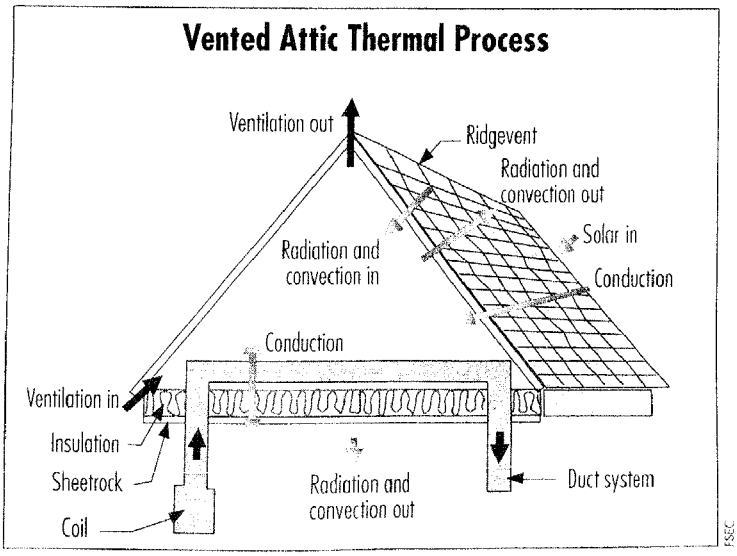


Figure 1. Roof and attic thermal performance exert a powerful influence on cooling energy use, as shown in this attic schematic. The air in the ductwork heats up as it travels through the hot attic.

We monitored the impact of roofing materials on cooling energy by monitoring seven side-by-side 1,144 ft^2 Habitat for Humanity houses in Ft. Myers, Florida. Six houses had identical floor plans, orientation, and R-19 ceiling insulation, but different roofing systems designed to reduce attic heat gain. The seventh house had an unvented attic with insulation on the underside of the roof deck rather than on the ceiling. The houses were completed in June 2000, and then extensively tested to ensure that the buildings were similar before monitoring was begun.

The homes were then monitored simultaneously in an unoccupied state from July 8 to July 31. Thermostats were set to keep each house at 77° F. We tested the following roofing materials (identification codes are given in parenthesis):

- standard dark gray shingle (control home) (RGS)
- light colored shingle (RWS)
- standard dark gray shingle with sealed attic and R-19 foam roof deck insulation (RSL)
- white "Barrel" S-shaped tile (RWB)
- white flat tile (RWF)
- terra cotta "Barrel" S-shaped tile (RTB), and
- white metal (RWM).

We measured building thermal conditions and air conditioning

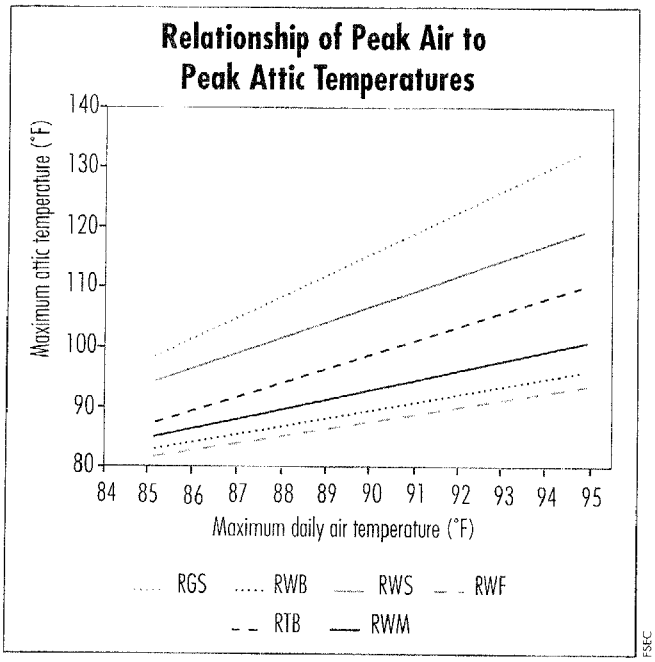


Figure 2. Highly reflective roof materials have a big impact on peak attic temperatures.

power on a 15-minute basis. Each of the examined alternative constructions exhibited performance superior to that of dark shingle (see Figure 2).

