Cool Roofs, Hot Topic

Energy Star-labeled roof products can bring significant savings for buildings in most parts of the country

— By Rita Tatum, Contributing Editor

Summertime is anything but easy for facility executives trying to get a handle on skyrocketing air conditioning loads. What if you could reduce your facility's peak cooling demand by 10 to 15 percent and fix the roof with the same capital expenditure? If your building is located where the sun shines brightly, and you currently have a black rooftop needing repair or maintenance or are in the process of constructing a new building, you definitely will want to investigate Energy Star®-labeled roof products.

These reflective roof products lower roof temperatures by up to 100 degrees F, thereby decreasing the amount of heat transferred into a building's interior. Although some reflective roof products may have a higher initial price than non-reflective alternatives, Energy Star-compliant roof products can save facility executives money and energy over the life of the roof by reducing the amount of air conditioning needed to keep a building comfortable. In addition, reflective roof products can potentially minimize the effects associated with thermal shock, reduce UV degradation, and extend the life of the roof.

"In general, building owners will save the most money on energy bills by installing an Energy Star-labeled roof product if their building has the following characteristics: high air conditioning bills, a large roof surface as compared to the building's overall size, lower levels of insulation and/or a location in a hot, sunny climate," points out Rachel S. Schmeltz, Energy Star program manager. "The most cost-effective time to install an Energy Star-labeled roof product is when re-roofing, constructing new buildings or maintaining a roof by applying a coating."

In February, the U.S. Environmental Protection Agency (EPA) announced its Energy Star Roof Products Charter Partner companies at the National Roofing Contractors Association (NRCA) convention in Phoenix. Under the program, manufacturers will be allowed to use the Energy Star label on reflective roof products that meet EPA's specifications for solar reflectance and reliability.

EPA's Energy Star roof specifications are not restricted to a particular type of roof product. However, the agency expects that initially metal roof products, single-ply membranes and roof coatings will be most widely available.

The agency also understands that the primary functions of roofs — water tightness, durability and longevity — cannot be compromised. Manufacturers of Energy Star-labeled roof products must back their compliant roof products with warranties that are comparable to their other roof products.

Air Pollution and Urban Heat Islands

Most energy generated in the United States relies on fossil fuels, the burning of which creates the air pollution associated with smog, acid rain, greenhouse gas emissions and global climate change. EPA is committed to reducing that pollution and the reflective roofing market is one way to

improve the environment particularly in urban areas and improve the building's rooftop simultaneously.

"By reducing the amount of energy needed to cool buildings, Energy Star-labeled roof products help to reduce the production of these air pollutants," says Schmeltz.

"Additionally, reflective roof products can help reduce the 'heat island effect,' a phenomenon in which cities can be 2 to 8 degrees F warmer than the surrounding countryside," explains Schmeltz. "Such heat islands occur, in large part, because many buildings and paved surfaces are designed with dark materials that absorb heat from the sun. This heat is released at night, causing the air temperature to remain high. The resulting elevated temperature leads to an increased demand for air conditioning in buildings, increased fuel use for vehicle air conditioning, increased levels of smog, and associated increased levels of heat-related and smog-related health problems. Installing reflective roofs helps reduce the heat island effect, decreasing the amount of smog in the air and benefiting the entire community."

"The urban areas are warmer because their dark surfaces absorb more solar heat and because there is less vegetation," explains Hashem Akbari, one of the principal investigators of heat island effects at Lawrence Berkeley National Laboratory (LBNL). "There are two quick fixes for summer heat islands. The least expensive is to move toward lighter colored surfaces, the way Mediterranean cities do. The other is to plant shade trees — another ancient tradition."

"The heat island effect also causes an increased probability that photochemical smog will form, because smog is more likely to form as the temperature increases," says Haider Taha, an LBNL scientist with the Environmental Energy Technologies Division. "Reducing the temperature of the urban heat island could reduce the formation of photochemical smog."

In areas such as Los Angeles, for every degree the temperature rises above 70 degrees F the presence of smog increases 3 percent. Lawrence Berkeley National Laboratory scientists estimate that if all buildings in Los Angeles used Energy Star-labeled roof products, the total energy and smog-related health care savings would be about $500 million annually.

But significant energy savings are not restricted to southern locations, according to LBNL researchers Akbari and Sarah Bretz.

