Letting Cooler Roofs Prevail

Lawrence Berkeley Natl Lab

Imagine it's a hot summer day, and you can choose between walking barefoot on a black asphalt sidewalk or one that's concrete. Unless you're a glutton for punishment, you'd probably choose the relatively cooler, light-colored concrete sidewalk, which reflects the sun's heat.

This idea of reflecting the sun's heat is at the heart of "cool roof" technology, which is growing in popularity in the United States. Developed through a collaborative partnership of federal researchers and companies, this innovative technology can be a powerful weapon in the battle to cut greenhouse gas emissions, while reducing urban pollution and energy consumption.

The basic idea underlying cool roofs is nothing new under the sun.

Lighter colors tend to reflect sunlight and heat, which is why people in tropical climates typically wear white or light-colored clothing. The same holds true for roofing materials. Buildings with dark-colored roofs are hotter than those with light-colored roofs. Employing the same principle, cool roofs are made of materials that reflect the sun's energy, so they're much cooler.

How much cooler? Cool roofs generally reduce the roof surface temperatures by 50 to 60 degrees Fahrenheit, and in some cases by as much as 90 degrees.

Consequently, this decreases the heat transferred to the building, which can reduce energy costs associated with cooling the building. Not only that, but cool roofs have other potential benefits, such as lower maintenance costs, longer-lasting roofs, and generally improved comfort for the building's occupants.

Cool roofs translate into environmental benefits by lowering greenhouse gases and emissions that go hand-in-hand with energy consumption. Also, since cool roofs last longer, they don't have to be replaced as frequently which, in turn, reduces roofing waste that ends up in landfills.

But there's another big environmental win that cool roofs offer – especially to city dwellers — the reduction of heat islands and concomitant smog.

What's a heat island? Think of it as an expansive canopy of warm, polluted air that covers an urban area where the temperature is higher than in the surrounding areas. So, these urban areas are islands of heat, surrounded by suburban and rural areas where trees and vegetation lend themselves to cool temperatures. Dark, heat-absorbing rooftops are big contributors to the growing problem of urban heat islands.

The Birth of a Collaborative Partnership

While cool roofs have become more common in the marketplace in recent years, they have been years in the making. For decades, two separate federally funded research institutions have been researching the possibilities of making roofs reflect the sun's heat and radiation: Lawrence Berkeley National Laboratory (Berkeley Lab) in Berkeley, Calif., and Oak Ridge National Laboratory (ORNL), managed by UT-Batelle for the Department of Energy, in Oak Ridge, Tenn.

"We've conducted building envelope research since the 1970s, and our first cool roof experiment took place in 1986," explains Andre Desjarlais, group leader of Building Envelope Research at ORNL. Building envelope research involves investigating the energy efficiency of a building's "skin" – its roof, walls, foundation and windows, as opposed to internal "working parts" such as the furnace, appliances, etc.

Meanwhile, the Environmental Energy Technologies Division (EETD) at Berkeley Lab had been studying solar reflectance of roofs since the early 1980s.

"Within the last 25 years, we have achieved global recognition for our work on heat mitigation and cool roof research," notes Hashem Akbari, head of the Heat Island Group at Berkeley Lab.

However, the two institutions had been approaching cool roof research from two distinctly different vantage points.

"We received U.S. Department of Energy funding for our research on building energy efficiency, whereas Hashem's Heat Island Group received U.S. Environmental Protection Agency funding to explore the environmental benefits of cool roof research," says Desjarlais.

But in time, a series of emerging trends and events brought the two institutions together in a collaborative partnership to bring cool roof technology to the marketplace.

As the new millennium dawned in 2000, the concerns over the environment and global warming became widespread in the U.S. Case in point: 71 percent of Americans reported being either actively involved in the environmental movement or sympathetic toward it.

Around that same time, concerns over the environment and energy consumption became particularly acute in California. From November 2000 through May 2001, Californians experienced a series of brownouts — planned partial shutdowns of energy for limited durations, designed to ease the demand on the power grid to avoid a complete energy blackout.

It became clear that controlling peak demand, rather than investing millions of dollars into new power plants, would be necessary to deal with California's looming energy shortage problem. Utility companies and energy policy experts soon discovered that cool roof technology offered an effective means to control peak demand. One of its biggest advantages is that it doesn't rely on changing or influencing people's energy consumption habits, such as turning off lights, doing laundry at off peak times or using energy-efficient appliances. Once the cool roof is installed, significant energy savings start adding up.

By 2001, the California Energy Commission began promoting cool roof technology, running ads to increase awareness of its benefits, and offering more than $20 million worth of rebates to building owners who installed cool roofs.

