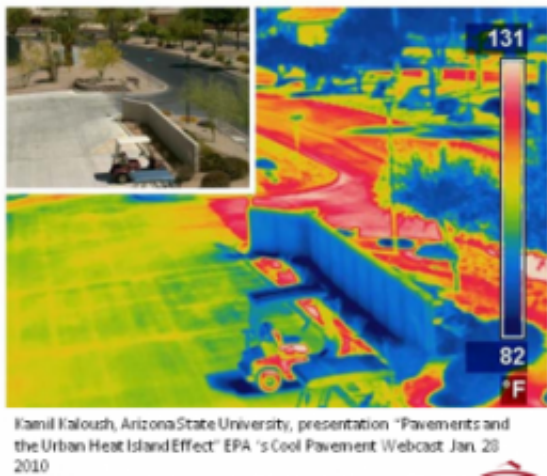


Global model confirms: Cool roofs can offset carbon dioxide emissions and mitigate global warming

July 19 2010



Lighter colored pavement is more reflective, resulting in a cooler surface temperature. (Photo courtesy ASU National Center of Excellence for SMART Innovations)

(PhysOrg.com) -- Can light-colored rooftops and roads really curb carbon emissions and combat global climate change? The idea has been around for years, but now, a new study by researchers at Lawrence Berkeley National Laboratory that is the first to use a global model to study the question has found that implementing cool roofs and cool pavements in cities around the world can not only help cities stay cooler, they can also cool the world, with the potential of canceling the heating

effect of up to two years of worldwide carbon dioxide emissions.

Because white roofs reflect far more of the sun's heat than black ones, buildings with white roofs will stay cooler. If the building is air conditioned, less air conditioning will be required, thus saving energy. Even if there is no air conditioning, the heat absorbed by a black roof both heats the space below, making the space less comfortable, and is also carried into the city air by wind—raising the ambient temperature in what is known as the urban heat island effect. Additionally, there's a third, less familiar way in which a black roof heats the world: it radiates energy directly into the atmosphere, which is then absorbed by the nearest clouds and ends up trapped by the [greenhouse effect](#), contributing to global warming.

Today, U.S. Energy Secretary Steven Chu announced a series of initiatives at the Department of Energy to more broadly implement cool roof technologies on DOE facilities and buildings across the federal government. As part of the effort to make the federal government more energy efficient, Chu has directed all DOE offices to install cool roofs, whenever cost effective over the lifetime of the roof, when constructing new roofs or replacing old ones at DOE facilities. Additionally, the Secretary has also issued a letter to the heads of other federal agencies, encouraging them to take similar steps at their facilities.

"Cool roofs are one of the quickest and lowest cost ways we can reduce our global [carbon emissions](#) and begin the hard work of slowing climate change," said Chu. "By demonstrating the benefits of cool roofs on our facilities, the federal government can lead the nation toward more sustainable building practices, while reducing the federal carbon footprint and saving money for taxpayers."

In the latest study, the Berkeley Lab researchers and their collaborators used a detailed global land surface model from NASA Goddard Space

Flight Center, which contained regional information on surface variables, such as topography, evaporation, radiation and temperature, as well as on cloud cover. For the northern hemisphere summer, they found that increasing the reflectivity of roof and pavement materials in cities with a population greater than 1 million would achieve a one-time offset of 57 gigatons (1 gigaton equals 1 billion metric tons) of CO₂ emissions (31 Gt from roofs and 26 Gt from pavements). That's double the worldwide CO₂ emissions in 2006 of 28 gigatons. Their results were published online in the journal *Environmental Research Letters*.

"These offsets help delay warming that would otherwise take place if actual CO₂ emissions are not reduced," says Surabi Menon, staff scientist at Berkeley Lab and lead author of the paper.

Co-author Hashem Akbari emphasizes that cool roofs and pavements are only a part of the solution: "Two years worth of emissions is huge, but compared to what we need to do, it's just a dent in the problem," says Akbari, the former head of the Berkeley Lab Heat Island Group and now Hydro-Quebec Industrial Research Professor at Concordia University in Montreal. "We've been dumping CO₂ into the atmosphere for the last 200 years as if there's no future."