"In fact, about half the U.S. population lives in heat islands." they say. "Of course, white roof systems will save more in hotter climates, such as Phoenix and Los Angeles. But for most building types, cool roof systems will have net savings in colder climates as far north as Chicago."

Energy savings

Estimated potential savings from the widespread use of reflective roofs are significant in many major cities. Consider these examples of potential annual net cooling energy savings in a major cities from around the nation, drawn from LBNL data:

- Los Angeles: $35 million
- Phoenix: $37 million
- Dallas/Fort Worth: $20 million
- Houston: $27 million
- New Orleans: $9 million
- Chicago: $10 million
- Atlanta: $9 million
- Miami/Ft. Lauderdale: $20 million
- Washington/Baltimore: $8 million
- Philadelphia: $3 million
- New York: $16 million

It's clear that, when it comes to energy savings from reflective roofing, geography is not destiny. Potential savings depend on a range of factors. For example, although Los Angeles has seven

times the population of Phoenix, it enjoys smaller potential annual net cooling savings because it has fewer air conditioned buildings and less cooling energy per square foot.

LBNL studies also show that electricity prices affect potential savings. Though Atlanta is certainly in a much warmer climate than New York, its 8 cents per kilowatt hour electricity cost could yield less savings than in New York, where electricity costs up to 16 cents per kilowatt-hour.

"In general, the best candidates for white roof systems in any city are buildings with high air-conditioning bills (more than $30 per 1,000 square feet), low insulation levels (less than R-11 ceilings) or ducts running through the attics," explains Bretz. "But a cool roof system will benefit most buildings in areas with hot, sunny summers."

There are a few areas where reflective roofs are not practical because their summer savings are more than offset by increased heating costs in winter. Generally, however, these locations have particularly cold climates like that found in Minneapolis or cloudy weather conditions with mild summers as is found in Seattle and San Francisco.

Individual energy savings depends on many factors, including geographic location and climate, electricity pricing, existing insulation levels in the building, the type of roof it replaces, what type of roof is installed and how well it is kept clean and maintained. However, in the right situations, cooling energy savings can be as high as 50 percent, says EPA. A reflective roof also can reduce peak cooling demand by 10 to 15 percent.

"As a result, facilities executives may be able to purchase smaller, less expensive HVAC systems," notes Schmeltz.

But Schmeltz also cautions that normal wear and tear takes a moderate toll on initial reflectivity. "The greatest decrease in solar reflectance occurs within the first few years after installation," says Schmeltz. "In addition, flat roofs may accumulate dirt and debris because rain cannot wash them clean. Following recommended maintenance procedures can minimize the amount of degradation and maximize energy savings over the life of the roof. As part of an overall asset management strategy for protecting your roof investment, building owners and facility managers should consider implementing a routine roof inspection and maintenance program that includes scheduled cleaning."

Rooftop experience

Other researchers also have found rooftop reflectivity can offer substantial energy savings. In a Florida Solar Energy Center test, eight shops in a commercial strip mall covered with a metal roof were measured for temperature and energy use. Then the roof over two of the shops was coated white. The following summer, energy loads in those two shops were reduced 25 percent. However, not all metal roof products require white coating to provide the benefits of reflectivity.

"On a typical summer day, smooth surfaces with fresh white coatings (reflectance near 80 percent) only heat up about 10 to 20 degrees F above the ambient temperature," explains Andre Desjarlais, program manager for Building Envelope Research at Oak Ridge National Laboratory (ORNL). "Coated rough surfaces or weathered surfaces with reflectance near 55 percent heat up 30 to 50 degrees above ambient temperatures. Some uncoated surfaces with reflectance near 10 percent can reach temperatures nearly 100 degrees F above ambient temperatures."

Applying white radiation control coatings to existing low-slope roofs with non-reflecting membranes has been the focus of research during the past decade at ORNL's Buildings Technology Center. For example, the facility currently is studying 24 different coatings and coating systems with the cooperation of several coating manufacturers and the Roof Coatings Manufacturers Association. White coatings and aluminum and asphalt emulsion coating types are represented in the study.

The RCMA study involves periodic measurement of the coatings' solar reflectances and infrared emittances and continuous measurement of the thermal performance of the coatings on

instrumented test sections.

Long-term monitoring data on cool roofs also is necessary. ORNL and the National Roofing Contractors Association (NRCA) began a project in 1991 on a roof in the Chicago area. Results from it show how white latex coatings, aluminum coatings and asphalt emulsions available then have performed since.

