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White Roofs Cool the World, Offset CO_2, and Delay Global Warming

As the threat of global warming becomes widely recognized, scientists have proposed geo-engineering techniques ("the artificial manipulation of the environments of the Earth, especially as a means of counteracting global warming"[1]) for quick response to counter the threat. Most proposed geo-engineering techniques are novel but unproven. Simple ideas, such as cool roofs and cool pavements, that save energy, improve comfort, and have been practiced for thousands of years should be the first adopted geo-engineering project.

Increasing the solar reflectance of urban surfaces results in reflecting more of the incoming global solar radiation, hence, counters global warming. In a recent study to be published in journal *Climatic Change*, Akbari, Menon, and Rosenfeld have quantified the effect of increasing the solar reflectance of urban surfaces in terms of CO_2 offset[2]. Most existing flat roofs are dark and have a typical solar reflectance of 10%-20% that can be increased by using white materials with initial reflectance of 70%-80%, aging to over 60%, an increase of over 40% in the solar reflectance. They estimate that for a house with 1000 ft^2 of roof area (or a non-residential building), the CO_2 emission offset is 10 tonnes. Currently, in Europe emitted CO_2 is traded at ~$25/tonne; this total CO_2 offset of 10 tonnes is worth $250.

Rosenfeld notes that "the idea of a white roof to cool a glass greenhouse is well known. A greenhouse traps heat efficiently in winter, but then it overheats in warm weather. The manager then whitewashes the panes so as to reflect solar radiation back out through the transparent atmosphere instead of permitting that radiation to enter the greenhouse where it is converted to heat and trapped."

It is fairly easy to persuade (or to require) owners of buildings with flat roofs to select white for their roof color, and in California this has been required since 2005. But in the case of sloped roofs there are architectural issues, so California compromises efficiency with aesthetics and only requires that roofs be "cool-colored" which are about half as effective as white. (This rule takes effect in July 2009). As to pavements the reflectivity can be raised on average only 15%, which leads to a CO_2 offset of four tonnes per 1000 ft^2, worth $100.

Of course, it is well known that white roofs save building's cooling-energy use by about 20% (and hence directly reduce CO_2 emissions from electricity generating power plants). The estimated U.S. potential savings for white roofs are in excess of $1 billion per year in net annual energy bills

[1] http://en.wiktionary.org/wiki/geoengineering .

[2] Akbari, H., S. Menon, and A. Rosenfeld. 2008. "Global Cooling: Increasing Solar Reflectance of Urban Areas to Offset CO_2," In press, *Climatic Change*.
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(cooling-energy savings minus heating-energy penalties). The global cooling effect of white roofs is equivalent to over 10 years of CO_2 reduction resulting from cooling-energy savings. Increasing the solar reflectance of urban surfaces (roofs and pavements) also reduces the summertime urban temperatures leading to an improved urban air quality and citizen comfort. The combined effect of the energy and air-quality savings from increasing the solar reflectance of urban surfaces in the U.S. alone can exceed $2 billion per year. The estimate of the worldwide energy savings is huge.

Over 50% of the world population now lives in urban areas, and by 2040 that fraction will grow to 70%.In urban areas, pavements and roofs constitute over 60% of urban surfaces (roofs 20-25%, pavements about 40%). The estimate of the global CO_2 emission offset for cool roofs and cool pavements is 44 Gt (billion metric tonnes), worth about $1100 billion. This 44 Gt CO_2 offset is more than one year's worth of the 2025 projected world-wide emission of 37 Gt of CO_2. Furthermore, assuming a plausible growth rate of 1.5% in the world's CO_2-equivalent emission rate, the 44 Gt CO_2-equivalent offset potential for cool roofs and cool pavements would counteract the effect of the growth in CO_2-equivalent emission rates for 11 years.

Akbari, Menon, and Rosenfeld propose an international campaign to organize all the large cities in tropical and temperate regions to develop programs to install white roofs and cool pavements when the roofs are first built or re-roofed and when pavements are installed or resurfaced. Akbari points out that "such an international 'cool cities' program is a win, win, win case. Cool roofs save cooling-energy use in air conditioned buildings and improve comfort in buildings that are hot but are not air conditioned (win #1). Cool roofs and cool pavements reduce summer heat islands, leading to better ambient air quality and comfort (win #2). And now this paper shows that cool roofs and cool pavements cool the entire globe (win #3)." Installing cool roofs and cool pavements in cities worldwide does not need delicate negotiations between nations in terms of curbing each country's CO_2 emission rates. An international cool cities program can be used as a model to organise the world in taking a coordinated step to mitigate global warming.

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