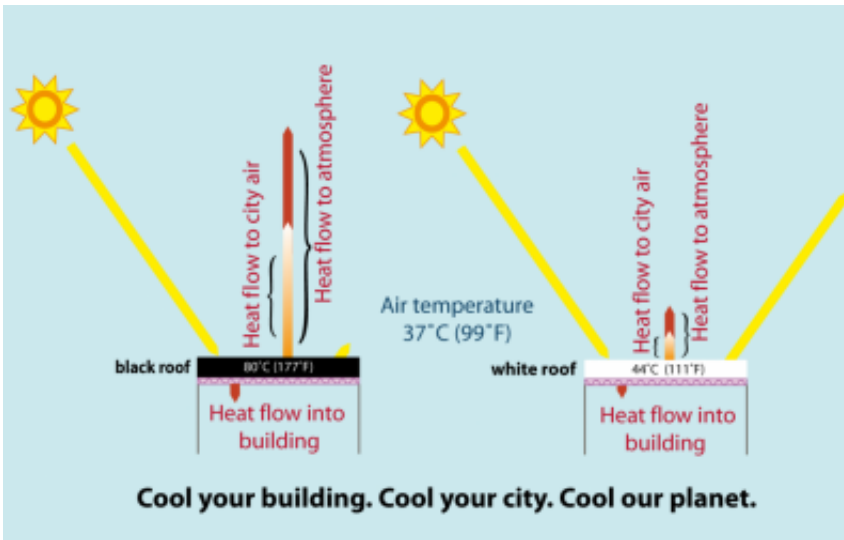
This study is a follow-up to a 2008 paper published in the journal *Climate Change*, which calculated the CO₂ offset from cool surfaces by using a simplified model that assumed a global average for cloud cover. The earlier paper, co-authored by Akbari, Menon and Art Rosenfeld, a Berkeley Lab physicist who was then a member of the California Energy Commission, found that implementing cool roofs and pavements worldwide could offset 44 gigatons of CO₂ (24 Gt from roofs and 20 Gt from pavements).

Equivalent to Getting 300 Millions Cars Off the Road

"If all eligible urban flat roofs in the tropics and temperate regions were gradually converted to white (and sloped roofs to cool colors), they would offset the heating effect of the emission of roughly 24 Gt of CO₂, but one-time only," says Rosenfeld, who returned to Berkeley Lab this year. "However, if we assume that roofs have a service life of 20 years, we can think of an equivalent annual rate of 1.2 Gt per year. That offsets the emissions of roughly 300 million cars (about the cars in the world) for 20 years!"

In both studies, the researchers used a conservative assumption of increasing the average albedo (solar reflectance) of all roofs by 0.25 and of pavements by 0.15. That means a black roof (which has an albedo of 0) would not have to be replaced by a pure white roof (which has an albedo of 1), but just a roof of a cooler color, a scenario that is more plausible to implement.

Roofs and pavements cover 50 to 65 percent of urban areas. Because they absorb so much heat, dark-colored roofs and roadways create what is called the urban heat island effect, where a city is significantly warmer than its surrounding rural areas. This additional heat also eventually contributes to global warming. More than half of the world's population now lives in cities; by 2040 the proportion of urbanites is expected to reach 70 percent, adding urgency to the urban heat island problem.



The surface of a black roof (left) heats up 78F above the air temperature, while the surface of a white roof (right) heats up only 12F. Additionally, with a black roof, far more heat flows both to the city and into the atmosphere (arrow lengths are proportional to energy radiated).

The Berkeley Lab study found that global land surface temperature decreased by a modest amount—an average of roughly 0.01degrees Celsius, based on an albedo increase of .003 averaged over all global land surfaces. This relatively small temperature reduction is an indication that implementing cool surfaces can be only part of the solution to the global climate change problem, the researchers say. To put the number in context, consider that global temperatures are estimated to increase about 3 degrees Celsius in the next 40 to 60 years if CO₂ emissions continue rising as they have. Preventing that warming would necessitate a 0.05 degree Celsius annual decrease in temperature between now and 2070.

Thus, even modest changes should not be dismissed. "Simply put, a cool roof will save money for homeowners and businesses through reduced air conditioning costs. The real question is not whether we should move

toward cool roof technology: it's why we haven't done it sooner," says Rosenfeld.

Other Studies Reach Similar Conclusions

Another recent study on cool roofs, led by Keith Oleson at the National Center for Atmospheric Research (NCAR) and published in Geophysical Research Letters, found that if every roof were painted entirely white, the CO₂ emission offsets would be approximately 32 Gt for summer and about 30 Gt annually. While the NCAR study used a different model, the calculated CO₂ emission offsets are similar to the results from the Berkeley Lab study and provide a useful and independent verification of the expected CO₂ emission offsets from increasing the reflectivity of roofs.

Some observers have pointed out that cool roofs do not make sense in cooler climates because of "winter penalties," since cooler buildings require more energy to heat. However, the energy savings from cooler buildings usually outweighs any increase in heating costs. Furthermore, in winter, there tends to be more cloud cover; also, the sun is lower and the days are shorter, so a flat roof's exposure to the sun is significantly reduced.

"Cool roofs have worked for thousands of years in the Mediterranean and Middle Eastern cities, where demand for air conditioning is low," says Akbari. "If you have a cool roof on your house, that will reduce your energy use from air conditioning and it's a gift that keeps on giving for many, many years, for the life of the roof."

More information: [Read the 2010 paper](#) by Surabi Menon, Hashem Akbari, Sarith Mahanama, Igor Sednev and Ronnen Levinson, "Radiative forcing and temperature response to changes in urban albedos and associated CO₂ offsets"

Provided by Lawrence Berkeley National Laboratory

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