



# **Keeping your Communities Cool**

## **Tools for Reducing Urban Heat**

**November 6<sup>th</sup>, 2014**

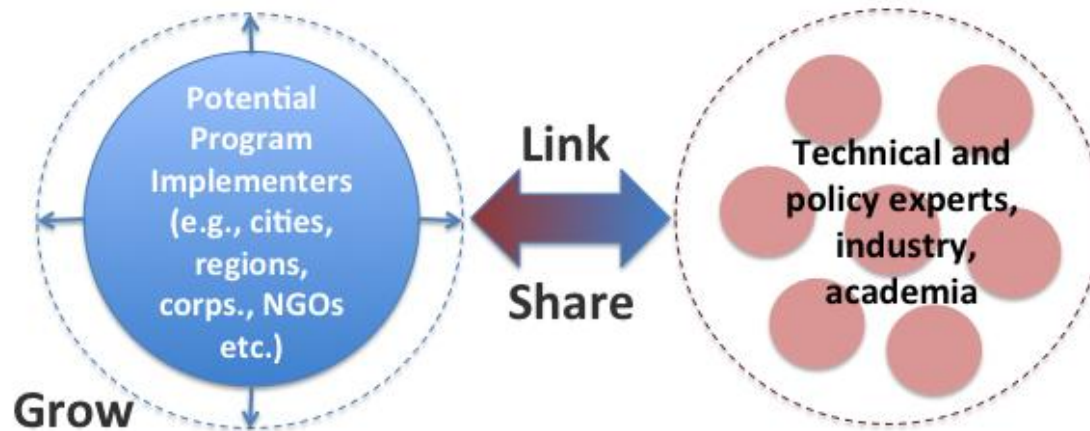


# Outline

- Introduction to GCCA
- Hot cities
- Cool science
- Benefits of reflective pavements
- Cool pavement options
- Other cooling strategies

# Global Cool Cities Alliance (GCCA)

The Global Cool Cities Alliance is dedicated to advancing policies and actions that reduce excess urban heat in order to cool buildings, cool cities, and to mitigate the effects of climate change through global cooling.



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# The Cool Roofs and Pavements Toolkit

## www.CoolRoofToolKit.org

- Science, costs, and benefits of cool surfaces
- Global best practices for program and policy implementation
- Sample materials and relevant organizations.
- A comprehensive “knowledge base”
- New: Networking Forum



**Cool Roofs and Cool Pavements Toolkit**

Toolkit Home Read the Guide Search the Knowledge Base Join the Conversation Additional Resources Toolkit Search GO

**Global Cool Cities Alliance**

**Focus On**  
**Welcome to the new Toolkit**

Welcome to the newly relaunched Cool Roofs and Cool Pavements Toolkit! We have added an interactive Forum to our existing [Primer and Implementation Guide](#) and [Knowledge Base](#). Now users can share news, engage in conversations, and ask questions to experts. [Join the conversation](#).

**In the Forums:**

ICC 2014 Committee Action Hearing (Group C Codes) (0 replies)

**In the Knowledge Base:**

Reducing Urban Heat Islands: Compendium of Strategies (Full)

Introduction to Cool Roofs and Pavements

**Read the Guide**

The Practical Guide to Cool Roofs and Cool Pavements was developed as an informative primer and implementation guide for cool roofs enthusiasts, from the curious to professionals.

**Join the Conversation**

Latest Activity:

Using the Roof Savings Calculator (0 replies)

Responding to 'Ballast Cooler Than You Think' (0 replies)

It's Unanimous – Los Angeles is a Cool City (0 replies)

**Search the Knowledge Base**

Enter keyword GO

The Knowledge Base is a growing repository for cool surface and urban heat island information! Search and browse more than 500 documents, videos, links, images, and presentation files.

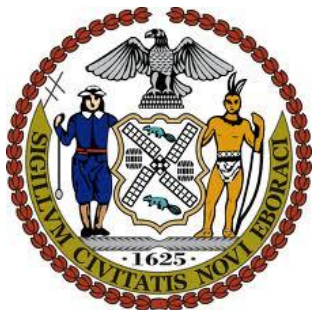
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## Partners



## Funders

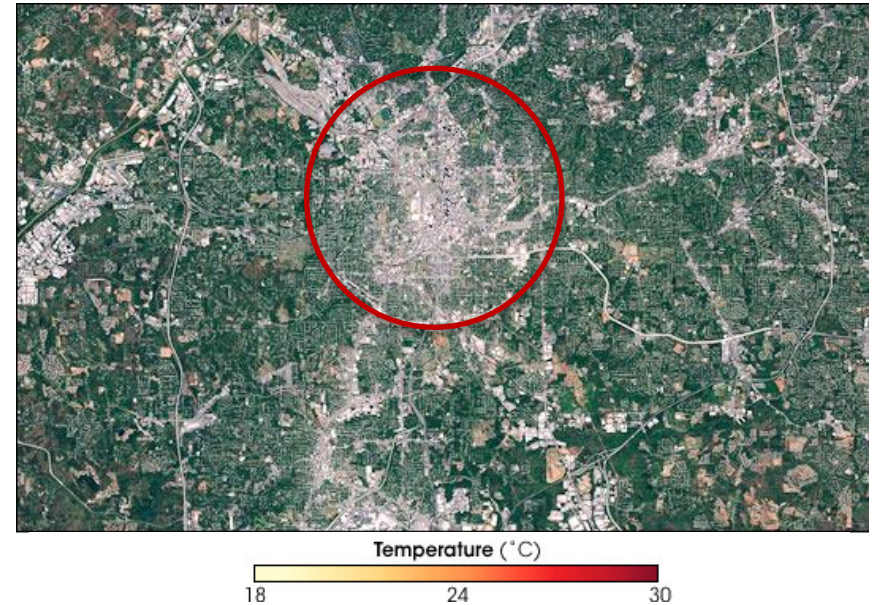
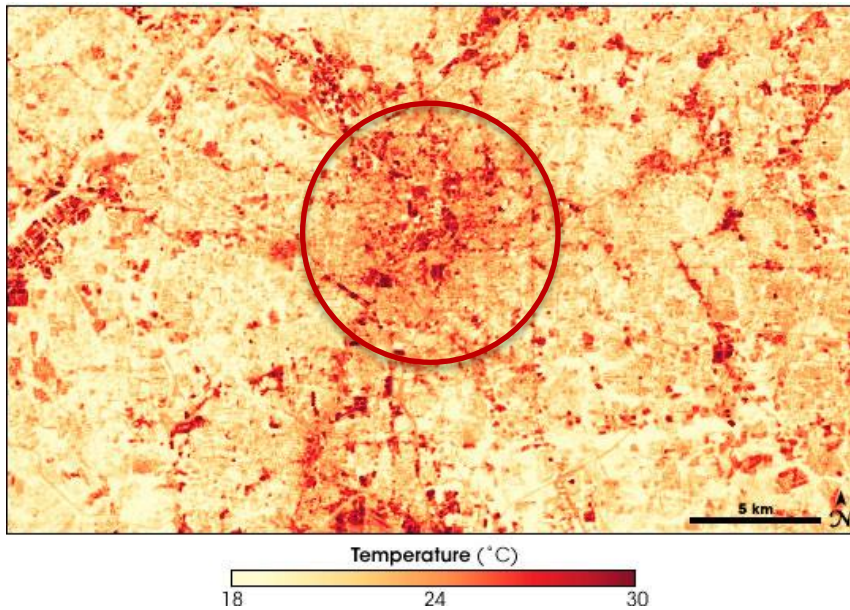




