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Cool roofing is increasingly a hot topic

In the United States, commercial and institutional buildings are responsible for almost two-thirds of national electricity consumption and more than one-third of total primary energy use. As a result, the current energy crunch has made conservation measures within these structures more important than ever.

Heating and cooling costs are generally the major controllable expenses associated with the operation of a building such as a hospital or medical centre. Therefore, any reduction in these costs through the use of energy efficient building envelope components makes sense.

Unfortunately, the roof can be the least energy efficient component of a building envelope. Is it any wonder, then, that cool roofing has become such a hot topic?

Cool roofing is gaining in popularity due to its ability to reduce cooling and heating energy usage. Utility companies are also interested in cool roofing because it can help reduce the peak demand in electricity during the afternoon hours of summer months, preventing power disruptions. And, from an environmental point of view, cool roofing can also help to mitigate a phenomenon known as the heat island effect.

Minimising heat gain

Cool roofing is based on the premise of minimising heat gain through the roof surface. To understand how this happens one must look at the solar energy spectrum as shown in Figure 1. Ultra violet (UV) energy in lower wavelengths amounts to only 3% of the total energy striking the earth's surface. Visible light energy is 40% and infrared (IR) energy in the longer wavelengths accounts for the largest percentage of the spectrum. When IR energy strikes the earth's surface, we feel it as heat.

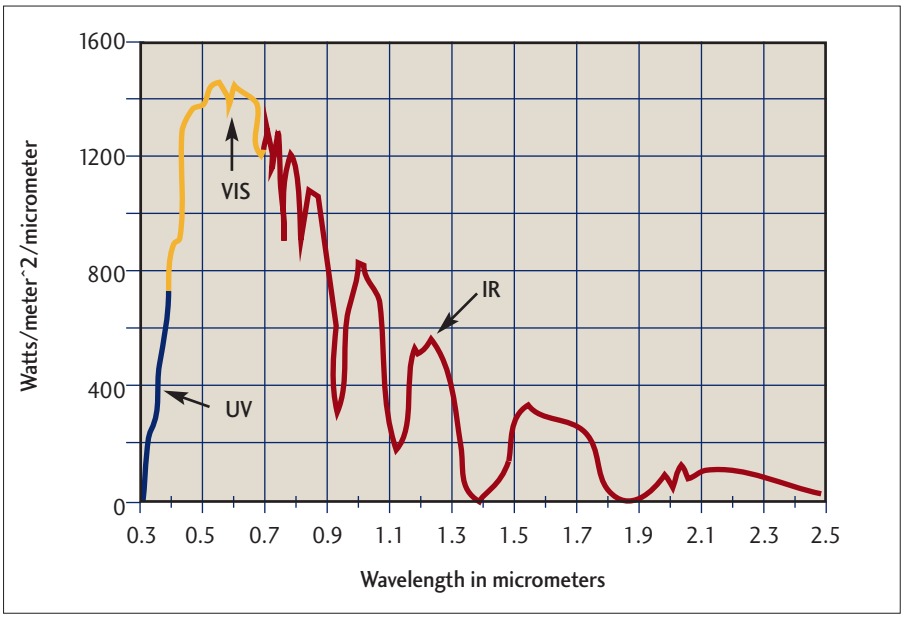

Figure 1: Solar energy spectrum.

Cool roofing is described by two main terms: solar reflectance and thermal emittance. Total solar reflectance (TSR) is the percentage of all solar radiation that is immediately reflected from a surface. Any energy that is not reflected from a surface is absorbed by the material. Some of this is transferred to heat which can be removed by convective transfer from air flow over the surface. Some of the heat can be conducted through the surface. More importantly, some of the heat can be re-emitted to the night sky in the form of infrared wavelength energy. The latter phenomenon is known as thermal emittance (TE). The combination of solar reflectance and thermal emittance properties of a material determine the surface temperature of a roof and its ability to "act cool".

Some typical radiative properties of common roofing materials are shown in Table 1. Metal roofing has a wide range of solar reflectance and thermal emittance values. In the unpainted condition, a metallic surface has a very low TE but a relatively high TSR. When a paint system is applied to the surface, the TE is very high regardless of the colour. However, the TSR can vary depending on the colour and/or pigmentation used.

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Growth

Metal roofing continues to grow in today's construction industry. In the residential sector, for example, metal's share is small but increasing faster than any other product. In commercial roofing, metal's share exceeds 30% in certain building types and applications.