The maximum attic temperature during the peak summer hour was 40°F higher than the ambient air temperature for the control house, while it was no greater than the ambient air temperature for the houses with highly reflective roofing systems (white tile and white metal). The light-colored shingle and terra cotta roofs showed temperatures in between these two extremes (see Figure 3). Our study showed that dark gray roofs reflect a mere 8% of the heat associated with sunlight, while white shingle and terra cotta tile roofs reflect 25% and 34%, respectively. White metal and white cement tile roofs provide the most dramatic results, reflecting 66% to 77% of the sun's energy.

Additional monitoring took place over a month-long period with the homes occupied. Again, the thermostat setpoints were kept constant. Although average cooling energy use rose by 36% due to the added heat gains from appliances and people, our analysis indicated no decrease in relative savings or in demand reduction from the highly reflective roofing systems.

Essentially, there were two classes of performance (see Table 1). The first class consisted of white shingle, terra cotta tile, and sealed attic construction, which produced energy savings of 200–600 kWh/yr (3%–9%) and demand reductions of 0.05–0.5 kW (2%–17%). The second class consisted of highly reflective roof systems, which produced energy savings of 1,200–1,600 kWh/yr (17%–23%) and demand reductions of 0.8–1.0 kW (28%–34%)

A white galvanized metal roof should save a customer who lives in an average-size 1,770 ft² home in Florida approximately $128 (23% savings at 0.08/kWh) annually in cooling costs, compared with a dark gray shingle roof on the same home. For the same size home, white, S-shaped cement tile produces the second-best savings of $110, or 20%, of annual cooling costs, followed by white flat cement tile, which saves $96 per year or 17% compared to the dark gray shingle. White shingle trims $24 or about 4% off the annual cooling bill, while terra cotta S-shaped cement tile nets a modest $15, or 3%, savings compared to dark gray shingle.

The sealed attic with an insulated roof deck would produce annual savings worth about $50, but with very little impact on peak demand. This is because the savings realized by this construction technique are very sensitive to solar irradiance—on cloudy days the sealed attic with insulated roof deck performed better than the other options, while on sunny, hot days it performed much like the control. Analysis revealed that the insulated roof deck system experienced peak wood decking temperatures that were more than 15°F higher each afternoon than the decking of the standard ventilated attic. Visual inspection also showed evidence of buckling of shingles by

