CONCLUSIONS

Our tests and data show that the combination of improved solar reflectance afforded by IrBCPs and underside venting make stone-coated metal roofs energy-efficient. These materials can offer excellent energy credits as steep-slope cool roof products. The light-gray stone-coated metal shakes offset-mounted with a batten and counter-batten system reduced the heat transfer penetrating the roof deck by about 45% compared to the heat penetrating the deck of an attic covered with an asphalt shingle roof. About 15% of the reduction was due to IrBCPs, while 30% of the reduction was due to subtile venting. The synergistic effects of solar reflectance and underside venting supported a 70% reduction in the heat flow penetrating the ceiling into the conditioned space. Subtile venting of the stone-coated metal roofs is just as important as the boost in solar reflectance for reducing the heat gain into the attic and conditioned space.

Heat flows for July 2005 were integrated over the daylight and nighttime hours to show cooling season performance of the various roof systems (Table 8). The fascia vent did not enhance underside venting and shows the least benefit for reducing deck and ceiling heat flows. Painting the underside of a light-gray stone-coated metal roof increases the thermal emittance, which, in turn, degrades the thermal performance of the stone-coated metal roofs. A low thermal emittance provides improved performance by retarding the radiation flow of heat transfer to the deck during this summer month (Table 8). The best performing non-retrofit roofs were the S-mission profile roofs on battens and the light-gray infrared reflective shake roof on battens and counter-battens. Reduction in heat penetrating the ceiling of these prototypes was about 70% of the heat penetrating through the control shingle roof. Retrofitting a stone-coated shake roof over an existing cedar shake roof proved to be beneficial and resulted in the best thermally performing roof system (Table 8).

Table 8. July 2005 cumulative heat flows through the roof deck and floor of the attic assemblies

Stone-coated and asphalt shingle roofs	SR & TE	Roof deck construction	Roof deck heat flux (Btu/ft^2)[a] Daylight	Roof deck heat flux (Btu/ft^2)[a] Nighttime	Attic floor heat flux (Btu/ft^2) 24-Hour
Control: asphalt shingle (SR ~ 0.093)	SR09E89	Direct-to-deck	4481.9	–599.3	1926.2
Shk-LG-IRRagg-Upt-CB	SR246E90	Counter-batten	2218.0	–119.6	677.3
Shk-DG-CNVagg-Upt-CB	SR08E90	Counter-batten	2871.3	–88.6	793.7
Shk-LG-IRRagg-Pt-CB	SR25E90	Counter-batten	2406.6	–123.4	1251.5
Shk-LG-IRRagg-Upt-CB-Fascia Vent	SR244E90	Counter-batten	2464.1	–207.8	1461.3
Shk-LG-IRRagg-Upt-DDk	SR25E90	Direct-to-deck	2890.3	–424.2	857.6
PVDF Metal-DG-IRRPnt-Upt-DDk	SR287E90	Direct-to-deck	2956.9	–568.8	780.2
S-mission-TC-IRRagg-Upt-batten	SR257E90	Batten	2583.5	–532.0	716.9
S-mission-TC-CNVagg-Upt-batten	SR15E90	Batten	2560.3	–315.0	633.5
Shk-LG-IRRagg-Upt-CB over cedar shake	SR24E90	Over cedar shake	1100.8	316.1	585.1

[a]Deck heat flux based on floor area of attic assembly.

During the winter exposure in February 2005 (Table 9), the underside air channel reduced the heat loss from the roof to the point that the heat loss from the ceiling of the stone-coated metal roofs was less than the loss for the asphalt shingle roof. The improved summer performance coupled with the reduced heat losses during the winter show that the infrared reflective metal roofs negate the heating penalty associated with a cool roof in Tennessee's moderate climate (3662 HDD_{65} and 1366 CDD_{65}.). Therefore, offset-mounting stone-coated metal roofs provides the metal roof industry the opportunity to market stone-coated metal roofs in the more predominant heating load climates.

Table 9. February 2005 cumulative heat flows through the roof deck and ceiling of the attic assemblies

Stone-coated and asphalt shingle roofs	SR & TE	Roof deck construction	Roof deck heat flux (Btu/ft^2)[a]		Ceiling heat flux (Btu/ft^2)
			Daylight	Nighttime	24-Hour
Control: asphalt shingle (SR ~ 0.093)	SR09E89	Direct-to-deck	1609.5	−2620.5	−2534.5
Shk-LG-IRRagg-Upt-CB	SR246E90	Counter-batten	867.6	−1040.1	−2417.4
Shk-DG-CNVagg-Upt-CB	SR08E90	Counter-batten	1242.4	−1173.2	−2348.3
Shk-LG-IRRagg-Pt-CB	SR25E90	Counter-batten	848.8	−1472.0	−2118.6
Shk-LG-IRRagg-Upt-CB-Fascia Vent	SR244E90	Counter-batten	1038.1	−1107.7	−2325.2
Shk-LG-IRRagg-Upt-DDk	SR25E90	Direct-to-deck	1294.0	−1165.6	−2268.6
PVDF Metal-DG-IRRPnt-Upt-DDk	SR287E90	Direct-to-deck	1324.9	−1239.5	−2242.4
S-mission-TC-IRRagg-Upt-batten	SR257E90	Batten	1091.6	−1514.7	−2157.0
S-mission-TC-CNVagg-Upt-batten	SR15E90	Batten	1217.3	−1102.7	−2073.3
Shk-LG-IRRagg-Upt-CB over cedar shake	SR24E90	Over cedar shake	366.0	−532.2	−1998.5

[a]Deck heat flux based on floor area of attic assembly.