

100 Cool Cities: Overcoming barriers of Cool roofs and cool pavements

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A global action plan: The big picture

- Develop an international program to install cool roof/pavement in world's 100 largest cities
- This is a simple measure that we hope to organize the world to implement **AND**
- **WE' D BETTER BE SUCCESSFUL**
- We can gain practical experience in design of global measures to combat climate change

100 Cool Cities



Global Cool Cities Alliance (GCCA)

- Non-profit international cooperation launched in 2009
- Mission: Advance policies and actions to increase solar reflectance of urban surfaces to
 - Cool buildings
 - Cool cities
 - Cool the world
- Membership: Open to all cities in the world



“100 Cool Cities” Charter Members

- Initial list of cities
 - NYC, Taipei, Tokyo, Osaka, Tallahassee, Rome, Milano, Athens, Sao Paulo, Hyderabad, Delhi, Los Angeles, Toronto, Montreal, Philadelphia, Chicago, Singapore, Washington DC, Kampala
- Where are other cities (?)
- Industry needs to co-lead

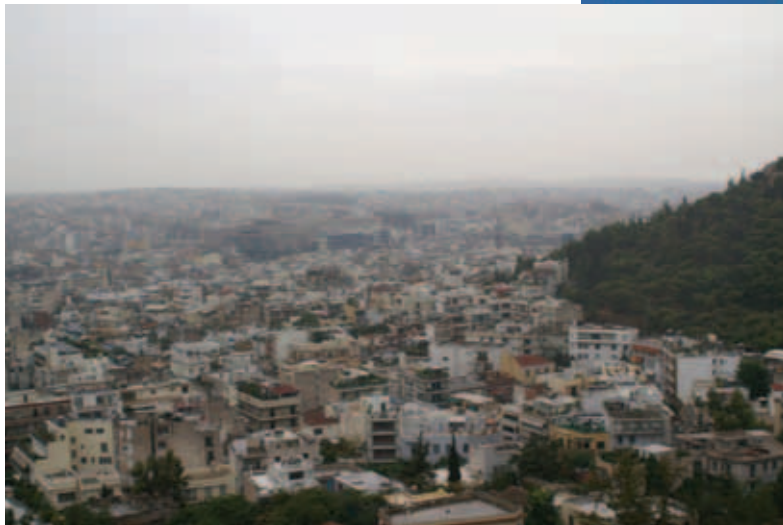
All cities are unique



Athens, Greece



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Beijing



Chicago