# Hot cities



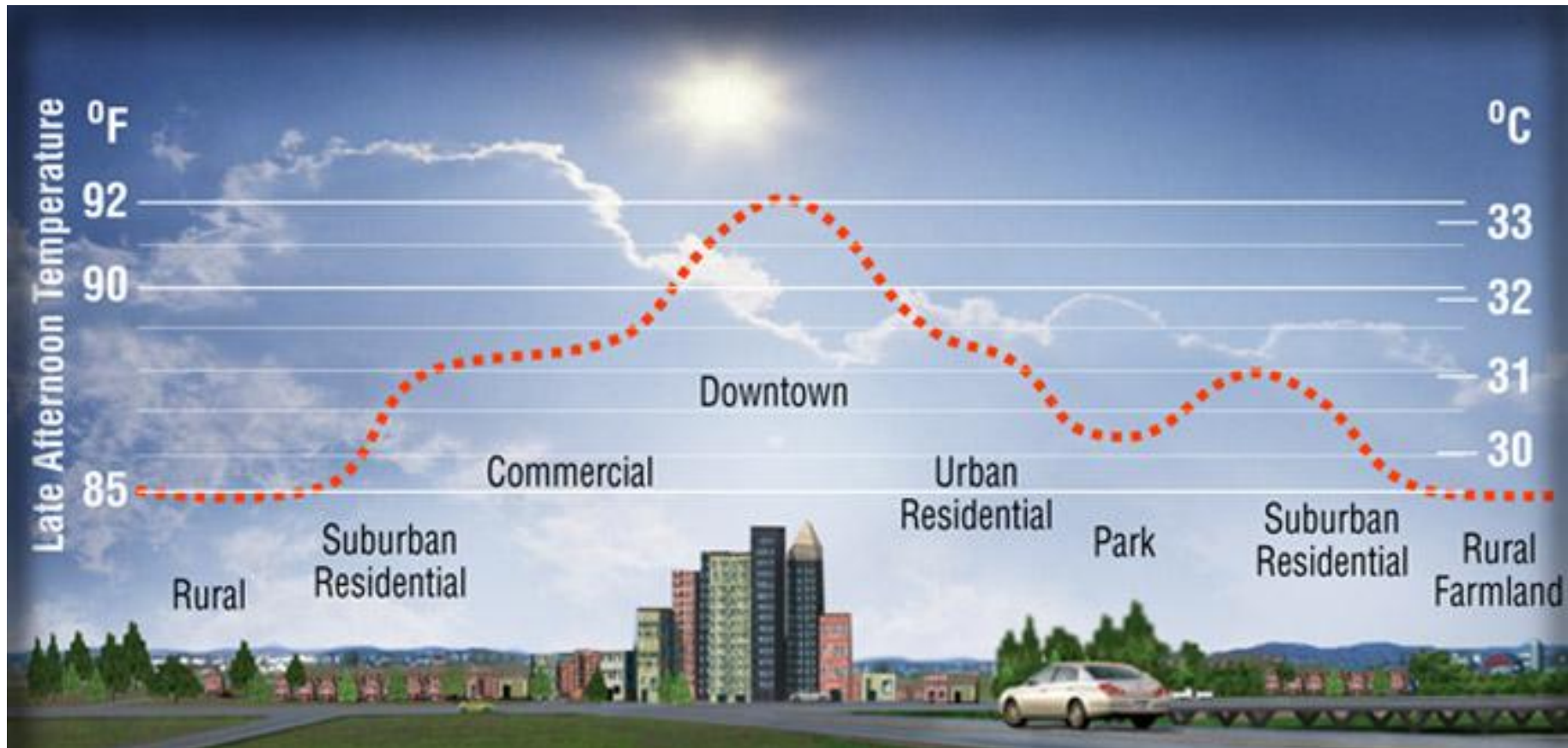
# Cities can be HOT



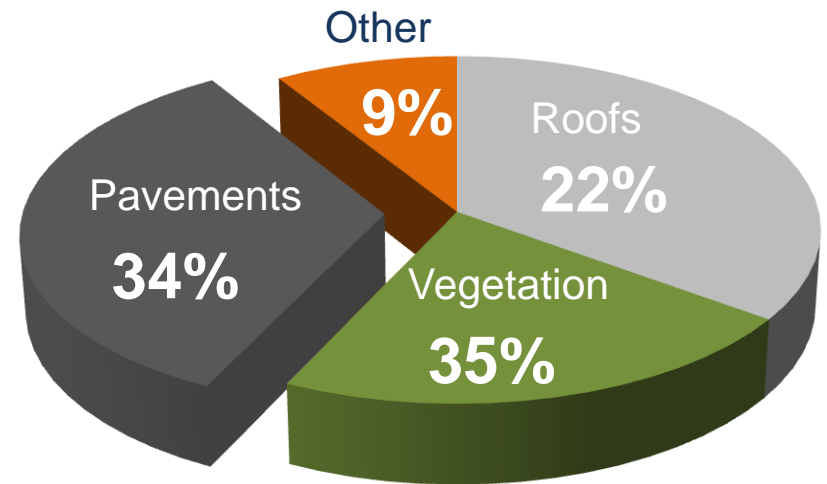
NASA infrared Atlanta



# Summer afternoons in the city



# One reason cities are hot is that they have many dark surfaces

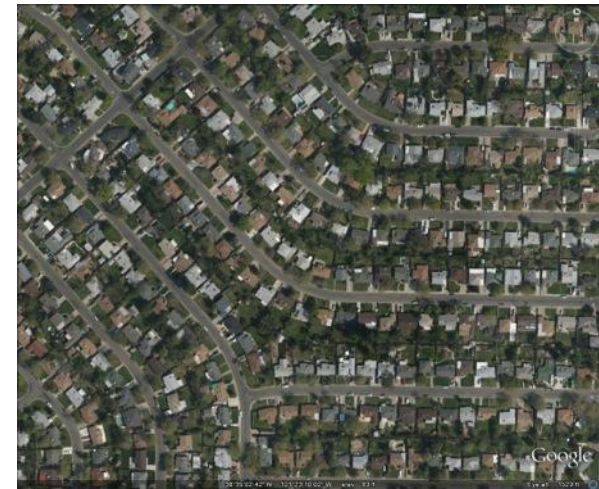
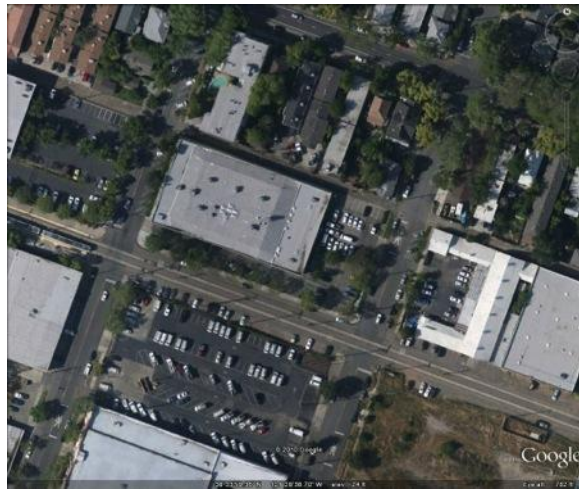


