Key Facts

Global Cool Cities Alliance

In most urban areas worldwide, a majority of surfaces are made up of roofs or pavements. Because most roofing and paving materials are dark and absorb over 80 percent of the incoming sunlight, our built environment heats cities and exacerbates the effects of climate change. If these surfaces are replaced by more reflective materials, we could instead cool our buildings, cities and the planet.

In North America, urban surfaces typically consist of 20 to 25 percent roofs and 30 to 45 percent pavements.[1,2]

White Roofs

When sunlight shines on a roof, some of it is reflected by the roof surface and some is absorbed and turned into heat. The fraction of sunlight that a surface reflects is called "solar reflectance"or "albedo." Solar reflectance can be measured from 0 to 1 or from 0 to 100 percent, ranging from about 0.04 (or 4 percent) for charcoal to 0.9 (or 90 percent) for fresh snow.

Most roofs are dark and reflect less than 20 percent of incoming sunlight. A new white roof reflects about 70 to 80 percent of sunlight.

Over time, white roofs will weather and soil, and the amount of sunlight they will reflect decreases to about 55 to 65 percent. Replacing a dark roof with an aged white roof still reduces the amount of sunlight absorbed by around 45 to 65 percent.[3] Codes and standards use the aged value of white roofs to calculate the benefits of white roofs.

Dark roofs can reach temperatures over 66 degrees Celsius (150 degrees Fahrenheit) on summer days. A white or cool roof under the same conditions would stay more than 28 degrees Celsius (50 degrees Fahrenheit) cooler than dark roofs.[4]

Cool Colored Roofs

Highly reflective roofs do not need to be white, but can come in popular colors such as red and grey.

Cool colored materials are available for all types of pitched and low-sloped (i.e. almost flat)[5] roofs. These materials include, metal, clay tile and concrete tiles.

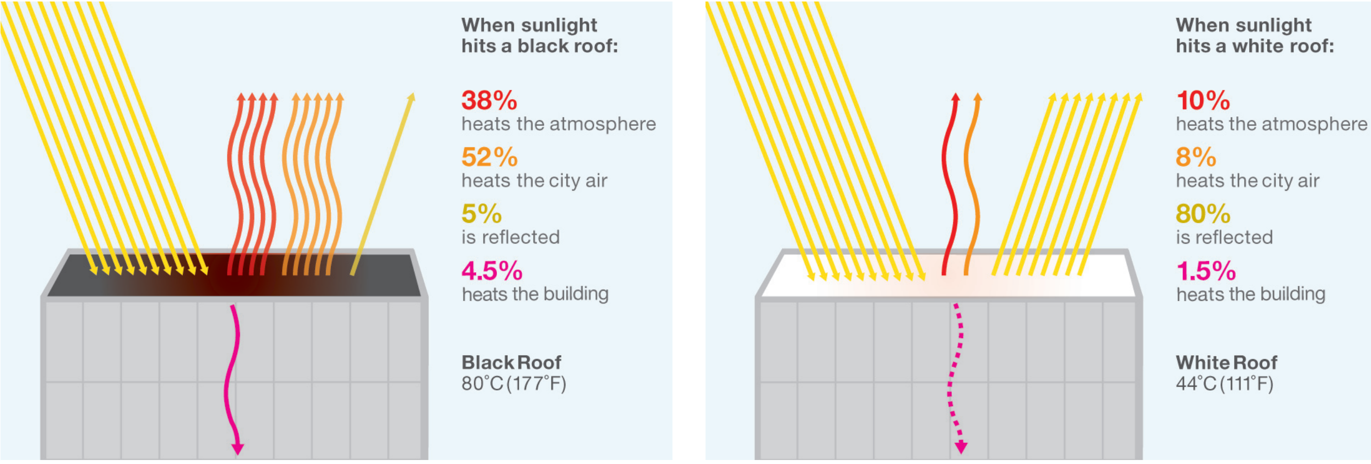
Highly reflective colored roofs typically have an initial solar reflectance of 30 percent to 55 percent, compared with around 5 percent for conventional dark steep slope roofs. Today's cool asphalt shingles have an initial solar reflectance of up to about 25 percent, but research is underway to increase reflectance.

Cool Pavements

Conventional paving materials can reach peak summertime temperatures of 50 to 65 degrees Celsius (120 to 150 degrees Fahrenheit), heating the air above them.[6]

Lighter colored pavements are readily available. Pavements can be lightened by using lighter colored aggregates, cement overlays, clear binders (i.e. resins), coatings, or light-colored cement. Many kinds of pervious pavements, including reinforced grass pavements, can also cool a pavement surface through the evaporation of moisture stored in the pavement.