Mumbai



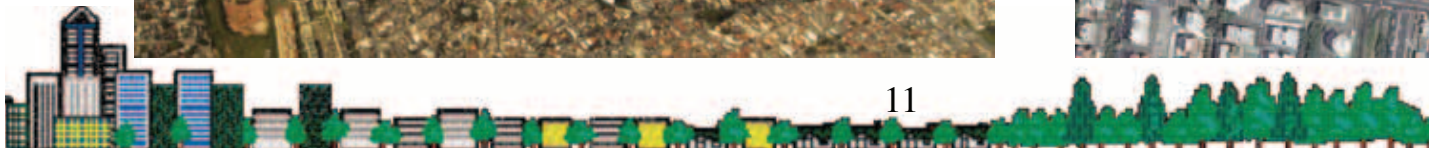
NYC



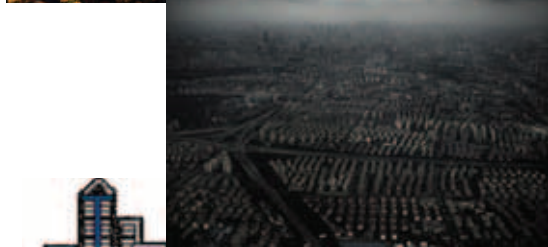
NYC with Cool Roofs



Sao Paulo: Mostly roofs and pavements



Shanghai



Singapore



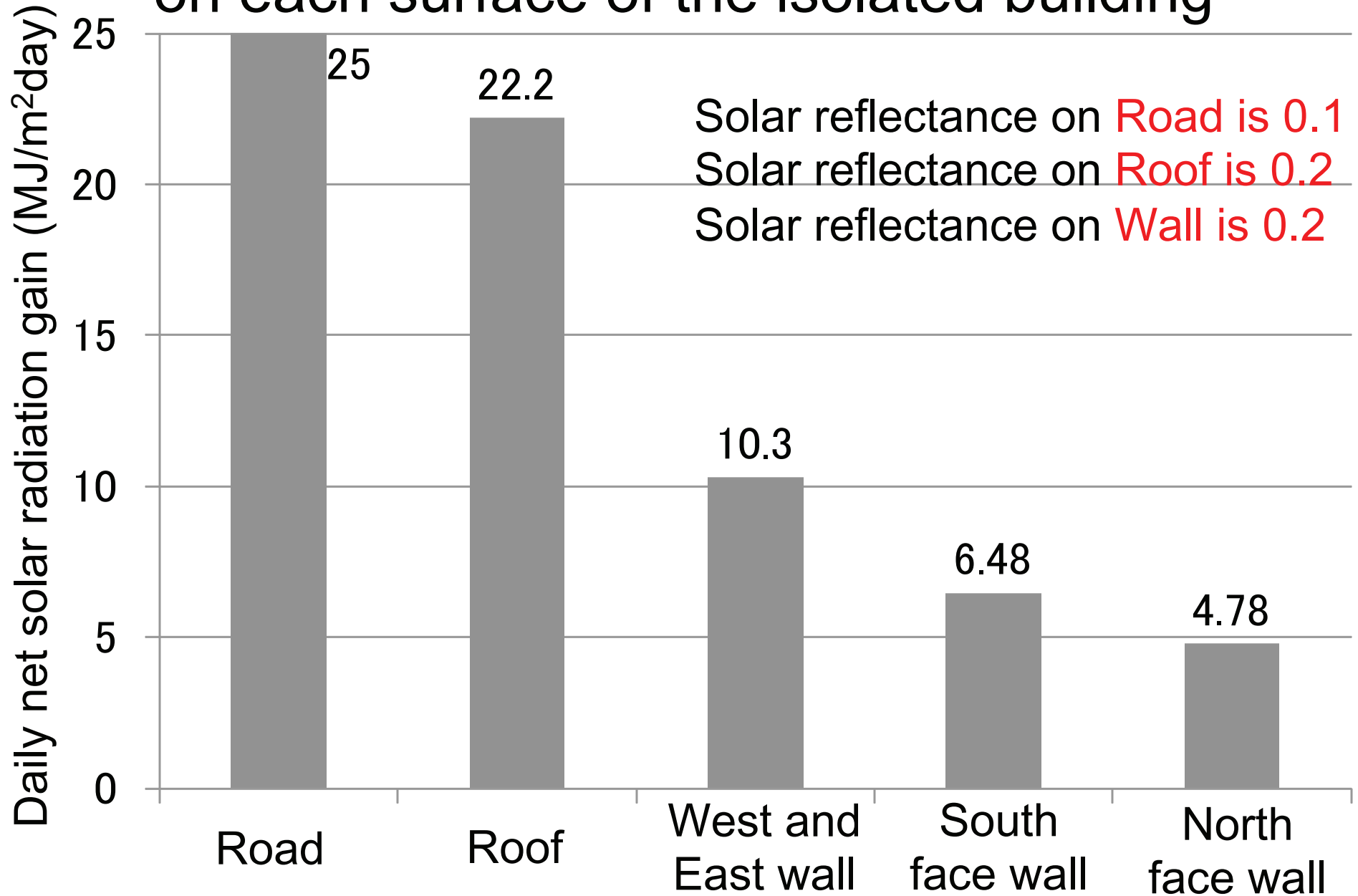
Taipei, Taiwan



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Daily net solar radiation gain in summer on each surface of the isolated building



Research Elements for 100 Cool Cities

- What needs to be done? An initial list
 - Develop a detailed land use database
 - Perform detailed analysis (Energy and AQ impacts)
 - Develop implementation programs (roofs, pavements, trees)
 - Coordinate work with national governments, regional agencies, municipalities and communities
 - Develop a feedback system
 - Develop regional energy codes, standards, guidelines
 - Develop demonstration projects



Implementation elements for 100 Cool Cities

Tall buildings

- Cool roofs
 - Cool roofing materials
 - Roof gardens
- Cool walls
 - Green walls
 - Cool wall materials
 - Shades
- Cool pavements
- Urban parks?
- Street misters

Low-rise buildings

- Cool roofs
 - Cool roofing materials
 - Roof gardens?
- Cool walls
 - Cool wall materials
 - Shades
 - Green walls?
- Shade trees
- Cool pavements



