White roofs are the trillion-dollar solution

Geoengineering, adaptation, and mitigation, part 2

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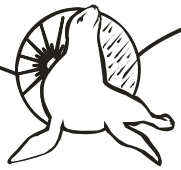
Part 1 introduced urban heat island mitigation (UHIM). It discussed how lighter colored (or reflective) roofs and pavement, plus urban trees, can save energy, cut CO2 emissions, cool a city, and reduce smog.

But a global "cool roofs" strategy can achieve far bigger benefits -- the equivalent of several trillion dollars worth of CO2 reductions -- since it can increase the albedo (reflectivity) of the planet, thereby directly reducing the absorption of incoming solar radiation and hence planetary warming. The strategy proposed below "**is equivalent to taking the world's approximately 600 million cars off the road for 18 years.**"



(100 m2 (~1000 ft2) of a white roof, replacing a dark roof, offsets the emission of 10 tonnes of CO2.)

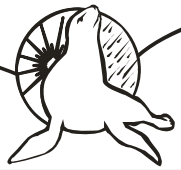
This is technically geoengineering, although I'd call it geoengineering-light or geo-reverse-engineering, since we are mostly undoing the albedo decrease caused by all the dark roofs and dark pavement we have covered the planet with.

A forthcoming article in *Climatic Change*, "Global Cooling: Increasing World-wide Urban Albedos to Offset CO2," [PDF] provides the detailed calculations. A two-page non-technical summary, "White Roofs Cool the World, Directly Offset CO2 and Delay Global Warming," [PDF] has been written by two of the country's leading UHIM experts: Lawrence Berkeley National Laboratory's Hashem Akbari and California Energy Commissioner Arthur Rosenfeld (coauthors with me on "Paint the Town White -- and Green"). I have reprinted it below:

As the threat of global warming becomes widely recognized, scientists have proposed using geoengineering (manipulation of the Earth's environment) to quickly respond to this threat. Most proposed geoengineering techniques are novel and unproven. Two simple technologies that have been around for thousands of years, cool roofs and cool pavements, should be the first geoengineering techniques used to combat global warming.

Increasing the solar reflectance of urban surfaces reduces their solar heat gain, lowers their temperatures, and avoids transferring heat back into the atmosphere. This process of "negative radiative forcing" counters global warming. In a recent study to be published in journal *Climatic Change* [PDF], Akbari, Menon and Rosenfeld have calculated the CO2 offset, or equivalent reduction in CO2 emission, achieved by increasing the solar reflectance of urban surfaces.

Most existing flat roofs are dark and reflect only 10 to 20% of sunlight. Resurfacing the roof with a white material that has a long-term solar reflectance of 0.60 or more increases its solar reflectance by at least 0.40. Akbari et al. estimate that so retrofitting 100 m2 (1000 ft2) of roof offsets 10 tonnes of CO2 emission. (For comparison purposes, we point out that a typical US house emits about 10 tonnes



of CO2 per year.) Emitted CO2 is currently traded in Europe at about $25/tonne, making this 10-tonne offset worth $250.

It is fairly easy to persuade (or to require) the owners of buildings to select white materials for flat roofs, and in California this has been required since 2005. However, the demand for white sloped roofs is limited in North America, so California compromises by requiring only "cool colored" surfaces for sloped roofs. (This rule takes effect in July 2009, see "California tightens building standards yet again.")

Use of cool-colored surfaces increases solar reflectance by about 0.20 and yields a CO2 offset of about five tonnes per 100 m2, or about half that achieved with white surfaces. The solar reflectance of pavement can be raised on average by about 0.15, offsetting about four tonnes of CO2 per 100 m2.

Over 50% of the world population now lives in urban areas, and by 2040 that fraction is expected to reach 70%. Pavements and roofs comprise over 60% of urban surfaces (roofs 20 to 25%, pavements about 40%). Akbari et al. estimate that permanently retrofitting urban roofs and pavements in the tropical and temperate regions of the world with solar-reflective materials would offset 44 billion tonnes of emitted CO2, worth $1.1 trillion at $25/tonne.

(Note that the price of CO2 will almost certainly need to exceed $100/tonne in the 2020s if we are going to catastrophic warming (see here). So the full benefit of this strategy would likely exceeds $4 trillion.)

How can the reader visualize this one time offset of 44 billion tonnes of CO2? The average world car emits about 4 tonnes of CO2 each year. Permanently increasing the solar reflectance of urban roofs and pavements worldwide would offset 11 billion car-years of emission. **This is equivalent to taking the world's approximately 600 million cars off the road for 18 years.**

Equivalent Car Offsets from Cool Roofs		
Duration of Program	**Annual CO_2 Offsets**	**Equivalent Cars Offset**
10 Yr	2.4 Billion t/yr	600 million Cars for 10 years
20 Yr	1.2 Billion t/yr	300 Million Cars for 20 years

If only roofs are changed from their current dark colors to white for flat roofs and cool colors for sloped roofs, we can offset 24 billion tonnes of CO2. If we take 20 years to implement just the cool roofs portion, it's the equivalent of taking half of the cars in the world off the road for every year of the 20 year program (see table). The offset provided by cooling urban surfaces affords us a significant delay in climate change during which we can take further measures to improve energy efficiency and sustainability.

Akbari et al. propose an international campaign to use solar reflective materials when roofs and pavements are initially built or resurfaced in temperate and tropical regions. They point out that such an international "cool cities" program is a win, win, win proposition.

Cool roofs reduce cooling-energy use in air conditioned buildings and increase comfort in unconditioned buildings (win #1). Cool roofs and cool pavements mitigate summer urban heat islands, improving outdoor air quality and comfort (win #2). This latest research shows that cool roofs and cool pavements can cool the entire globe (win #3). Installing cool roofs and cool pavements in cities worldwide does not require delicate international negotiations about capping CO2 emission rates.

Part 3 will look at how cool roofs could fit into a green stimulus package.