Tucson, Arizona. ©2010 Google



A new white roof (right) absorbs about 80 percent less sunlight than a black roof (left).

Benefits to Individual Buildings

Energy savings potential Because cool roofs reduce the need for air conditioning, the net annual energy use[7] for a one-story building is reduced by 10 to 20 percent upon raising the solar reflectance of the roof from 10 to 20 percent to 60 percent.[8]

US cost savings potential Retrofitting 80 percent of the 2.6 billion square meters of commercial building roof area in the US would yield net annual energy savings of over $700 million, and offer an annual CO_2 reduction of over 6 million tonnes.[9]

Cost-effective, high-value investment Investing in cool roofs is cost-effective and often delivers very fast paybacks based on net energy savings. Depending on the materials used, the added cost to choose a white roof instead of a dark roof for a low-sloped (i.e. almost flat) roof on a commercial or multi-story residential building is typically between $0 to $2.20 per square meter ($0 to $0.20 per square foot), resulting in a US average simple payback period of 0 to 6 years through energy savings alone.[10] If the roof needs to be replaced anyway, choosing a white material may incur no premium at all.

Improved comfort In an un-air conditioned building, replacing a dark roof with a white roof can cool the top floor of the building by 2 to 3 degrees Fahrenheit,[11] enough to make these living spaces noticeably more comfortable and save lives in extreme heat waves.

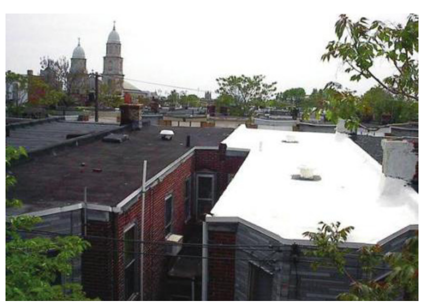
City-Wide Benefits

Urban heat island effect Cities are often far warmer than the surrounding landscapes. Urban surfaces absorb more light than natural landscapes. Cities lack vegetation to cool landscapes through evaporative cooling. Urban areas release more heat from human activity including air conditioning, vehicles, and industry. The difference between ambient air temperatures in a city and its surrounding rural areas can be 3 to 4 degrees Celsius (5 to 7 degrees Fahrenheit) in summer months.[12] This phenomenon is called the "urban heat island effect."

City-wide cooling benefits Cool roofs can help reduce such heat island effects. Simulations run for several cities in the US have shown that urban summertime air temperature can be reduced by 2 to 4 degrees Celsius (4 to 9 degrees Fahrenheit) by installing highly reflective roofs and pavements and planting shade trees citywide.[13] Cooling cities could reduce temperature-related deaths during the summer and especially during heat waves.[14]

Air quality benefits Reduced urban temperatures not only makes cities more comfortable, but also improves air quality because NOx and volatile organics cook more quickly into smog on hot days. According to a study of the Los Angeles basin, a combination of lighter surfaces and shade trees could reduce exposure to unhealthy air by 10 percent.[15]

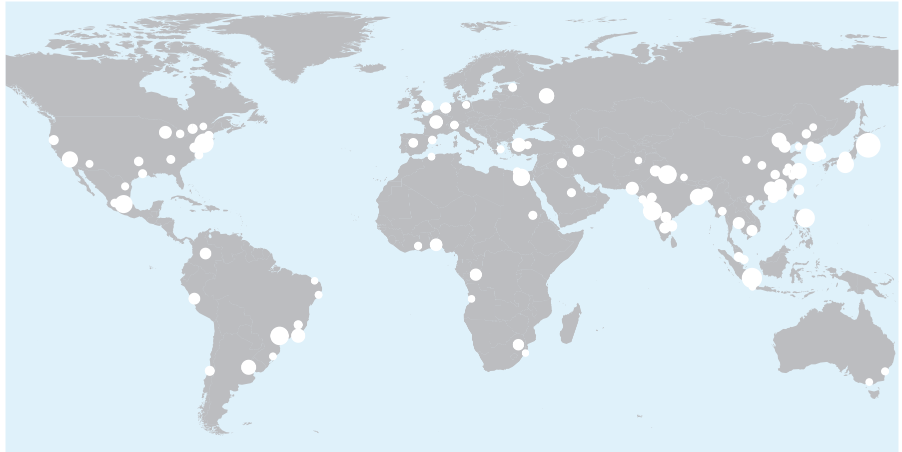
Savings from improved air quality Across the US, the potential energy and air quality savings resulting from increasing the solar reflectance of urban surfaces is estimated to be as high as $10 billion per year.[16]



RetroFIT Philly program. ©Nigel Maynard

Reduced urban temperatures not only makes cities more comfortable, but also improves air quality.