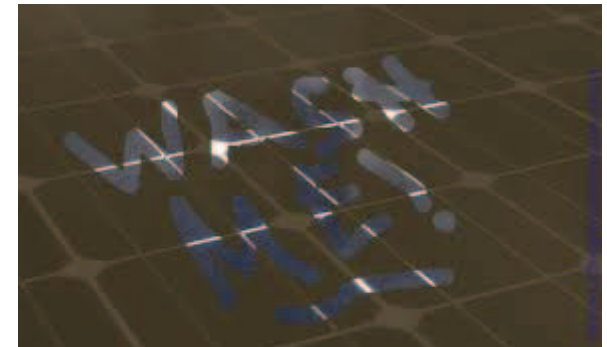
Standards

- Buildings: Energy part of codes
- Pavements: Structural only
- Enforcement
 - Developed countries
 - Developing countries (Southeast Asia)



Effect of climate on ageing of roofing and pavement material

- Hot and dry
 - Pollutants: Dirt and soot
 - Physical and chemical changes (stresses)
- Mild
 - Same as hot and dry, less stress
- Cold
 - Rain and snow effect
 - Significant physical and chemical changes
- Hot and humid
 - All the above + biological growth



Double standards

- It is widely accepted to maintain
 - Walls
 - Windows
 - Roofs (not for reflectivity)
 - Pavements (not for reflectivity)
- No-one addresses what is the
 - R-value of an aged insulation
 - Performance of an aged appliance
- Some yet expect
 - Cool roofs should not change



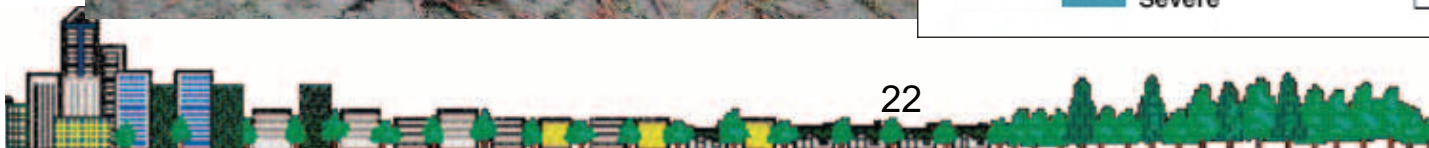
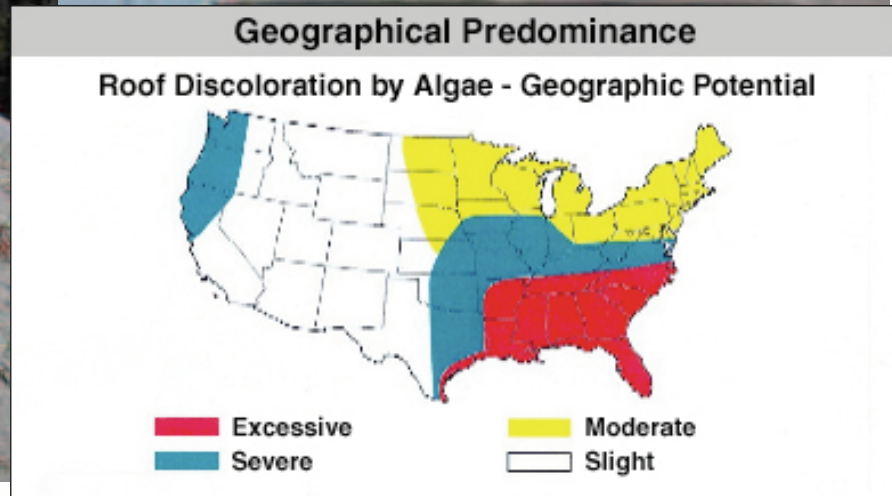
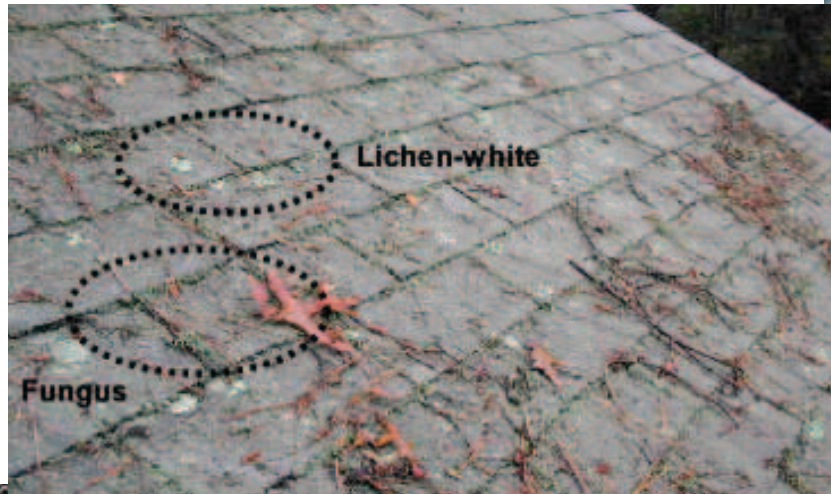
Double standards

