Cool Roofing: A Solution to National Energy & Environmental Challenges
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Lowered air conditioning demand. Reduced urban heat island effect. What building product can deliver both of these features to the building owner looking to reduce energy costs and their environmental footprint?

Reflective, or "cool," roofing is the answer, roofing that delivers high solar reflectance and thermal emittance values. Solar reflectance, also known as albedo, is a measure of a material's ability to reflect the visible, infrared and ultraviolet wavelengths of sunlight. Thermal emittance is a measure of a material's ability to release absorbed, or non-reflected, heat. Both properties are measured on a scale of 0 to 1; the coolest roofs have the highest values. A third measure, solar reflectance index, may be used and represents both solar reflectance and emittance in a single value.

It's one of the fastest-growing building and construction trends today, and owners of large commercial buildings have more reasons than ever to incorporate cool roofs into their building design. It is a sure-fire way to reduce heat gain in their interior spaces, and curb the roofing surface's contribution to the urban heat island effect, that measurable increase in ambient urban air temperatures that comes with every new heat-absorbing roof, road and parking surface that replaces natural vegetation in the environment.

When Is A Roof System Cool?

There are multiple entities that provide guidance on the attributes of a cool roof . Reflective roofing technologies are increasingly called for in federal, state and local energy codes – most notably, California's building energy code, Title 24, prescribes a cool roof for low slope, non-residential applications in new construction and rennovation– and specifiers are turning to the Cool Roof Rating Council's (CRRC) product rating database to help make purchasing decisions.

CRRC measures the solar reflectance and thermal emittance of roofing products, and reports them via an online directory (www.coolroofs.org). Each year, CRRC conducts random testing to ensure the credibility of this directory. The program allows manufacturers and sellers to label their roofing products according to the specific properties CRRC measures. Roofs qualifying for Title 24 in California must be tested by a CRRC-approved lab and receive a CRRC label. CRRC does not specify minimum requirements for solar reflectance or thermal emittance, however.

A product rating system that does specify minimum requirements is ENERGY STAR®, the joint program of the U.S. Environmental Protection Agency and the U.S. Department of Energy designed to help businesses and consumers make energy-efficient product choices. For low slope roof applications, a roof product qualifying for the ENERGY STAR label under its Roof Products Program must have an initial solar reflectivity of at least 0.65, and weathered reflectance of at least 0.50. Emittance is not a current criterion for this program, although that may change in the future. (Title 24's requirements, in comparison, call for initial thermal emittance of 0.75 or better and initial solar reflectance of 0.70 or better.)

How Cool Makes A Difference

How can you get a quantitative analysis of the potential energy savings for your building without performing a detailed building energy simulation? Simple web-based tools developed by federal agencies can help assign an estimated value on the annual energy savings that can accrue during the life of a typical white reflective roof vs. a non-reflective black roof. The U.S. Department of Energy Cool Roof Calculator calculates the net cooling savings from installing a cool roof on an air conditioned building, and considers any resulting differences in heating costs. The site can be accessed at http://www.ornl.gov/sci/roofs+walls/facts/CoolCalcEnergy.htm.

The savings potential was brought home dramatically in 2001 by the Lawrence Berkeley National Laboratory (LBNL), which measured and calculated the reduction in peak energy demand associated with the surface reflectivity of a reflective white vinyl roof that replaced a black rubber roof on a major retail store in Austin, Tex. Vinyl, or PVC, roofs achieve some of the highest reflectance and emittance measurements of which roofing materials are capable. It is not uncommon for such a roof system to reflect 80 percent or more of the sun's rays and emit at least 70 percent of the solar radiation that a building absorbs.

A black asphalt built-up roof, by contrast, reflects 6-26 percent of solar radiation, resulting in greater heat transfer to the building interior and greater demand for air conditioning – a strain on both operating costs and the electric power grid.

In full sun, that black roof typically undergoes a temperature rise of as much as 50 (10°C) to 90 (32 °C) degrees, reaching midday temperatures of 150 (66 °C) to 190 (88 °C) degrees in summer. A white vinyl roof on the same building typically increases only 10 to 25 degrees above ambient temperatures.

The LBNL findings were consistent with this, recording an average daily summer temperature for the black roof surface of 168 (76 °C) degrees. Once retrofitted with a white reflective surface (with the same insulation and HVAC systems in place), it measured 125 (52 °C) degrees, a 43 (24)-degree reduction.