But the California Energy Commission took its mission a step further. In 2002, it brought together researchers at the Berkeley Lab and ORNL for a collaborative Public Interest Energy Research (PIER) project aimed at improving cool roof technology and expanding its availability and use in the California marketplace.

"The project also involved industrial partners representing 95 percent of the roofing material-type market in the United States," added Akbari. "They were essential to our success."

Among the originally participating companies were 3M, American Rooftile Coatings, BASF, Custom-Bilt Metals, Elk Premium Building Products, Inc., Ferro Corp., GAF Materials Corp., Hanson Roof Tile, International Specialty Products Minerals, MCA Tile, MonierLifetile and the Shepherd Color Co.

"We already had been working with a lot of these manufacturers before 2002, but our cooperative research project with ORNL made the relationship with our industry partners more 'formal,'" says Akbari. "Since then two dozen other manufacturers have expressed interest in joining us."

The Cool Color Challenge

One of the biggest challenges facing the partnership between Berkeley Lab, ORNL and the manufacturers was to develop cool roof technology available in a rainbow of colors appealing to a wide range of residential customers.

At the time, existing cool roofs were available in just light colors. For commercial buildings, having a white or light-colored roof is a non-issue. This is because commercial buildings' roofs typically are flat and out of the public eye, so it really doesn't matter what color the roof is.

But most homeowners are very particular about the color of their roofs. Many U.S. homeowners may not buy lighter-colored cool roofs, even it could help them save money by cutting their air conditioning bills.

With this in mind, Berkeley Lab scientists worked with industry partners, including Ferro Corp. and Shepherd Color Co., testing different types of materials and pigments, with the goal of creating a large palette of cool colors. Using solar spectrometers, the researchers identified the pigments contained within colors that reflect what is known as "near-infrared" radiation, which comprises more than half of the energy in sunlight. Armed with this new information, they developed software enabling manufacturers to use these pigments to create roofing materials with "high solar reflectance" – the ability to reflect solar radiation both in the visible and near-infrared parts of solar spectrum.

The next step involved the development and testing of roofing materials containing these "cool colors." Residential roofing experiments involved roofing made of coated asphalt shingles, clay or concrete tiles, or metal. And this is where the industrial partners came into play.

Companies donated materials and shared information, working with Berkeley Lab researchers on developing experimental cool colored materials with just the right combination of pigmentation to achieve optimal reflectivity. Utilizing these prototype materials, Berkeley Lab and ORNL conducted field tests to determine their effectiveness.

"These experiments typically involve using sensors to measure the amount of heat flowing into the house from the attic," explains Desjarlais.

Frank Klink, Ph.D., a laboratory manager in 3M's Industrial Mineral Products Division, notes that the cool roof initiative resulted in great enhancements to the sand-like granules 3M manufactures for coated asphalt shingles.

"The value of increased reflectance is further enhanced by the granules' naturally high thermal emittance," he explains. "This means that whatever solar energy is not reflected is readily dissipated, further helping to keep the roof cool. Incorporating these factors into roofing helps reduce building cooling costs, especially on the hottest days of the year when electrical demand peaks."

The Success Story Continues

> *An interesting aspect of the cool roof PIER project is that the resulting technology has not been patented or licensed. It's available free of charge to any roofing product company wishing to take advantage of it.*

Akbari says the project has successfully achieved its goal of promoting the use of cool roofs in the marketplace, not only in California, but beyond.

"The popularity of cool roofs is catching on in other parts of the country," he says.

In different cities throughout the U.S., the projected annual cost savings from using cool roofs is considerable. For example, Phoenix can save as much as $26 million in annual cool energy costs, while Los Angeles can save $15 million.

As for the environmental benefits, a single 3,000-square-foot home with a cool roof can reduce its yearly carbon dioxide emissions by one ton. And based on field tests, cool roofs can save residents and building owners 20 percent in annual cooling energy use. Given these great benefits, it's no surprise that the Berkeley Lab research team is exploring other uses for cool colors – for car surfaces, clothing, tools and camping gear.

Tony Chiovare is president and CEO of Custom-Bilt Metals, a partner in the project and one of the first manufacturers to use cool roof technology in metal shingles. For him, the cool roof "revolution" makes good sense from both an environmental and a business standpoint.

"I'm a capitalist, there's no question about that," he says. "But if we can promote technologies like this one that help us reduce energy consumption and benefit the environment, we all win!"

This story was originally published in 2008.

To see available technologies from research institutions, click here to visit the AUTM Innovation Marketplace.