

# Global Cooling: Policies to Increase World-wide Urban Albedos to Offset CO<sub>2</sub>

Hashem Akbari

Heat Island Group  
Building, Civil, and Environmental Engineering Department  
Concordia University  
Montreal, Canada

Tel: 514-848-2424 X3201

E\_mail: [HAkbari@ENCS.Concordia.CA](mailto:HAkbari@ENCS.Concordia.CA)  
[Hashem@HashemAkbari.com](mailto:Hashem@HashemAkbari.com)

**Second International Conference on  
Countermeasures to Urban Heat Islands  
Berkeley, CA      21-23 September 2009**

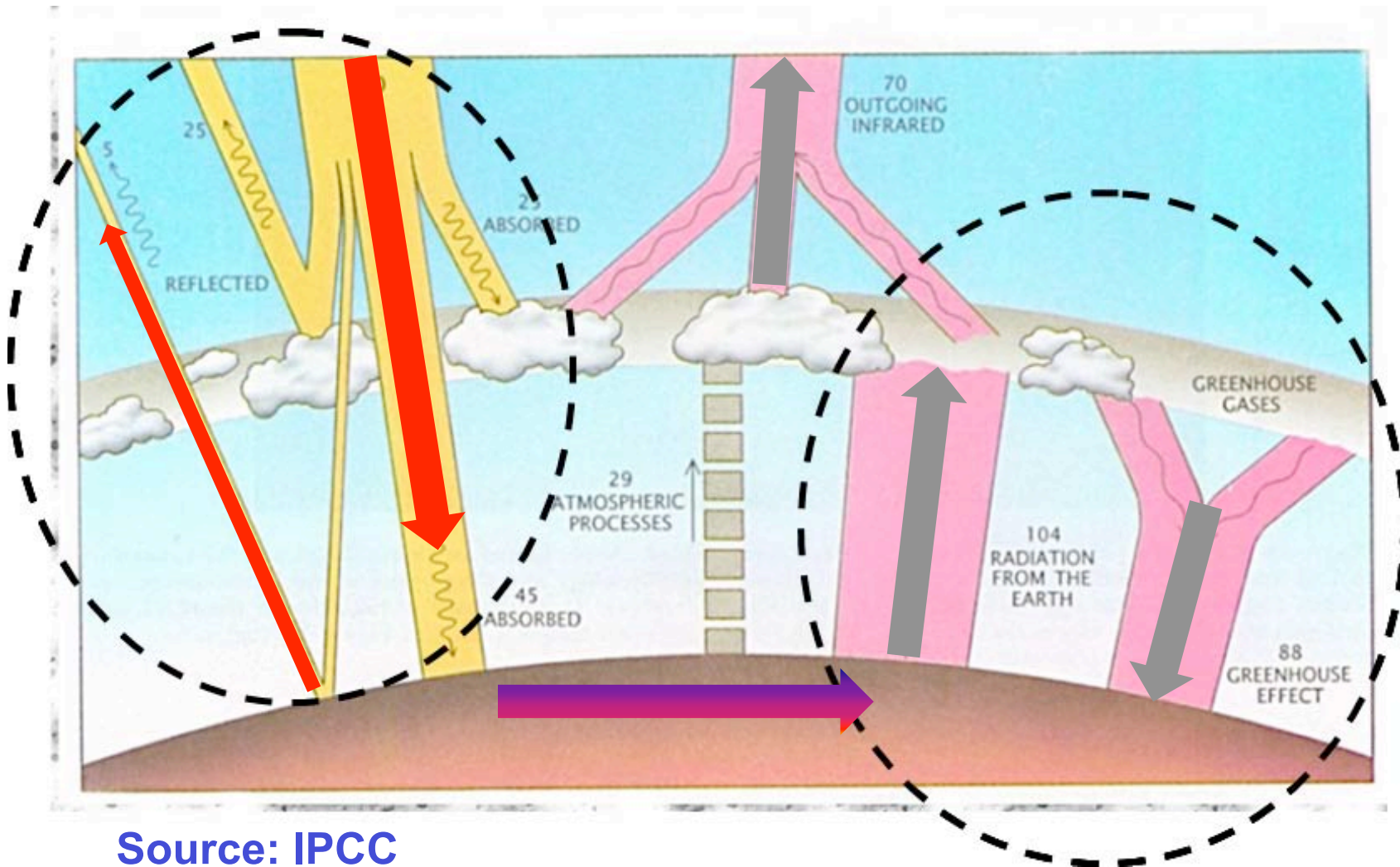
- *Published in Climatic Change 2009, May-June.*
- **Global Cooling: Increasing World-wide Urban Albedos to Offset CO<sub>2</sub>**

