EPDM ROOFING ASSOCIATION

The Impact of Cool Roof Mandates on Urban Heat Islands

Comparative Analysis Summary of Local Cool Roof Policies on UHI

Overview of Research

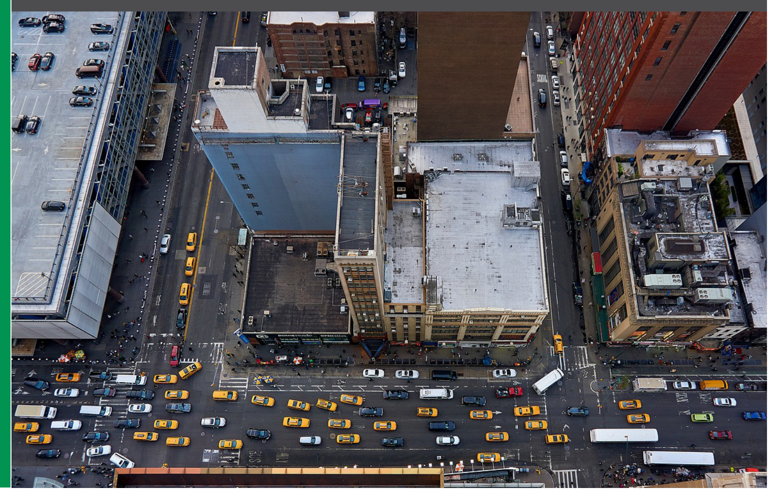
The growing awareness of climate change, as well as the related issues of urban heat islands and steadily increasing energy costs, has led to a growing interest in the effectiveness of reflective, or **"cool" roofing**. To better understand the measurable impacts of commercial roofing surfaces on urban heat islands (UHI), ERA conducted an analysis of existing data and previous studies to review and contribute to the research and analysis in this area.

Proponents and manufacturers of reflective roofing have recommended its use throughout the US to save energy, and some cities have moved toward mandating the use of cool roofs on all new construction and roof replacement. However, roof systems and their assembly are complex and require many different considerations before designing an appropriate solution.

Both the causes of and the strategies for reducing UHI effects vary widely - from increasing vegetation cover, to cool roofs, to cool pavements, to smart growth. The relative contribution of commercial building roofs to a given urban area's UHI effects depends on the percentage of total urban surface area accounted for by commercial roofing. As such, understanding the impact that cool roofs have on UHI requires additional and more comprehensive research.

Research Objectives

- Contextualize the causal factors and mitigation strategies for UHI effects;
- Estimate the impact of commercial roofing on UHI;
- Conduct independent analysis, using methodologies from other studies, to test the hypothesis that cool roof mandates demonstrably reduce UHI effects;
- Understand the implications for public policy and further research.



Factors Contributing to Urban Heat Islands (UHI)

REDUCED NATURAL LANDSCAPES

Loss of natural vegetation and water bodies which cool the atmosphere

URBAN MATERIAL PROPERTIES

Building materials such as roofing or pavement which absorb or reflect solar energy

URBAN GEOMETRY AND LANDSCAPE

The size, dimensions, and space of urban structures that influence wind flow and solar energy retention

HEAT FROM HUMAN ACTIVITY

Vehicle use, air conditioning, and building systems that generate heat

WEATHER AND GEOGRAPHY

Wind speed, cloud cover, humidity, and proximity to water, mountains, and other features

DID YOU KNOW?

29% Commercial roofing accounts for roughly 29% of **total building roof area** in a city.

3% Commercial buildings **without cool roofs** account for approximately 3% of buildings in a city.

10X Paved, vegetated, and vacant land account for **10 times more area** in a city than commercial roofs.

Phase I: Analysis of Select Cities with Cool Roof Mandates

In Phase I of research, the ERA studied ambient temperatures in **three urban areas** that have implemented cool roof mandates and compared these to temperatures in three similar localities that did not impose such mandates. In this phase, the ERA analyzed corresponding changes in urban land surface color in those localities to **understand the incremental effect** of commercial roof solar reflectance on UHI effects.