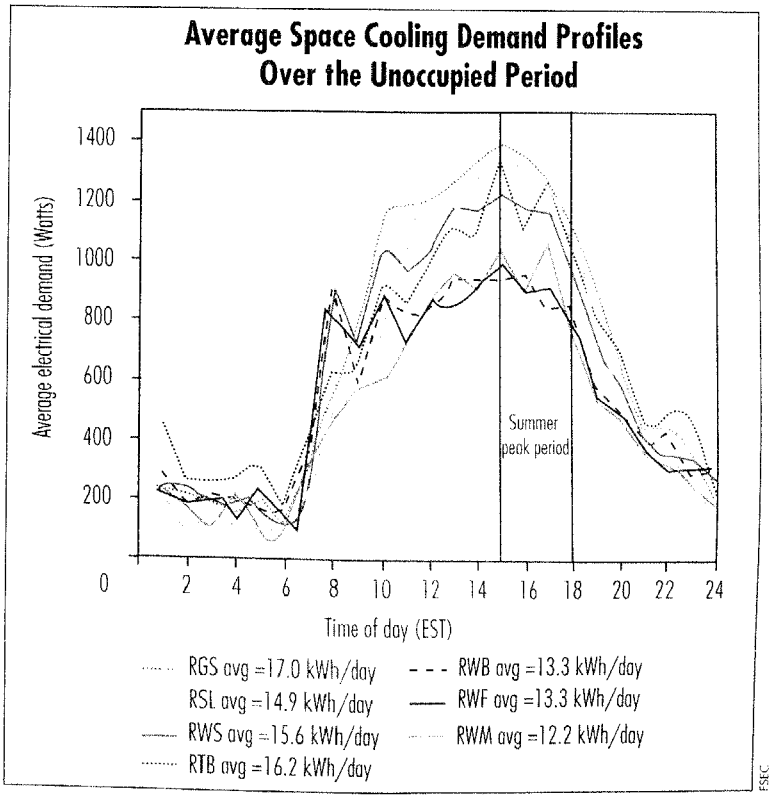


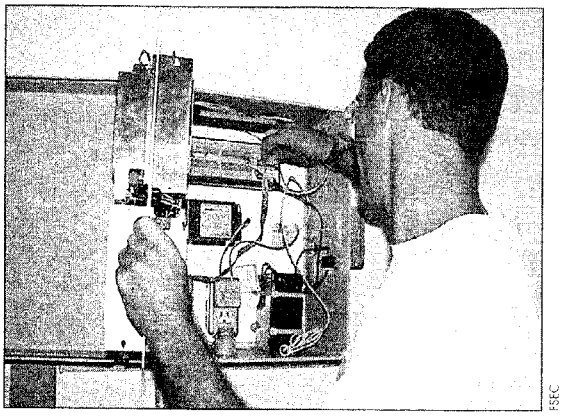
Figure 3. Highly reflective roof materials produce demand reductions of 28%–34%.

What Color is Your Energy-Efficient Roof?

The cover of this issue of *Home Energy* shows a palette of some of the new spectrally selective pigments available from Ferro Corporation of Cleveland, Ohio. All pigments have solar reflectances of 65% or greater, and all are highly reflective in the near infrared range.

They can be readily used for both metal roofing and for tiles to produce roofing with attractive color and high solar reflectance. Because of their energy efficiency, these pigments would automatically qualify for Florida's new residential "reflective roofing" credit (65% greater tested solar reflectance) set to become law on January 1, 2002.

MCA Tile Roofing Products in Corona, California, is making roof tiles with the pigments. Classic Products of Piqua, Ohio, is one of the firms manufacturing metal roofing with them. (Classic Products is also developing heat barrier finishes that reflect radiant heat even in dark colors.)



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Thermal conditions and air conditioning power were recorded with data loggers.

the end of the summer monitoring period. These results suggest that while this construction technique is promising, it should be used only in conjunction with reflective roofing materials or light-colored tile roofs to achieve good energy performance and roof system longevity.

Perhaps the most important finding was that reflective roofing systems can have a *very* big impact on residential space cooling demand during utility coincident peak periods. Although the sealed attic construction provided little peak reduction, the white shingle and terra cotta tile constructions provided peak reductions of approximately 15% compared with the control. However, the very reflective white tile and white metal roofing systems showed summer afternoon peak A/C demand reductions of 28%–34%—very large in magnitude compared with the other options.

The research was sponsored by the Florida Power and Light Company (FPL) and by the Industrialized Housing Partnership of the U.S. Department of Energy's Building America program. Project coordinator Craig Muccio of FPL said that the utility "wanted an opportunity to quantify savings using commonly available roofing materials. It was a rare opportunity to have identical houses, which Habitat for Humanity was generous enough to lend us. Now we can add a dollar amount to how much we can reduce air conditioning costs." FPL has used the findings to support credits for highly reflective roofs in the energy performance calculations of the state building code and to examine how best to promote the selection of white and light-colored roofs. Such roof systems also strongly reduce the cooling demand during utility coincident peak periods and may be among the most effective methods for deferring the need for new generating capacity.

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Table 1. Summary of Normalized Savings and Demand Reductions from Regression Estimates

Case Description	Cooling Savings		Peak Demand Reduction	
	kWh	Percent*	kW	Percent*
Control	0	0%	0	0%
White Shingle	300	4%	0.48	17%
Sealed Attic	620	9%	0.13	5%
Terra Cotta Tile	180	3%	0.36	13%
White S-Tile	1,380	20%	0.92	32%
White Flat Tile	1,200	17%	0.98	34%
White Metal	1,610	23%	0.79	28%

* Percentages relative to typical values for average sized detached South Florida homes.

For more information:

Parker, D.S., J.K. Sonne, J.R. Sherwin, and N. Moyer, *Comparative Evaluation of the Impact of Roofing Systems on Residential Cooling Energy Demand.* Contract Report FSEC-CR-1220-00, Cocoa, Florida, Florida Solar Energy Center, November 2000. The study was conducted in Fort Myers, Florida, by FSEC for Florida Power & Light Co., with the cooperation of Habitat for Humanity of Lee County, Florida. It is available at www.fsec.ucf.edu.

Ferro Web site: www.ferro.com. MCA Tile Web site: www.mca-tile.com

Classic Products Web site: www.classicroof.com.