**Hashem Akbari and Surabi Menon**  
*Lawrence Berkeley National  
Laboratory, USA*

**Arthur Rosenfeld**  
*California Energy Commission,  
USA*

- **A First Step In Geo-Engineering Which Saves Money and Has Known Positive Environmental Consequences**

# Solar Reflective Surfaces Also Cool the Globe



Source: IPCC

**100m<sup>2</sup>(~1000 ft<sup>2</sup>) of a white roof, replacing a dark roof, offset the emission of 10 tonnes of CO<sub>2</sub>**



# How to Relate to 10 Tons of CO2

- First – This is 10 tons ONCE, not 10 tons/year;
- But familiar measures are usually in terms of tons/year;
- So we will look at how many years of emissions 10 tons will offset

	Tons CO2/Yr	Years Equivalent to 10 Tons
Average US House Emits	10	1
Average US Car Emits	5	2
Average Global Car Emits	4	2.5
Average CFL <b>Saves</b>	.05=1/20	200

# **CO<sub>2</sub> Equivalency of Cool Roofs World-wide (Tropics+Temperate)**

- Cool Roofs alone could offset a total of 24 Billion Tons (Gt) CO<sub>2</sub>
- Worth > €240 Billion (Pre-recession was €600B)
- To Convert 24 Gt CO<sub>2</sub> one time into a rate
- Assume 20 Year Program, thus 1.2 Gt CO<sub>2</sub>/year
- Average World Car emits 4 tCO<sub>2</sub>/year,

**equivalent to 300 Million Cars  
off the Road for 20 years.**

(600 million cars in the world)

# The white revolution

THE INDEPENDENT

TIMES ONLINE

THE NEW REPUBLIC  
*A Journal of Politics and the Arts*

THE HINDU

THE VANCOUVER SUN

ANSA.it



Le Monde.fr

METEO ITALIA

THE WALL STREET JOURNAL

zeroEmission.TV  
guardian.co.uk

San Francisco Chronicle

BBC

THE CHRISTIAN SCIENCE MONITOR

Los Angeles Times

The New York Times

www.jamejonline.ir



# White is 'cool' in Bermuda





and in Santorini, Greece



and in Hyderabad, India



...and in Gujarat, India

# Cool Roofs Policies

- **Standards, Building Codes, Rating, and Labelling in U.S.**
  - **ASHRAE Standard 90.1-2007** prescribes cool materials for low-sloped roofs on nonresidential buildings in some U.S. climates.
  - **ASHRAE Standards 90.1-2004 and 90.1-2001** offer credits for cool materials for low-sloped roofs on nonresidential buildings in some U.S. climates.
  - **ASHRAE Standard 90.2-2004** offers credits for cool materials for all roofs on residential buildings in some U.S. climate zones.
  - **2008 California Title 24 Standards** prescribe cool materials for roofs on residential and nonresidential buildings in some California climate zones.
  - **2005 California Title 24 Standards** prescribe cool materials for low-sloped roofs on nonresidential buildings in all California climate zones (but one coastal region) and offers credits for steep-sloped roofs on residential and nonresidential buildings in all California climate zones.