Naturally, facility executives can expect the greatest energy savings on cooling bills when an Energy Star-labeled roof product is installed on a building with a low or nonexistent level of roof insulation.

“However, energy-efficient buildings should have both reflective roof surfaces and adequate insulation,” says Schmeltz.

One notable study of the effects of insulation and solar reflective roofs was conducted at Tyndall Air Force Base in the Florida Panhandle. At Tyndall, 1,500 square foot single-story concrete block building’s annual energy use under different situations was predicted in a Department of Energy (DOE) 2.1E computer model. The model of the existing building was calibrated against measured electrical power used by the building.

Annual cooling energy use was estimated for the building with various roof coatings and levels of low-slope roof foam insulation. The solar reflectances varied from 75 percent for the fresh white coating on a smooth roof to 52.5 percent for a weathered white coating and just 20 percent for an uncoated oxidized metal roof. Roof R-values corresponded to insulation thicknesses of 2 inches, 1 inch and none.

With no insulation, the annual cooling energy for the uncoated building was roughly 10,000 kilowatt-hours. The weathered white coating was 23 percent more energy efficient, needing slightly less than 8,000 kilowatt-hours, while the fresh white coating was 43 percent more efficient at a little less than 6,000 kilowatt-hours.

With 1 inch of insulation, the uncoated roof’s annual cooling energy needs dropped to slightly more than 6,000 kilowatt-hours and both the weathered and white coating difference drops as well. The weathered coating was now 12 percent more efficient than the uncoated roof (needing about 5,800 kilowatt-hours) and the new white coating was 23 percent more efficient (requiring roughly 5,000 kilowatt-hours).

Adding a second inch of insulation to all three roof scenarios caused the uncoated roof to dip under 6,000 kilowatt-hours for annual cooling energy. The weathered coating performs 8 percent better at conserving energy (approximately 5,200 kilowatt-hours) and the fresh white coating performs 13 percent better (roughly 5,000 kilowatt-hours).

“When installing a reflective roof while constructing a new building, doing a major renovation or replacing your whole roof system, you should consult with your roofing contractor to maximize savings by making sure the optimum level of R-value in insulation is installed,” says Schmeltz.

E-mail comments and questions.

Energy Star Launches Roof Products Program With 65 Charter Partners

Energy Star-labeled roof products are the newest addition to the highly successful Energy Star program. Products bearing the Energy Star label are more energy efficient than standard products,

so they **save energy and money**. In general, Energy Star-labeled products appliances, HVAC equipment, office equipment, residential lighting and even homes reduce energy costs by at least 30 percent.

"Approximately $40 billion is spent annually in the U.S. to air condition buildings," says Rachel Schmeltz, Energy Star program manager. "Reflective roof products that meet the Energy Star specifications can help to reduce energy bills by up to **50 percent** and reduce peak cooling demand by **10 percent to 15 percent**. Energy Star-labeled roof products protect the environment by reducing the amount of energy that must be generated to air condition buildings, thereby reducing the amount of pollution released into the air by power plants." As in other Energy Star programs, the Energy Star Roof Products Program is a voluntary partnership designed and implemented by the U.S. Environmental Protection Agency and the U.S. Department of Energy.

Working with roofing industry representatives, EPA now has developed specifications for roofing products, **based on their reliability and energy efficiency** as measured by solar reflectance. Manufacturers can put the Energy Star label on roof products that meet or exceed these specifications.

The Energy Star Roof Products Program, launched at the National Roofing Contractors Association convention and exhibition in Phoenix, began with 65 charter members. Energy Star specifications are not restricted to any type of roof product. However, EPA expects that initially **metal, single-ply membrane and roof coating products** will be most widely represented.

Information on the Energy Star labeled Roof Products is available through the Energy Star hotline at 1-888-782-7937 or on the web (choose "roof products" from the product menu).

Do You Know Your Roof's True Colors?

When the sun shines, roof temperatures range from comfortably warm to egg-frying hot. The temperature of a roof depends on **how much sunlight it can reflect**. Lawrence Berkeley National Laboratory tested different roofing materials when the ambient air temperature was 55 degrees F. Here are the peak temperatures found by the study:

	Degrees F
Black acrylic paint	142
Galvanized steel	138
Black acrylic paint infrared reflecting film	123
"White" fiberglass/asphalt shingle	118
Clay terra cotta tile	112
Red acrylic paint	106
Light green acrylic paint	104
White acrylic paint	74
Hyper white acrylic paint	65

Studies by Lawrence Berkeley National Laboratory (LBNL) and the Florida Solar Energy Center have found **considerable variances in differing roofing materials**, including single-ply membranes, built-up roof systems, metal roofing and modified bitumen, the types most commonly found on commercial and institutional buildings.