- It is widely accepted that insulation is good in all climates (is it?)
- Some say, with more insulation not need for cool roofs
- Some seek alternatives to cool roofs
- Cool roofs needs to be justified for cost
- Cost is defined arbitrarily
- Some say it is the roofing system

Any roof on AC building performs better if it is Cool



Roof and Cool roof aging



White low-sloped roofs for AC buildings

- Annual AC savings of $\sim 0.5 - 1.0$ $\$/\text{m}^2$; $5 - 10$ kWh/m^2
- Annual CO_2 savings of $3.8 - 7.5$ kg/m^2
- CO_2 savings over 20 years life of roof $75-150$ kg/m^2
- **NPV of 20 years AC savings of $\sim 7.5-15$ $\$/\text{m}^2$**
- Maximum incremental cost for most roofs 2.5 $\$/\text{m}^2$

A no brainer



Cool-colored steep-sloped roofs for AC buildings

- Annual AC savings of $\sim 0.3-0.5$ $\$/\text{m}^2$; $3-5$ kWh/m^2
- Annual CO_2 savings of $2.3 - 3.8$ kg/m^2
- CO_2 savings over 20 years life of roof $45-75$ kg/m^2
- NPV of 20 years AC savings of $\sim 4.5-7.5$ $\$/\text{m}^2$
- Maximum incremental cost for most roofs 2.5 $\$/\text{m}^2$

Go for it



White low-sloped roofs for non-AC buildings

- Global cooling offset: 100 kg/m²
- Current value of CO₂ offset: 25 \$/tonne
- **Global cooling value of white roofs: 2.5 \$/m²**
- Incremental cost for most roofs: 0 - 2.5 \$/m²
- Give 1 \$/m² rebate every 10 years
- Save the remainder 1.5 \$/m²; see it grow to 2.5 \$/m² in 10 years

Does it work?



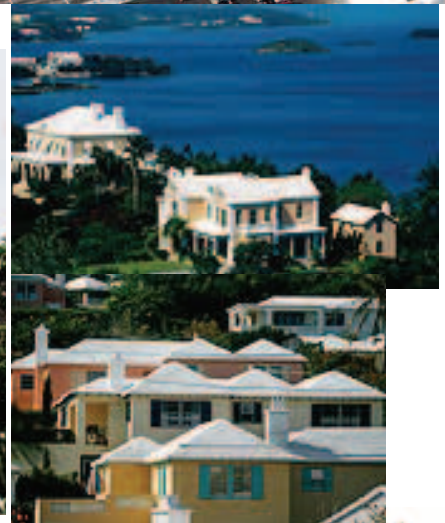
Cool pavements

- Global cooling offset: 40 kg/m²
- Current value of CO₂ offset: 25 \$/tonne
- Global cooling value of cool pavements: 1 \$/m²
- Incremental cost of cool pavements: 0 - 2 \$/m²

*How can we make it work?
Cool pavements last longer?*



100m² of a white roof, replacing a dark roof, offset the emission of 10-20 tonnes of CO₂



References

- Akbari and Mathews. 2010. PALENC2010
- Akbari et al. 2009. *Climatic Change*, 95, 3-4
- Akbari et al. 2003. *Landscape and Urban Planning*, 63 (1-14)
- Kiehl and Trenberth. 1997. *Bull. Am. Meteo. Soc*, 78, 2 (197-208)
- Menon et al. 2010. *Environ. Res. Lett.* 5, 1
- Rose et al. 2003. LBNL-51448, Berkeley, CA
- Takebayashi and Moriyama. *Solar Energy*, 38(8)