Average urban fabric above tree canopy in Chicago, IL, Houston, TX, Sacramento, CA, and Salt Lake City, UT

A square kilometer in Sacramento, CA



# About 1/3 of urban surfaces are paved



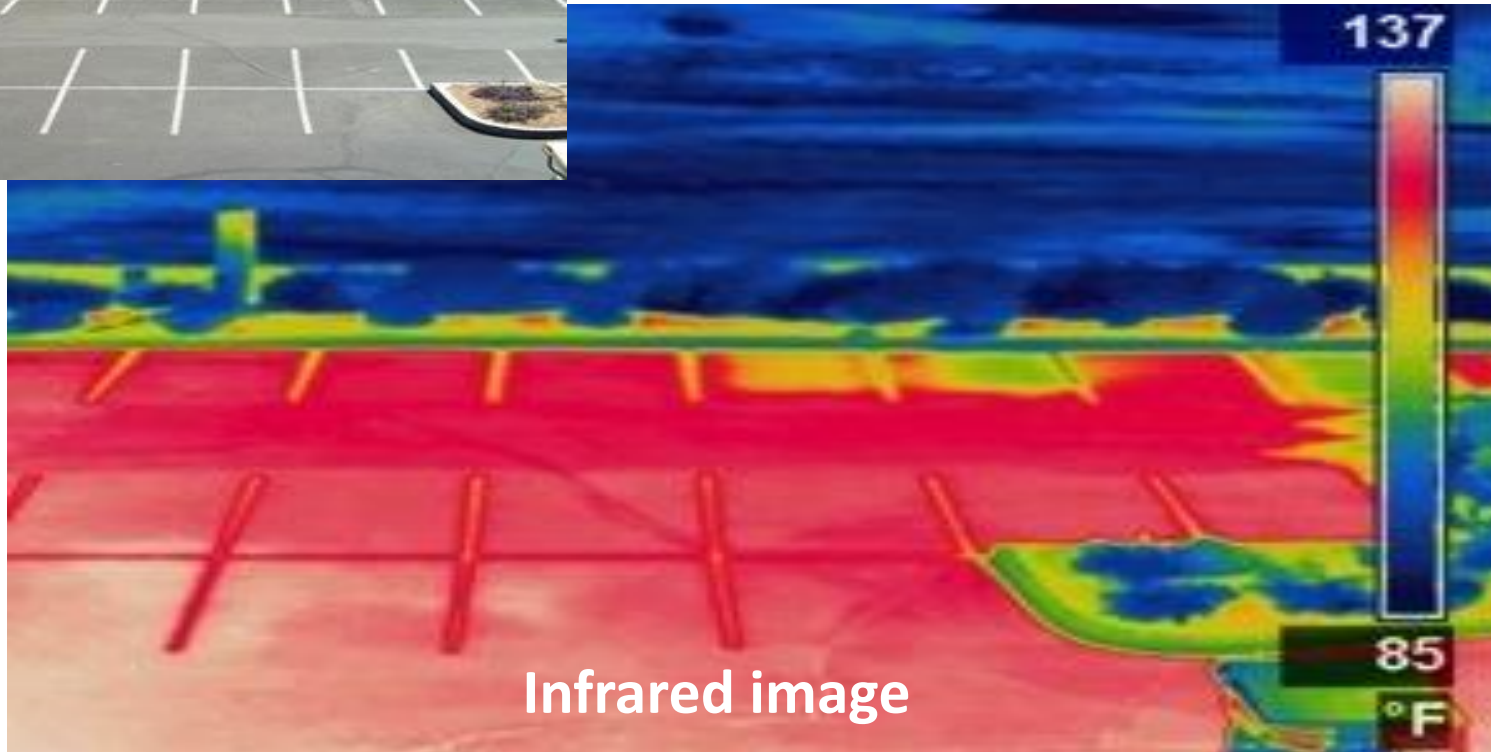
Of that third, about

- 45% are streets (usually asphalt concrete)
- 15% are sidewalks (usually cement concrete)
- 40% is exposed parking (usually asphalt concrete)