Permanently installing cool roofs and pavements worldwide would have the equivalent cooling effect on global temperatures as taking 600 million cars[19] off the road for 20 years.



The most populous cities in the world.

Benefits to the Planet

Global cooling potential Permanently replacing the world's roofs and pavements with highly reflective materials will have a cooling effect equivalent to removing 44 billion tonnes of CO_2 from the atmosphere, an amount roughly equal to one year of global man-made emissions.[17]

- About 9 square meters (100 square feet) of white roofs will offset climate warming effect of one tonne of CO_2.[18]
- If switching to a lighter pavement option increases albedo by 25 percent, cool pavements would offset approximately 0.5 tonnes CO_2e per 9 square meters, or 300 tonnes CO_2e per lane mile.
- Assuming the average car emits 4 tonnes of CO_2 per year, the combined "offset" potential of replacing the world's roofs and pavements with highly reflective materials is equivalent to taking all of the world's approximately 600 million cars[19] off the road for 20 years.
- Assuming that a medium sized power plant emits three million tonnes of CO_2 per year, worldwide adoption of cool roofs and cool surfaces would offset the emissions of 500 such plants, or 1,000 gas fired power plants, for 20 years.

Global Cool Cities Alliance invites you to join our effort.

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GlobalCoolCities.org

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1 H. Akbari, S. Menon, and A. Rosenfeld. 2009. "Global cooling: increasing world-wide urban albedos to offset CO_2." *Climatic Change*, 94 (3–4), 275–286. and US EPA. 2008. "Reducing Urban Heat Islands: Compendium of Strategies."

2 The figures represent the most common ranges of urban land area by type. Pavements can comprise up to approximately 70 percent of urban land area.

3 Assumes that an aged dark roof absorbs 85 percent to 95 percent of sunlight.

4 B. Urban and K. Roth. 2010. "Department of Energy Office of Energy Efficiency and Renewable Energy Building Technologies Program: Guidelines for Selecting Cool Roofs."

5 All roofs have some pitch so as to drain rain water. "Low-sloped" roofs describe most commercial and high-rise residential buildings that appear flat.

6 US EPA. 2008. "Reducing Urban Heat Islands: Compendium of Strategies."

7 In some regions of the US, replacing a conventional roof with a cool roof will increase the need for heating energy. However, a cool roof almost always reduces the cooling load more than it increases the heating load. See R. Levinson and H. Akbari. 2010. "Potential benefits of cool roofs on commercial buildings: conserving energy, saving money, and reducing emission of greenhouse gases and air pollutants." *Energy Efficiency*, 3 (1), 53–109 for more information.

8 H. Akbari, S. Menon, and A. Rosenfeld. 2009.

9 R. Levinson and H. Akbari. 2010. "Potential benefits of cool roofs on commercial buildings: conserving energy, saving money, and reducing emission of greenhouse gases and air pollutants." *Energy Efficiency*, 3 (1), 53–109.

10 The average annual energy cost saving (cooling energy saving minus heating energy penalty) for a white roof on a commercial building is $0.36 per square meter ($0.033 per square foot). Levinson and Akbari. 2010.

11 M. Blasnik. 2004. "Impact Evaluation of the Energy Coordinating Agency of Philadelphia's Cool Homes Pilot a REACH grant funded project to help Philadelphia's low-income senior citizens deal safely with excessive summer heat." (Final Report, M. Blasnik & Associates, Boston, MA). (accessed May 2011 at http://www.ecasavesenergy.org/pdfs/coolhomes_finalimpact_11–04.pdf).

12 http://eetd.lbl.gov/HeatIsland/HighTemps/

13 H. Akbari, M. Pomerantz, and H. Taha. 2001. "Cool Surfaces and Shade Trees to Reduce Energy Use and Improve Air Quality in Urban Areas." *Solar Energy*, 70 (3), 295–310.

14 R. Basu and BD. Ostro. 2008. "A Case-Crossover Analysis Identifying the Vulnerable Populations for Mortality Associated with Temperature Exposure in California." *American Journal of Epidemiology* 168(6):632–7, and BD. Ostro, L. Roth, S. Green, and R. Basu. 2009. "Estimating the Mortality Effect of the July 2006 California Heat Wave." *Environmental Research*, 109(5):614–9.

15 H. Taha. 1997. "Modeling the Impacts of Large-Scale Albedo Changes on Ozone Air Quality in the South Coast Air Basin." *Atmospheric Environment*, 31 (11), 1667–1676.

16 Akbari et al. 2009.

17 Ibid.

18 Ibid.

19 International Energy Agency. 2008. "Energy Technology Perspectives 2008." ISBN 978–92–64–04142–4.