CITIES EXAMINED IN PHASE I	Control Group (Cool roofs not mandated)	Experimental Group (Cool roofs mandated)
City Pairing 1	Newark, NJ	New York City, NY
City Pairing 2	Indianapolis, IN	Chicago, IL
City Pairing 3	Baltimore, MD	Washington, D.C.

PHASE I: ANALYSIS RESULTS AND CONCLUSIONS

Air Temperature Recordings

Air temperatures recorded at weather stations are influenced primarily by local conditions and rarely factor in surrounding areas.

Urban Density

Urban density alone is not a good proxy for air temperature as anthropogenic and environmental factors also influence temperature.

Minimal UHI Reduction

There was little to no relative reduction of daytime UHI noted among paired cities after a cool roof mandate was imposed.

Margin of Error

The margin of error in the temporal urban heat island intensity analysis is significant enough in most cases to negate any trends observed in UHI.

Variable Results

Only one city pair saw a relative reduction in nighttime UHI temperatures after the experimental city imposed a cool roof mandate.

Daytime VS. Nighttime UHI

Nighttime UHI for all for three city pairs was always positive and on average stronger when compared to daytime UHI that exhibited comparatively lower UHIs and negative UHIs for two of the six cities.

Phase II: Analysis of Cities with High UHI and White Roofing Mandates

The objectives for Phase II were similar to Phase I, in that ERA sought to assess the relative role of commercial cool roofs on local urban heat islands, but with increased analytical rigor. In this phase, ERA used higher resolution imagery to enable **more rigorous analysis** of the commercial zoning areas of interest, reframed the analysis to **evaluate changes in UHIs for a city unto itself** in order to enable direct assessment of correlation between UHIs and cool roofs, and also limit the UHI analysis of weather station data.

CITIES EXAMINED IN PHASE II

Chicago, IL and Portland, OR

Chicago, IL and **Portland, OR** were selected for analysis because their **high amounts of white roofing** and **high urban heat islands** make them both good candidates for evaluating whether there are perceptible effects from the installation of commercial cool roofs on local UHI. Additionally, preliminary analysis of NOAA weather station and GIS data indicated both cities have high availability of local weather stations with complete data and high-resolution GIS data, as well as plenty of satellite imagery.

PHASE II: ANALYSIS RESULTS AND CONCLUSIONS

Weak Daytime UHI

Daytime UHI was not strong when compared to results from the CCCSP and results varied widely based on weather station selection.

Weather Station Influence

Daytime urban heat island effect also varied according to the quantity of weather stations and selected time period.

Day-to-Day Variability

On a day-to-day basis, daytime UHI was highly variable with instances where consecutive days flipped between positive and negative UHI.

Matching Daytime UHI

Daytime urban heat islands were found to be closest to those reported in the CCCSP when all nonpositive UHI's were filtered from the dataset.

Nighttime UHI

Nighttime UHI was found to be strong and significant with no nonpositive UHIs over the analysis period.

No Standard Methodology

Because there is no standardized method for determining UHI, UHI is contextual and based on the researchers' needs and objectives.

Phase III: Comparative Analysis of Daytime and Nighttime UHI

In Phase III of the research, **thirteen cities** were analyzed using a temperature based UHI analysis that evaluated **daytime and nighttime changes in UHI** for thirteen US cities on an annual basis **over a period of more than a decade**. The research looked at the strength and significance of daytime and nighttime UHIs with existing published research and the probability of UHI being as prominent as indicated in existing research using alternate weather stations and summertime periods, following the methods used in existing published research.

CITIES EXAMINED IN PHASE III

Las Vegas, NV; San Diego, CA; Portland, OR; Louisville, KY; Kansas City, MO; Baltimore, MD; Washington, D.C.; Albuquerque, NM; Philadelphia, PA; Denver, CO; Columbus, OH; Buffalo, NY; Minneapolis, MN

These **thirteen cities** were selected for analysis to **compare the strength and significance of daytime and nighttime UHIs** with results published in a commonly cited climate science publication (CCCSP) and the probability of UHI being as prominent as indicated in the CCCSP using alternate weather stations and summertime periods, following the same methods used in the CCCSP.