# And we all know that pavements can get HOT



## Rio Verde, Arizona



Pavement is **> 30°F** hotter than vegetation

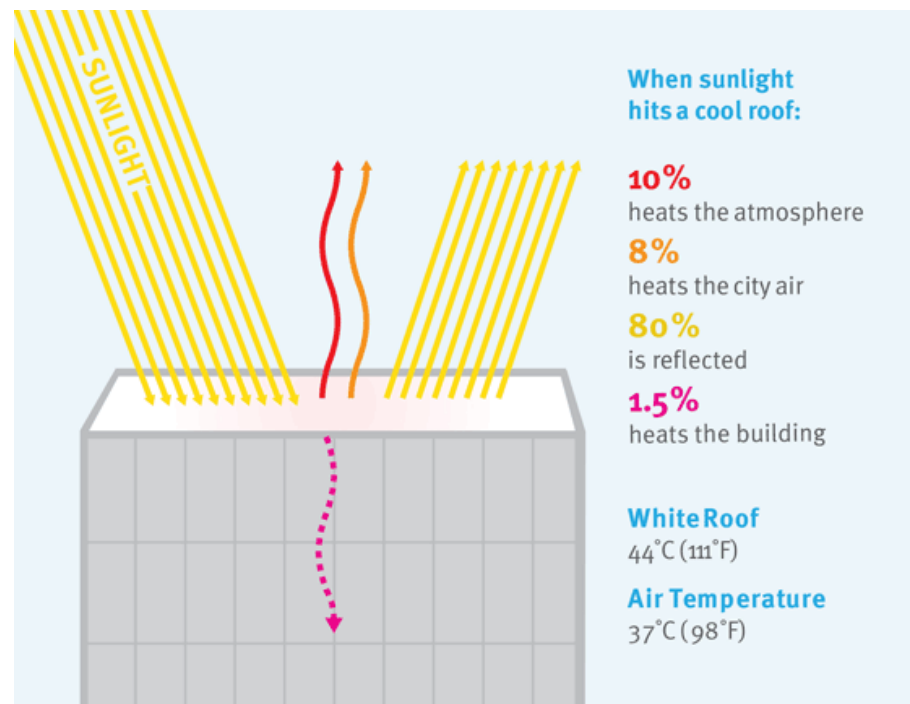
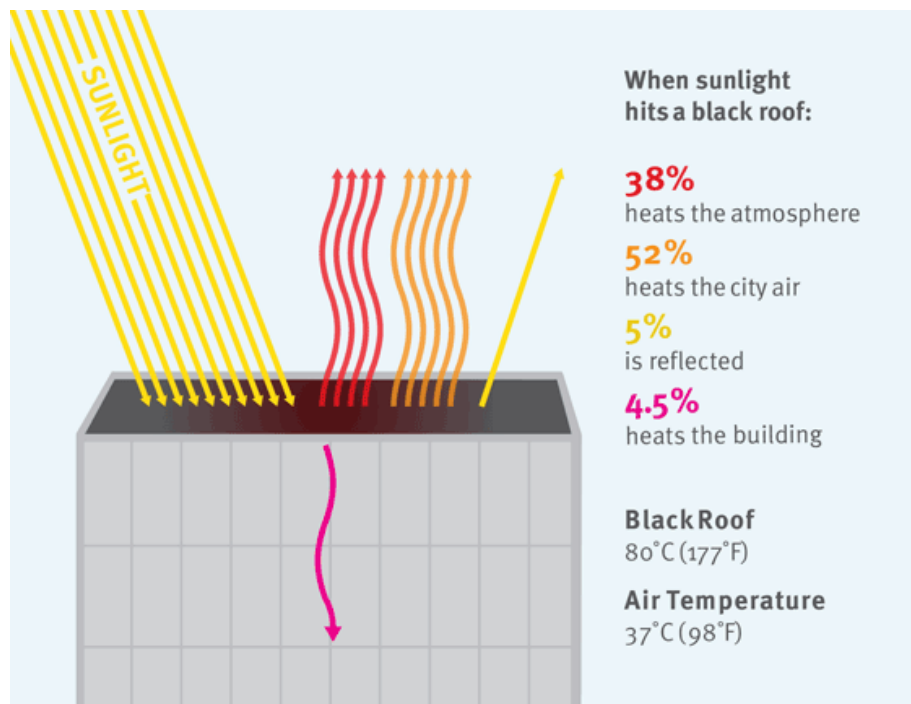
Image: Larry Scofield - APCA