Certainly, cool roofing is an ever-increasing segment. A 2006 survey in *Metal Architecture* magazine revealed that almost 29% of architects across the US stated that cool roofing qualities influenced their use of metal. An even higher percentage responded in the Southwest, Pacific and Northwest regions.

Metal roofing is available in a variety of

surface finishes, profiles, textures and substrates. Prepainted metal roofing is popular because of the aesthetic appeal and designs that become possible with colour. One of the main ingredients in exterior paint systems is pigments which impart colour to the surface. A blue paint looks blue to the naked eye because the pigments used in that paint film absorb all the visible wavelengths of colours except for blue which is reflected back to our eyes.

In general, dark colours absorb most of the visible light striking the surface while lighter colours reflect most of that solar energy. This would suggest that colour is an indication of how much solar visible energy will be reflected. The amount of infrared energy that is reflected is often a function of the colour as well, but recently new pigment technology has been introduced to change that assumption. New IR reflective pigments in paint systems allow for darker colours to actually reflect more total solar energy.

Cool metal roofing that is painted is available with special paint systems that feature a new pigment technology that increases TSR with corresponding lower surface temperatures. More importantly, these cool pigments do not affect the colour of the product, meaning that traditional colours can be matched with identical colours of the new paint systems with higher TSR values.

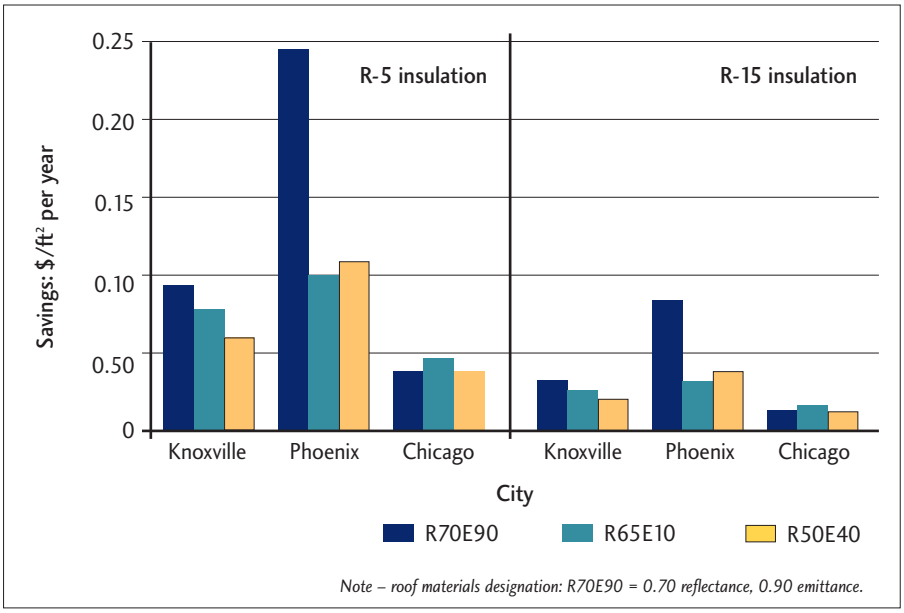
Research

Over the past five years, many research programmes have been conducted to characterise roofing products in the area of cool roofing. Oak Ridge National Laboratory (ORNL) conducted a three-year evaluation of a variety of metal roofing products installed in low slope and steep slope orientations and in a variety of environments.

The results from this work were used to develop whole building energy savings calculators for low and steep slope roofing. An example of the output from this calculator is shown in Figure 2. The ORNL study also showed differences in metal roofing compared to other types of roofing materials in terms of durability and degradation of TSR over time.

Prepainted metal roofing was found to retain its initial TSR values by 95% over as much as 30 years' exposure. In comparison, the research showed some membrane products lost 40% of their TSR after only three years due to dirt retention. Findings also showed that metal roofing's minor loss in reflectance was similar across all climates in the US.

Figure 2: Example of roof energy savings from ORNL calculator.



Note – roof materials designation: R70E90 = 0.70 reflectance, 0.90 emittance.

> 'Metal roofing is available in a variety of surface finishes, profiles, textures and substrates.'

The Florida Solar Energy Center (FSEC) has been evaluating the energy efficiency of roofing materials for some time. Its test facility allows for full size roofing panels to be exposed, allowing for measurement of temperatures and heat transfer into the space beneath.