Many **single-ply membranes** are available in white with reflectances of 70 to 80 percent or more. For some single plies, including EPDM, a dark membrane can be combined with a white coating to achieve the same reflectance, provided the coating is properly applied. Built-up roofing systems (BUR) vary widely, from 5 to 80 percent, depending on the surfacing.

For **BURs surfaced with aggregate**, LBNL reflectance data ranges from 10 percent for dark aggregate to nearly 50 percent for white marble chips. Covering dark aggregate with a white cementitious coating can increase reflectance to 55 or 60 percent. Using a white reflective coating on a built-up roof can yield higher reflectances of 70 to 80 percent.

Metal roof products are available with white coatings, which raise solar reflectances to about 65 percent. In addition, other metal roof products are available **without a coating** that meet the Energy Star specifications.

According to Florida Solar Energy Center and LBNL studies, **modified bitumen's reflectance** ranges from 5 to 25 percent, but it is possible to increase reflectivity to about 65 percent by adding a white reflective coating.

Concrete and clay tile may be purchased in white, increasing solar reflectance to about 70 percent, as compared to 20 to 30 percent for red tile.

Energy Star Product Specifications: Low-Slope Roofs

Low-slope roofs, with a slope of 2:12 inches or less. (For roof products that may be applied to either low-slope or steep-slope roofs, such as roof coatings and single ply membranes, the low-slope values are the applicable Energy Star specifications.)

ENERGY EFFICIENCY	PERFORMANCE SPECIFICATION
Initial solar reflectance	Greater than or equal to 0.65
Maintenance of solar reflectance	Greater than or equal to 0.50 three years after installation under normal conditions
RELIABILITY	
Manufacturers warranty for defects in materials and manufacturing	Each company's warranty for reflective roof products must be equal in all material respects to the warranty offered by the same company for comparable non-reflective roof products. A company that sells only reflective roof products must offer a warranty that is equal in all material respects to the standard industry warranty for comparable non-reflective roof products

Energy Star Product Specifications: Steep-Slope Roofs

Steep-slope roofs, with a slope greater than 2:12 inches. (For roof products that may be applied to either low-slope or steep-slope roofs, such as roof coatings and single ply membranes, the low-slope values are the applicable Energy Star specifications.)

ENERGY EFFICIENCY	PERFORMANCE SPECIFICATION
Initial solar reflectance	Greater than or equal to 0.25
Maintenance of solar reflectance	Greater than or equal to 0.15 three years after installation under normal conditions
RELIABILITY	
Manufacturers warranty for defects in materials and manufacturing	Each company's warranty for reflective roof defects in materials and products must be equal in all material manufacturing respects to the warranty offered by the same company for comparable non-reflective roof products. A company that sells only reflective roof products must offer a warranty that is equal in all material respects to the standard industry warranty for comparable non-reflective roof products

Rating Cool Roofs

The recently formed Cool Roof Rating Council's (CRRC) mission is to **"implement and communicate fair, accurate and credible radiative energy performance rating systems for roof surfaces."** CRRC plans to "develop tools that help customers evaluate other features of cool roofs that will affect their ability to provide sustained radiative benefits."

CRRC membership is diverse. Members include representatives from roofing materials manufacturers, roof consultants, energy service providers, governmental officials and environmental groups among others.

In addition, CRRC hopes to "provide analytical tools to help code officials, electric utilities and specifiers/builders accurately assess the energy performance of reflective roofing products, **which will aid in product selection, building load estimation and equipment sizing.** And develop

educational materials and tools that help customers understand the benefits of reflective roofing products, e.g., energy savings, air quality improvement, and extended life of a roof system."

Some compare CRRC to the National Fenestration Ratings Council, a third-party organization that develops and issues ratings for windows. **CRRC plans to develop a procedure for rating roofs,** according to Peter Kelly, assistant administrator for CRRC.

Another association looking at cool roofs is SPRI, which represents sheet membranes and component suppliers to the roofing industry. SPRI is sponsoring research at Oak Ridge to evaluate the intermediate and long-term reflectivity of thermoplastic roof membranes. A question SPRI wants addressed is how quickly membranes change.

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