Cool science

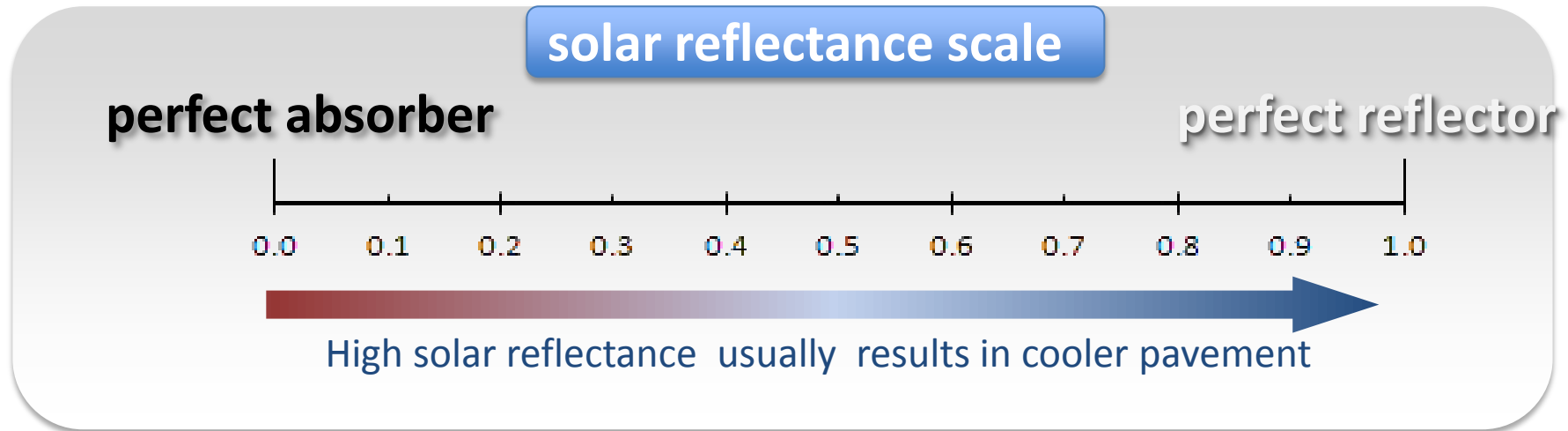


# Hot city surfaces warm the air

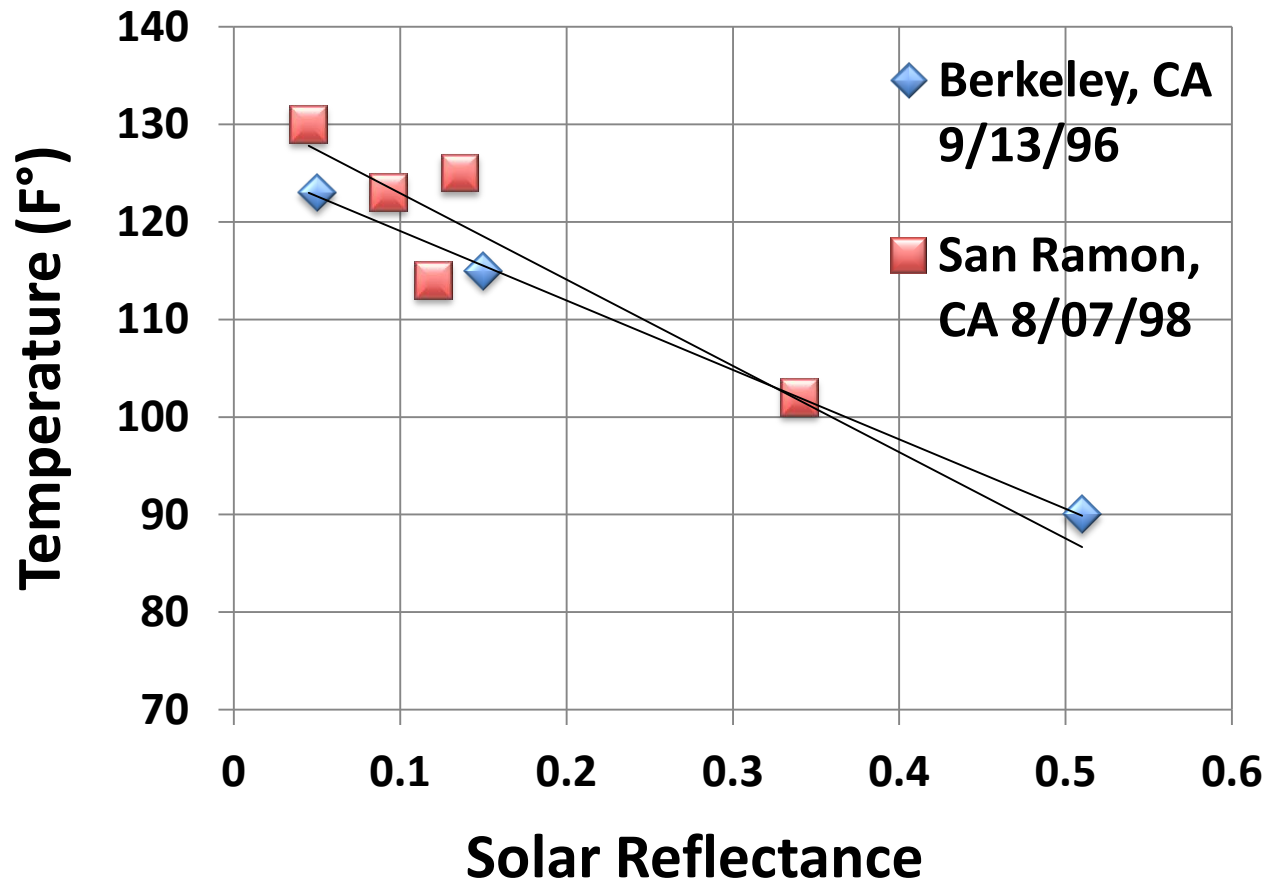


## How do you measure reflectivity?

Solar reflectance (SR) = fraction of sunlight reflected



High solar reflectance →  
low pavement temperatures



Increase pavement SR by 0.1 to decrease temperature ~ 7°F

## Example from the LBNL Cool Pavement Showcase

**SR 0.06**



**58.8°C (138°F)**

**SR 0.32**



**46.2°C (115°F)**

**SR 0.46**



**41.4°C (107°F)**

- Measurements performed in Berkeley, 26 June 2012
- Ambient air temperature at 2:45 pm PDT 22.5°C (72.5°F)
- No wind or clouds