An example of the performance of roofing materials with regard to roof temperatures is shown in Figure 3.

Note that the white painted metal roofing showed excellent performance. In the latter part of the afternoon, the metal roof surface cools below that of tile roofing, due to the difference in thermal mass between the two products. This translates into lower air conditioning costs over the course of an entire day.

Using that information, Florida Power & Light, in cooperation with Habitat for Humanity and FSEC, conducted a real-world experiment with homes featuring different roofing materials, including painted metal. The results showed that the metal roof saved 23% in cooling energy, which was the highest level of savings among the roof systems tested.

Programmes and initiatives

In addition to the obvious energy-saving benefits of cool roofing to a building owner, its use is also influenced by codes, standards, rebate/incentives, or marketing programmes. And, in this regard, the landscape is bursting with an ever-increasing list of cool roofing programmes and initiatives.

These policies can be national and local programmes, each with their own unique criteria and definitions of cool roofing. Most of the programmes are voluntary, but some have mandatory criteria. They often pertain to both low and steep slope roofing. The Environmental Protection Agency (EPA) expanded into the cool roof arena with the introduction of its Energy Star Roof Products Program in 1998.

EPA has determined that favourable mortgage lending programmes meet utility incentives and qualify for some government rebates.

EPA estimates that an Energy Star labelled roof can lower a roof temperature by as much as 100°F. The lower surface temperature translates into lower heat flow into the attic space below the roof and reduces the load on the air cooling system. To date, more than 60% of the products listed on the Energy Star labelled directory are metal roofing products or coatings used specifically in the metal roofing industry.

The Cool Roof Rating Council (CRRC) was

Table 1: Roofing material radiative properties.

	Solar reflectance	Thermal emittance
Metal (unpainted)	0.60-0.80	0.04-0.10
Metal (painted)	0.10-0.75*	0.80+
Comp asphalt shingles	0.05-0.25	0.90
Single ply membranes	0.70-0.80	0.85+
Built up roofing	0.05-0.80	0.90
Modified bitumen	0.05-0.25	0.90
Concrete/clay tile	0.20-0.70*	0.90

** Depending on colour.* *Source: ORNL and LBNL.*

established in 1998 as a non-profit organisation to develop a methodology for evaluating and labelling all types of roofing products. Its programme was launched in 2002. This organisation is comprised of roofing manufacturers, distributors, suppliers, trade associations, contractors, consultants, government agencies, educational institutions, code bodies, energy suppliers and independent laboratories. The CRRC is now recognised by the CEC as the sole entity responsible for labelling roofing products that are allowed in the California Energy Code Title 24. It is important to note that the CRRC does not establish criteria or definitions for cool roofing.

California is leading the way with an energy code as part of its overall building code. The latest version of its state building and energy code, Title 24, has been adopted and has become effective. That state energy code contains prescriptive language specific to cool roofing requirements for low slope and steep slope roof applications.

Another important incentive for the use of cool metal roofing is the Energy Policy Act of 2005 which was signed into law by President George W. Bush on 8 August 2005. The Act provides tax incentives for commercial construction.

An eligible commercial contractor can receive a tax deduction equivalent to $1.80 for every square foot of the building, if the building is designed to conserve energy. The use of energy efficient building envelope components is required, and a cool metal roof can be used to lower the cooling energy use in the building.

