# RISK REDUCTION GUIDANCE

## ALBEDO MANAGEMENT USING COOL MATERIALS

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**ABSTRACT**

Albedo is a measure that quantifies the proportion of incoming radiation reflected from a surface (from 0 to 1). Higher albedo materials reflect more shortwave radiation. In the built environment – principally in roofing and paving – these materials reduce heat hazard intensity and thus health impacts. Most urban environments have albedos between 0.15 and 0.2. There are no studies that have directly observed impacts of albedo management on health care utilization or mortality. On average, in simulation studies, increasing urban environment albedo by 0.1 drops temperatures by 0.09°C (0.16°F) and heat-related mortality by 1.8%. Albedo management is more effective when combined with other strategies, particularly increasing urban vegetation. The literature regarding the timing and cost of implementation is limited. Materials for increasing pavement albedo are approximately $7 per square meter ($m^2$) or $6,250 per city block. Approximate installation costs for a new high albedo flat roof are $28/$m^2$ and $80/$m^2$ for a new high albedo residential pitched roof.

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### What is the intervention?

Albedo is the fraction of incoming solar radiation that a surface reflects. Land cover, and in particular the albedo or surface reflectivity of different land cover materials, can amplify or diminish local temperatures(Vargo et al. 2013). Associations between albedo management and health outcomes derive from associations between albedo and temperature and, in turn, temperature and health. Communities with higher-temperature streets are associated with higher rates of medical emergencies during extreme heat events (O'Brien et al. 2020). High albedo surfaces that reflect solar radiation reduce local temperatures, i.e., the heat hazard, and can be an important risk reduction strategy (Stone et al. 2014).

Albedo management is the use of highly reflective or cool materials in retrofitting and new public and private construction, particularly of roofs and roads. Albedo management protects health by reducing temperatures for people in and around places built with cool materials. Multiple strategies can be used to increase albedo, and the two most commonly reviewed in the literature include white roofs and high-albedo street coatings. Changing street albedo is easier for governments, as they have access to, and own, streets (Guerin 2017), while most roof albedo changes must be made by private individuals or companies once every few decades. Increasing street albedo is also thought to be the more effective intervention of the two for individuals at ground level (Santamouris et al. 2017), but increasing albedo of roofs has a much larger impact on the costs of cooling the buildings (Gilbert et al. 2017).

Simulation studies have found that there is a synergistic effect of employing multiple albedo management strategies (Park et al. 2020). Not only can high-albedo surfaces decrease temperatures, but they can also impact energy use by decreasing the resources that would otherwise be used on other cooling methods such as air conditioning (Jandaghian and Berardi 2020), (Baniassadi et al. 2022).

**How effective is the intervention at protecting people's health?**

Albedo management is focused on increasing albedo over baseline. All things equal, the population health effect of an intervention to increase albedo will be roughly proportional to the area affected. There are no studies examining the observed effect of albedo management interventions on unplanned health care utilization, emergency department visits, hospitalization, or mortality, at either the individual building level or at larger neighborhood or city scales.

Simulation studies provide some insight into the potential health impacts of large-scale changes in urban albedo. In the analysis of multiple simulation studies mentioned above, the average baseline urban albedo was 0.16, and the average estimated increase with complete adoption of albedo management interventions was estimated at 0.24, resulting in an average estimated urban albedo after intervention of 0.40. In these studies, increasing the albedo of an urban environment by 0.1 would, on average, reduce the temperature by 0.09°C (0.16°F) and reduce heat-related mortality by 1.8%. A number of location-specific factors, including demographics, particularly poverty, and housing quality, were found to affect the relationships between changing albedo, temperature, and mortality (Santamouris and Fiorito 2021). A study of Los Angeles County found that increasing tree cover by 40% and increasing roof albedo by 45% and pavement albedo by 35% could theoretically decrease heat-related mortality by 18% (Kalkstein et al. 2022).

**How long does the intervention take to implement?**

There is relatively little information on the implementation of albedo management interventions, particularly at the large scale required in order to have a significant effect on population health.

Information from the press and gray literature provides some limited insight, particularly regarding albedo management of streets. As noted, government actors are more likely to pursue albedo management focused on streets, which they control (Guerin 2017). Very generally, city roads are resurfaced every 15 to 20 years. The city of Los Angeles, California has taken the lead and embraced albedo management as a climate adaptation strategy, covering pavement surrounding 15 city blocks with higher-albedo coatings from 2015 to 2019 with the aim of converting an additional 1,500 by 2030 (Barboza 2019). This suggests a standardized rate of approximately 100 blocks, or 6.5 square miles, per year.

Roofing is typically replaced every two to three decades. No information is available about the potential rate of wide-scale conversion of roofs to high albedo materials.

**How much does it cost?**

The costs of increasing an area's albedo vary by approach, and there is little literature on the topic. Gray literature and estimates published on the world wide web serve as a general guide, and are reported here in 2023 US dollars, converting for inflation where necessary. Estimates for the material required for pavement coating commonly used to increase albedo start at $7 per square meter ($m^2$) (CoolRoads 2023) or $6,250 per block (Molera Alvarez 2022). The average cost of installing a cool roof on a residential home is approximately $11,200 (fixr.com 2021), or $80/$m^2$. The average cost of installing a flat white roof on an industrial building is approximately $28/$m^2$ (Sproul et al. 2014). As noted, combining cool materials interventions with other strategies, particularly urban greening, has the potential to reduce costs and increase overall effectiveness (Park et al. 2020).

**Are there downsides to consider?**

Interventions to increase albedo at the street level in urban canyons (locations where streets are flanked by tall buildings) is not recommended as this has been found to decrease thermal comfort of pedestrians by increasing sensible heat load (Nasrollahi et al. 2020).

**What other strategies should be considered?**

Other heat risk reduction strategies, namely increasing tree cover, can also simultaneously change the albedo of urban areas. Tree cover primarily reduces heat risk through its creation of shaded spaces, but can also reduce heat through transpiring water and through providing higher albedo surfaces (Nasrollahi et al. 2020; Schwaab et al. 2021).

**What are some good sources of additional information?**

Information from ARUP, a group focused on sustainable urban development, on its million cool roofs challenge

Berkeley Lab Heat Island Group information on cool materials

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