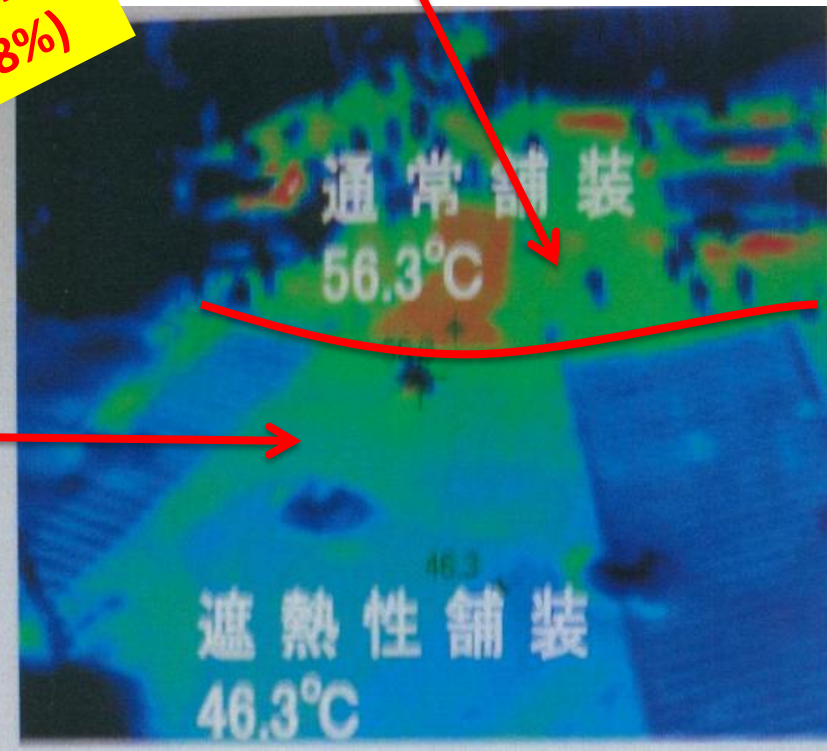
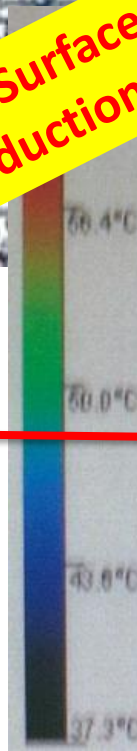
Japan



“Standard” Pavement

10°C Surface Temp  
Reduction (18%)

Cool Coated Pavement





A stylized, minimalist illustration of a city skyline at the top of the slide. It features white silhouettes of various buildings and structures against a solid light blue background. The skyline includes a prominent tall building in the center, several smaller buildings to the left and right, and some thin vertical lines representing antennas or chimneys.

# Benefits of reflective pavements

# Improved outdoor comfort

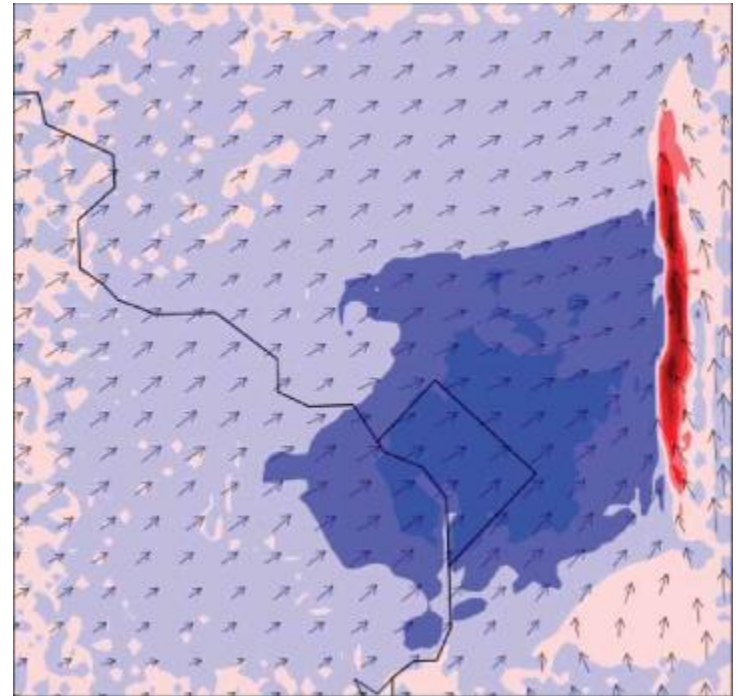
- An urban park in Athens, Greece installed 4500 m<sup>2</sup> of cool pavements
- Reduced peak air temperatures by 2°C (Santamouris et al. 2012)



