URBAN HEAT ISLAND MANAGEMENT IMPACT ON SCHOOL FACILITIES

INTRODUCTION

Local Educational Agencies planning future construction projects should factor in the urban heat island (UHI) impacts on their campus to ensure the health and well-being of students and staff. Urban schools that maintain tree-shaded landscaping and/or turfed recreational fields in the heart of urban development zones can help mitigate the most adverse UHI impacts on the campus and the surrounding community. Shade and evapotranspiration from trees, plants and turf in these park-like settings significantly lower surface and air temperatures and reduce air pollution and carbon dioxide concentrations. Heat island reduction strategies for roof areas can also significantly lower the cooling load of school buildings during hot summer months, thus conserving electric energy resources and energy costs.

WHAT IS AN URBAN HEAT ISLAND?

An urban heat island is a city or metropolitan area that is significantly warmer than its surrounding rural areas; it is a microclimate that is created by human activities. The phenomenon is primarily the result of modification of land surfaces combined with dampened air turbulence next to tall buildings and structures. However, man-made waste heat emissions generated from urban energy sources (cars, air conditioners, industrial processes) is an important secondary contributor to UHI.

Urban areas have a higher density of structures and impermeable surfaces which often have different thermal mass properties (e.g., heat capacity and thermal conductivity) and surface radiative properties (e.g., albedo and emissivity) compared to the mostly natural surfaces found in rural areas. For example, concrete and asphalt roads and parking lots have great capacity to store heat. This causes urban surfaces to heat up much more rapidly than in rural areas during the day.

While UHI effect results in higher surface temperatures during the day-time, air temperature warming is typically felt more at night-time. In fact, some UHI zones have measured night-time temperatures 22 F° higher than surrounding undeveloped areas. This diurnal effect is explained by the fact that high daytime surface temperatures create convective winds which promote better atmospheric mixing, but more stable night-time conditions create inversion layers that keep warm air near the surface.

WHAT ARE THE ADVERSE IMPACTS OF HEAT ISLANDS?

The most adverse impact of increased summer temperatures is on human health. For example, high temperatures are correlated to higher incidents of heat stroke, heat exhaustion, heat fainting and heat cramps. Mortality rates increase exponentially with maximum temperatures during a heat wave which is exacerbated in URI zones. Higher UHI temperatures at night deprive residents of cool relief needed during a heat wave, thus impeding recovery. Persons with cognitive health issues, diabetics and persons with cardiovascular/cerebrovascular conditions are at higher risk during a heat wave.

Some studies have shown that high UHI intensity traps air pollution that collects at night beneath the UHI induced inversion layer. This can affect air quality on the next day. These primary pollutants include volatile organic compounds, carbon monoxide, nitrogen oxides, and particulates. The concentration of primary pollutants combined with higher UHI temperature can produce ozone at surface level, a particularly harmful secondary pollutant.

Besides the primary temperature effects, heat islands can produce secondary effects on local meteorology, including changes to local wind patterns, development of clouds and fog, changes to humidity, and rates of rainfall. Some UHI cities have measured substantially higher rainfall rates 20 to 40 miles downwind of the location by 48% to 116%.

There are conflicting studies as to whether urban heat islands contribute directly to mean global warming. Some studies have concluded that UHI accounts for 30% of global warming, but other studies conclude the UHI is a local phenomenon that does not impact mean global temperature trends. However it is more certain that urban heat island effects will increase the severity of global warming effects as climate change progresses. An indirect link between global warming and UHI exists because higher urban temperatures result in more energy usage which increases greenhouse gas production.

RATING SURFACE MATERIALS ACCORDING TO THEIR ABILITY TO REJECT HEAT

The most common method of rating a roofing material's ability to reject heat is solar reflectance index (SRI). This measurement is determined by the roof's albedo and emissivity characteristics. Roof surfaces that have good SRI are known as cool roofs, but the rating depends on slope characteristics and the age of the roof. (Generally, the higher the SRI; the better the roof's heat rejection performance.)

Minimum solar reflectance index, by roof slope

	SLOPE	INITIAL SRI	3-YEAR AGED SRI
Low-slope roof	< 2:12	82	64
Steep-sloped roof	>2:12	39	32

Solar reflectance (SR) is the best method to rate non-roof materials which have high thermal mass. Hardscape materials that are selected to reject heat should have a 3-year aged SR value of at least 0.28. Generally, light-colored concrete and pavers have favorable SR.

BEST PRACTICES TO REDUCE URBAN HEAT ISLAND EFFECT FOR SCHOOLS

- Install cool roof products which meet appropriate standards for initial SRI, depending on roof-slope
- Use high-albedo hardscape materials with 3-year aged SR value of at least 0.28
- Use open-grid pavement systems for parking to reduce hardscape
- Plant trees to provide shade over paved areas like sidewalks and playgrounds
- Use vegetated roof if feasible
- Cluster site development to maximize land in its natural condition, promoting large areas of natural vegetation or areas with a park-like setting
- Minimize on-site parking in urban areas that have public transportation. Adopt policies that encourage carpooling, vanpooling and bicycle use
- Use shading devices to support solar panels on parking lots
- For urban schools, build underground parking garages or multi-level parking structures

CONCLUSIONS

Urban schools which are surrounded by dense development have the most to gain by implementing best practices to control UHI effects. The benefits of reducing heat island impacts include improved student health and well-being, less air pollution and lower energy costs during the cooling season. Schools in UHI zones that maintain shaded, park-like areas and/or recreational fields will mitigate adverse UHI effects within the campus environment and the surrounding community.

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