PHASE III: ANALYSIS RESULTS AND CONCLUSIONS

Daytime VS. Nighttime UHI

Daytime UHI was found to be less pronounced and more variable when compared to nighttime UHIs, which tend to be significant and positive.

Day-to-Day Variability

On a day-to-day basis, daytime UHI was highly variable with instances where consecutive days flipped between positive and negative UHI.

No Standard Methodology

Because there is no standardized method for determining UHI, UHI is contextual and based on the researchers' needs and objectives.

Air Temperature Recordings

Air temperatures recorded at weather stations are influenced primarily by local conditions and rarely factor in surrounding areas.

Weak Daytime UHI

Daytime UHI was not strong when compared to results from the CCCSP, and results vary wildly according to weather station selection.

Weather Station Influence

Daytime urban heat island also varied according to the quantity of weather stations and selected time period.

UHI Research Takeaways

As indicated in this three-phase research study, an increased presence of cool roofs. whether by mandates or market occurrence, **was not proven** nor shown to mitigate the effect of urban heat islands. Because there is no standardized method for determining or analyzing urban heat islands, research examining UHIs is contextual and influenced by the researchers' needs and objectives. As such, there is a great **need to find consensus** on what are the appropriate methods used to define measurement of UHI - in a manner that produces reasonably consistent results to fit the analysis construct and research objectives.

While the different phases of UHI analysis in this research study examined different cities and emphasized different methods of analysis, there were several themes that remained consistent throughout all three phases.

WHAT ARE THE TAKEAWAYS from the research?

- There are many factors that impact UHI, only one of which is commercial rooftops.
- There are no standardized methods for determining UHI; methodology is highly-variable
- Daytime UHI was more variable and less pronounced than nighttime UHI.
- There is a need for stronger and higher quality daytime UHI calculations.
- Air temperatures only reflect conditions near weather stations and not broader areas.
- Analysis of daytime UHI shows inconsistent results and is influenced by many factors.
- The impact of cool roof mandates on UHI is inconclusive and requires more research.

Recommendations for Further Research

Based on the findings of this three-phase study, there are several areas that require further research to better understand the complexity of constructing efficient roof structures that yield a positive impact on UHI. Based on the examiniation of UHI effect throughout several U.S. cities, **the following areas should be studied** to fully understand the implications of cool roofs.

- Assess the strength and significance of daytime UHI for the **top 10 US cities with UHIs** following the CCCSP study.
- Document the extent of daytime UHI compared to nighttime UHI and the **probability of UHI being as prominent** as indicated in the CCCSP study using alternate weather stations and seasons.
- For each analyzed city, conduct limited research to assess the **magnitude and timing of impact** from other environmental factors that may influence urban heat islands over the analysis period.
- Conduct **high-resolution GIS analysis** evaluating building level changes in white roofing and nearby landscape changes in vegetation that may influence local urban heat islands.
- Determine whether the use of **nighttime rather than daytime** urban heat island could reasonably be used to support the UHI/ cool roof analysis.

What are the Implications for Policy?

Research conducted between 2019-2021 suggests that reliance primarily on reflectivity to deal with UHI is misplaced and remains unproven. Cool roofs must be **compared to other strategies for reducing UHI** effects using a robust and consistent methodology, including increasing vegetation and improving paved surface albedo, each of which accounts for many times the total area of low-albedo commercial roofs. ERA is recommending that we **pause the development of policies that require reflective roofing mandates** and call upon the government and organizations to conduct additional research to assess the relative value of all tactics that might diminish the impact of UHI.

About ERA

The EPDM Roofing Association (ERA) represents the manufacturers of many single-ply roofing products. Through ERA, the leading roofing industry manufacturers speak with a focused voice to provide technical and research support, offer sustainable and resilient roofing solutions, and communicate the longstanding attributes, consistency, and value of various single-ply roofing systems.