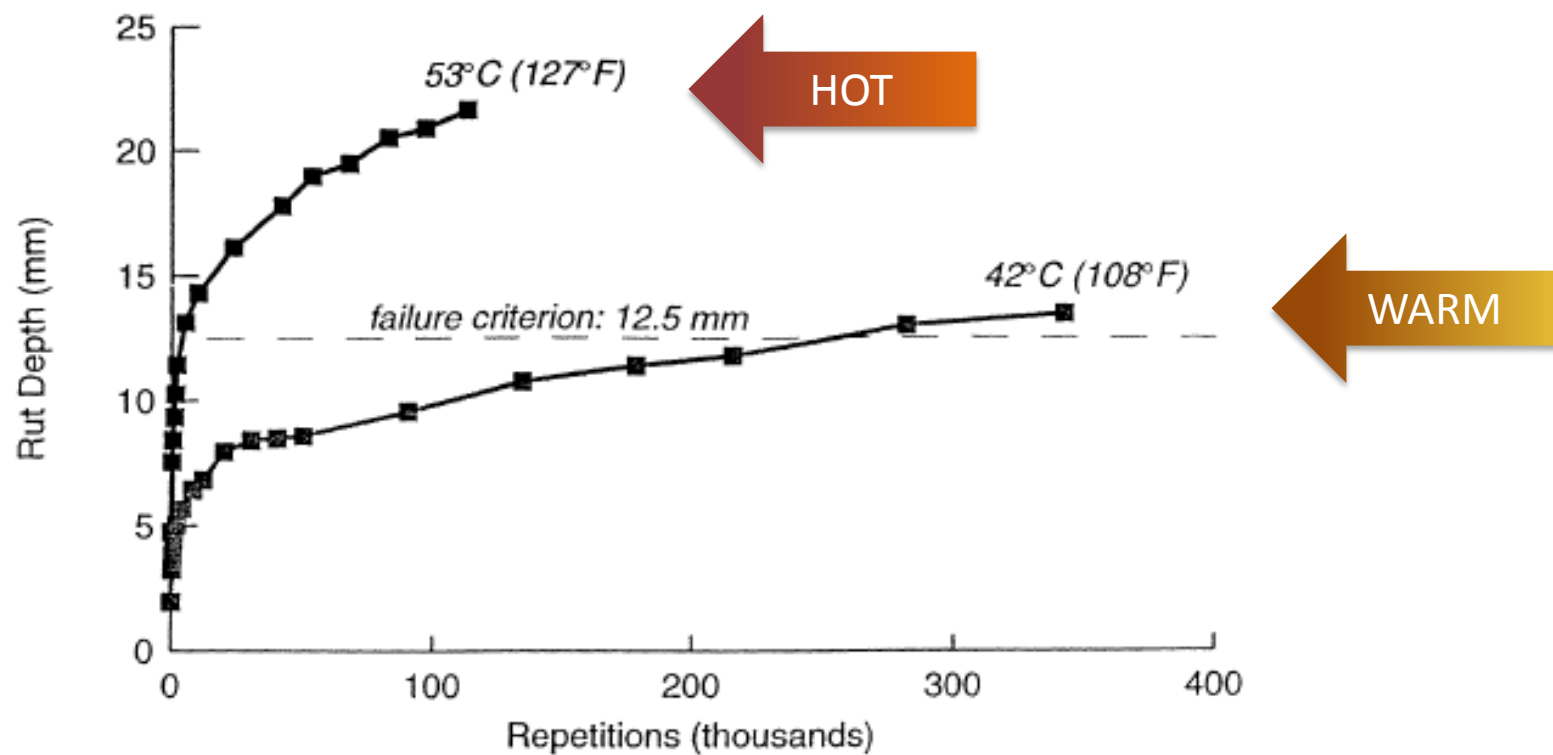
Flisvos Park in Athens, Greece (Santamouris et al. 2012)

# Health benefits

- Studied 4 actual multi-day heat waves and resulting mortality.
- Modeled a 0.1 increase in reflectivity, a 10% increase in vegetation, and a combined scenario.
- Found an average 7% reduction in mortality with UHI mitigation.
- Expanding study to Baltimore, NYC, and LA



## Longer pavement life



**Fig. 2. Depth of Rutting vs Number of Repetitions of a Standard Axle Load, Wide-base Single Tire, at Pavement Surface Temperatures of 42°C and 53°C**

Source: Pomerantz, Akbari, Harvey (2000)

## Enhanced visibility and safety

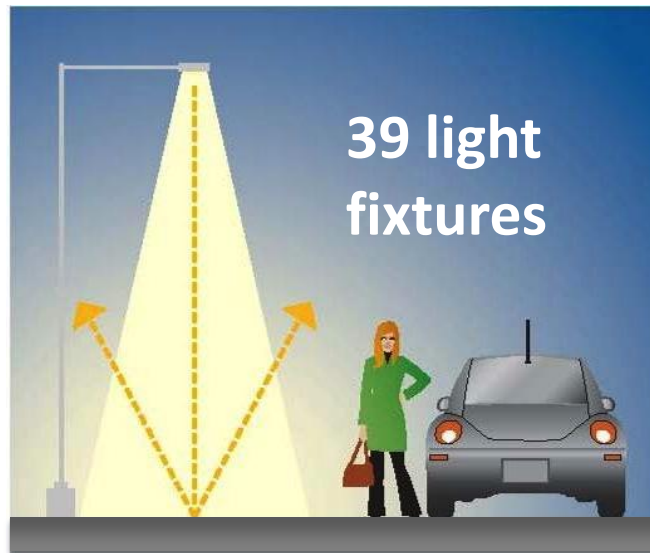


- Nighttime illumination
- Reflected illumination is roughly proportional to solar reflectance

Source: Pomerantz et al (2003)



## Energy savings



**Dark pavement**

=



**Light pavement**

- Reduced energy for street lighting
- Also reduces indoor air conditioning demand

## Preserved water quality

- EPA's Clean Water Act addresses **heat pollution** – temperature is “pollutant of concern”
- Ultra urban streams warm by 8°F one hour after summer squalls
- A change of 5°F over 5 hours can induce stress in most species of fish



Brook Trout

Photo: Eric Engbretson

## Other benefits

- Improved air quality
  - Increases in temperature lead to increases in smog
  - \$10 billion energy and health cost reduction opportunity in the U.S. alone.
- Reduced peak electricity demand and avoided adoption of air conditioning
- Greater resiliency to heat events and climate change
- Canceled emissions of CO<sub>2</sub>
  - 44 billion tons of emissions would be “canceled” if hot cities converted to cool roofs and pavements
  - About 1.5 years' worth of current CO<sub>2</sub> emissions

A stylized white silhouette of a city skyline is positioned at the top of the slide against a solid light blue background. The skyline includes various building shapes, a prominent tower, and some utility poles with wires.

# Cool pavement options

## Pavement materials span a range of solar reflectance

<i>Material</i>	<i>Solar Reflectance</i>
<b>Black acrylic paint</b>	<b>0.05</b>
<b>New asphalt concrete</b>	<b>0.05 – 0.10</b>
<b>Aged asphalt concrete</b>	<b>0.10 – 0.15</b>
<b>Aged gray-cement concrete</b>	<b>0.20 – 0.35</b>
<b>New gray-cement concrete</b>	<b>0.30 – 0.50</b>
<b>New white cement concrete</b>	<b>0.70 – 0.80</b>
<b>White acrylic paint</b>	<b>0.80</b>



## Cooler asphalt concrete pavements



Cool: Use light-colored aggregate\*  
Aggregate shows as asphalt binder rubs off  
Initial SR  $\approx 0.05$  (increases over time)



Cooler: Use reflective coatings, slurries, overlays on top of asphalt  
Initial SR  $\approx 0.25-0.55$

\* **Depends on availability of suitable aggregate.**  
Don't want to ship heavy rocks over long distances.