LBNL also found that the retrofitted vinyl membrane delivered an 11 percent decrease in aggregate air conditioning energy consumption, and a corresponding 14 percent drop in peak hour demand, compared to the original black roof. Without considering any tax benefits or other utility charges, annual energy expenditures were reduced by $7,200 or $0.07/sq. ft.($0.75/sq. m)

While logic would seem to dictate that vinyl roofs are best specified in southern climate zones only, net annual energy savings are typical even in northern climates.
Although there are fewer cooling degree days, cool roofs can have more impact on energy cost than energy use, cutting consumption during peak power demand when rates are the highest and offsetting any minimal wintertime increases in heating costs.

Whether in northern climates or southern, cool roofs cut down on the urban heat island effect by lowering surrounding air temperature, which in turn reduces demand for building cooling and minimizes a building's carbon footprint.

Another direct effect of urban heat islands is an increase in harmful ground-level ozone, the primary constituent of smog. Ozone at ground level forms through a chemical reaction between oxides of nitrogen (NOx) and volatile organic compounds (VOCs) – from motor vehicle and other emissions – in the presence of sunlight.

In urban heat islands, the combination of asphalt parking lots and road pavement, sparse vegetation, and expanses of black roofs can raise air temperatures as much as 10 degrees higher than the temperature of the surrounding countryside. In some densely populated areas, a quarter of the land cover may be roof surface alone. Relative to remedying the other sources of the problem, replacing dark roofing requires the least amount of investment for the most immediate return.

Building Green With Cool Roofs

Curbing the urban heat island effect, along with reducing energy consumption, are significant objectives of the green building programs Green Globes™ and LEED®, and reflective roofing can help meet the criteria of both of these sustainable construction programs.

Green Globes, an online tool, uses performance benchmark criteria to evaluate a building's probable energy consumption, comparing the building design against data generated by the EPA's Target Finder, which reflects real building performance. A building's information is verified by a Green Globes-approved and trained licensed engineer or architect.

As many as 17 points direct points under Site Credit 7.2.2 and 7.3.1. and assistance towards the attainment of up to 91 additional points may be awarded for the use of either highly reflective materials or a vegetated green roof or both. To qualify for a rating, roofing materials must have a solar reflectance of at least .65 and thermal emittance of at least .90.

Green Globes for New Construction is the first American National Standards Institute (ANSI) standard for commercial green building design.

LEED, the U.S. Green Building Council's Leadership in Energy and Environmental Design certification, provides product performance standards in designing buildings, but does not certify products.

For a roof to receive LEED Sustainable Sites Credit 7.2, at least 75 percent of the surface of a roof must use materials having a Solar Reflective Index (SRI) of at least 78. This criterion may also be met by installing a vegetated roof for at least 50 percent of the roof area, or installing a high albedo and vegetated roof that, in combination, meets this formula: (Area of SRI Roof/0.75)+(Area of vegetated roof/0.5)≥Total roof area LEED will allows for a lower SRI if the weighted rooftop SRI average meets the following criterion: (Area SRI roof/Total roof area)*(SRI of installed roof/Required SRI)≥75%. A cool roof roof can qualify for the attainment of 1 point under Sustainable Sites Credit 7.2 and contribute towards the attainment of up to 28 additional Points

In this vein, a separate but related area of cool roofing pertains to constructing the roof that many think of as the ultimate in cool, the planted roof. Vinyl roof membranes are often used in concealed applications such as the waterproofing layer in planted roofs and plaza decks. The permanent hot-air welded seams do not deteriorate in the perpetually moist environment of a vegetated roof, and those same seams provide the highest resistance to root penetration of any waterproofing membrane.

The other variation on cool roofs is solar applications, which are gaining considerable momentum in the commercial building sector. Solar panels and systems are compatible with a vinyl roof; in fact, some solar companies will only use vinyl membranes for their systems because the material's proven long lifecycle, high reflectivity, superior fire ratings and hot-air welded seams assure that the roofing substrate will be functioning as long as the PV modules themselves.

Resources

The Emergency Economic Stabilization Act of 2008, extended until 2014 the federal tax deduction for energy efficient commercial buildings with qualifying systems, including roofs. The amount deductible is up to $1.80 per square foot of building floor area for buildings achieving a 50% energy savings target.

Other incentives can be found in:

» The Database of State Incentives for Renewable Energy – a state by state compilation of energy efficiency policies and incentives administered by federal and state agencies, utilities and local organizations.

» The U.S. Department of Energy's State Energy Program (SEP) – allocates funds for states to design and implement their own energy efficiency programs.