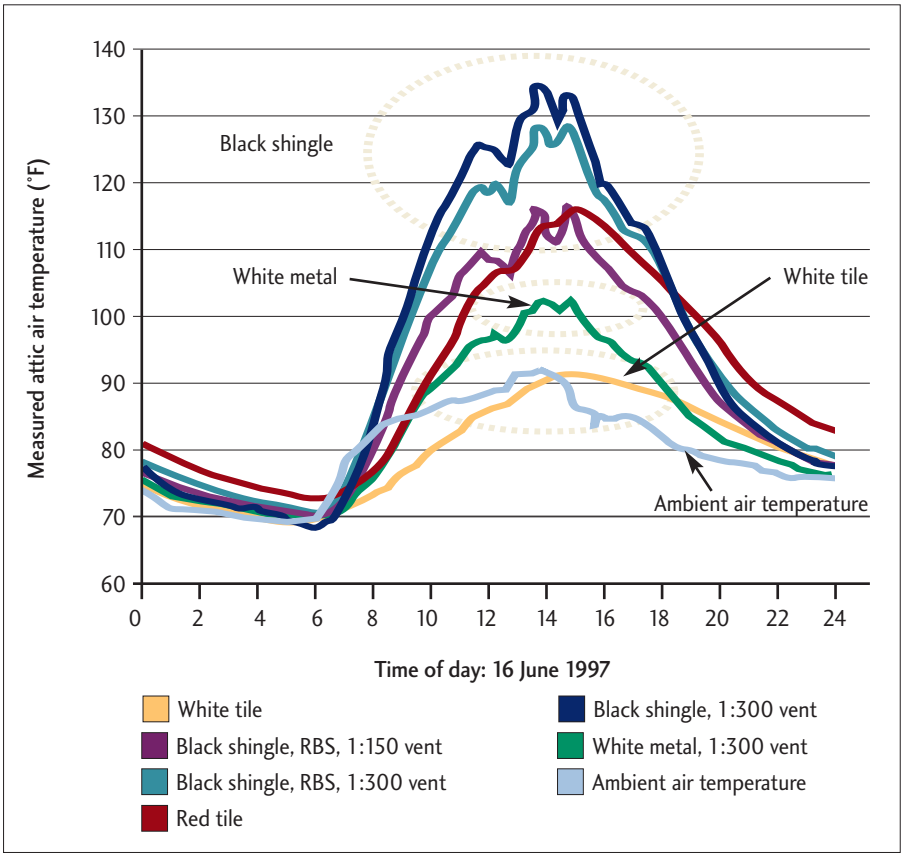
More information on these tax credits and tax deductions can be found on the Internal Revenue Service's website www.irs.gov

Whole-building design programme

Another programme gaining in popularity in the construction industry is the US Green Building Council's Leadership in Environmental and Energy Design (LEED) programme started in 2000. This is a whole-building design programme that encourages an integrated design and construction process whereby points are awarded for the use of sustainable products or building practices.

The flagship for LEED has been its New Construction (NC) programme. Other programmes include Existing Buildings, Commercial Interiors, Core and Shell Projects, Neighbourhood Development, Homes and Schools. Four levels of LEED certification are possible based on a graduated system of points awarded. An increasing number of LEED certification requirements for federal, state and local public building construction projects are being mandated.

Figure 3: FSEC data on roofing materials' effect on attic temperatures.



Metal roofing can contribute directly or indirectly to 24 points in the LEED-NC certification point system in several categories. Its high recycled content can be used to raise the overall building's average recycled content in order to receive points in the Material Resources credits.

The fact that metal is 100% recyclable helps with the waste management section of LEED. A cool metal roof can contribute to improved energy efficiency which is rewarded with points in the Energy and Atmosphere credits. Points for building re-use and/or material re-use are available due to the durability and longevity of a metal roof. One credit can be awarded for metal in the Heat Island Roof section where cool roofing is defined.

In version 2.2 of LEED-NC, a credit is available for a roof system whose Solar Reflective Index (SRI) meets the values in Table 2 for a system that covers a minimum of 75% of the roof surface area. Using the calculation of SRI according to ASTM E1980, this LEED requirement means that prepainted metal roofing with a solar reflectance value of 0.66 or greater would comply for low slope, and prepainted metal roofing with a solar reflectance value of 0.30 or greater would comply for steep slope roofing. This allows a wide variety of colours to be LEED compliant when metal roofing is specified.

'Cool' choice for any building

As the cool roof movement continues to grow in the wake of rising oil, gas and electricity costs, metal roofing is poised to become the product of choice. With its wide range of TSR/TE properties, it can be engineered to optimise the energy efficiency of a roof system depending on the climate and application.

For cooler climates where heating dominates, a lower TE may be desirable which can be met with an unpainted metal roof. In contrast, in warmer climates where cooling loads dominate, a high TSR and TE is desirable which can be met with a prepainted metal surface using lighter colours and/or IR reflective pigmentation. This design flexibility, combined with the sustainability, strength, durability, and low life cycle cost makes metal roofing a "cool" choice for a healthcare facility.

Table 2: LEED version 2.2, sustainable sites credit 7.2: heat island effect: roof.

Roof type	Slope	SRI (minimum)
Low-sloped roof	≤2:12	78
Steep-sloped roof	>2:12	29

Source: Eley Associates, 2003

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