# Cooler cement concrete pavements



Source: Concrete Technology Laboratory

Cool: Gray-cement concrete with light colored fine aggregate

Initial SR  $\approx$  0.30-0.40



Source: Slag Cement Association

Coollest: Slag concrete, in which slag replaces about 50% of gray cement

Initial SR  $\approx$  0.40 – 0.60

## Other cool pavements

### Permeable

- Work best in climates where it is hot & rainy



Source: Concrete Technology Laboratory



Source: Natural Pave

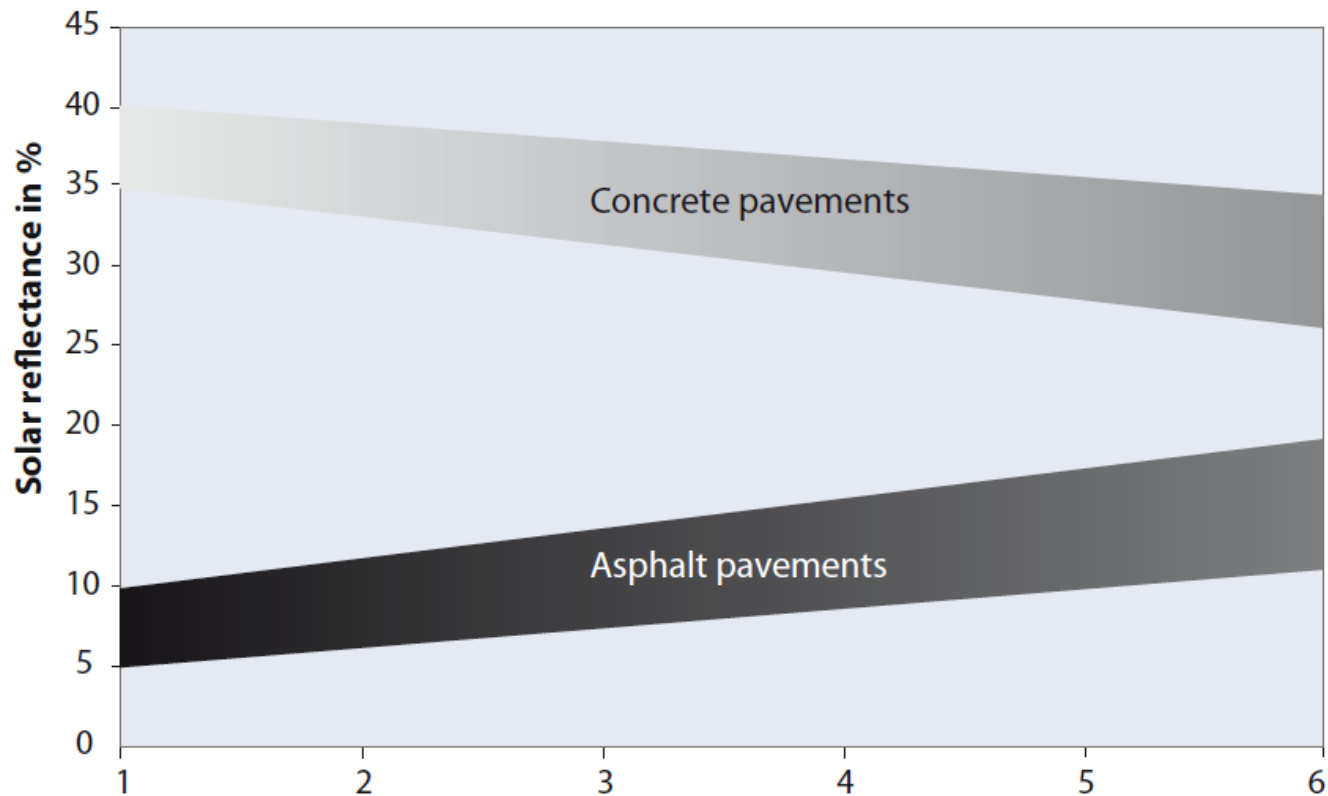
### Resin binders

- Clear binders therefore solar reflectance of aggregate most important factor

### Reinforced grass pavement



# Solar reflectance changes over time



# StreetBond - Quest Construction Products Richmond, CA



**Example of an epoxy-modified acrylic coating**



## ArmorTop - Western Colloid Mission Viejo, CA



*Before*



*After*

**Example of a modified asphalt emulsion seal coat**



# Nano-crete - Emerald Cities Phoenix, AZ



**Example of a cool  
cementitious  
coating**

## UC Davis Demonstration

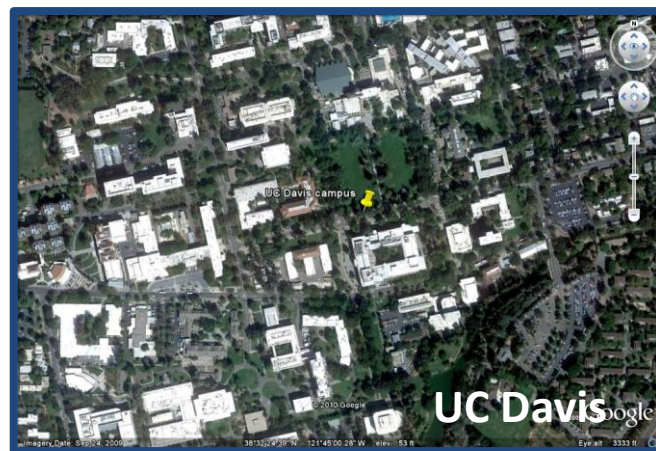
- Six test pavement sections
- Will allow LBNL to compare cooler options against conventional types by monitoring the following:
  1. surface temperature
  2. solar reflectance (and changes over time)
  3. heat flux



A stylized, minimalist illustration of a city skyline at the top of the slide. It features white silhouettes of various buildings and structures against a solid light blue background. The skyline includes a prominent tall building in the center, several smaller buildings to the right, and a structure with a grid-like pattern on the left.

# Other cooling strategies

# Cool roofs



# Not just white





# Shade trees





# Thanks for your time!

## Questions?

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