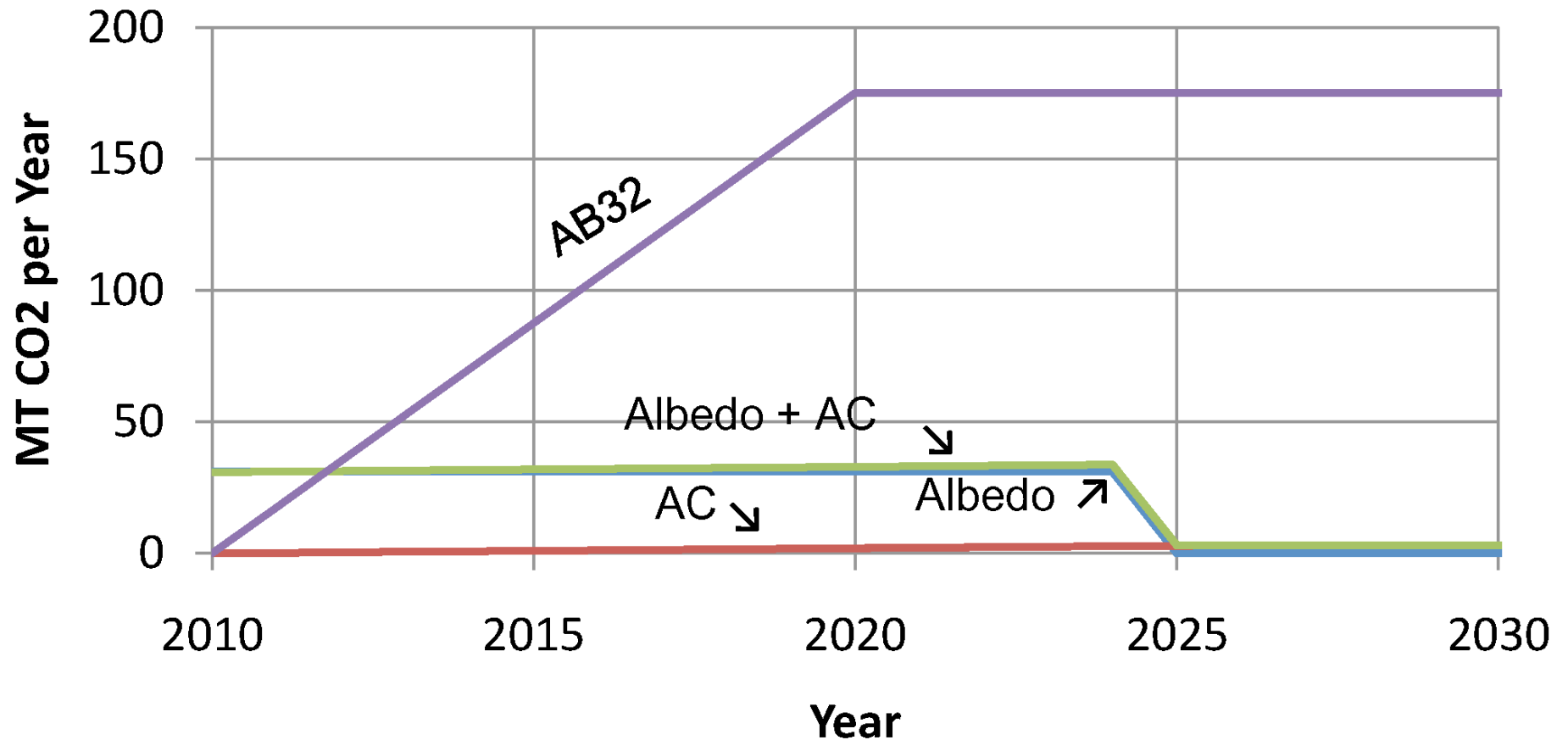
# Cool Roofs Policies (Continued)

- **2003 International Energy Conservation Code** allows commercial buildings to comply by satisfying the requirements of ASHRAE Standard 90.1.
- **Chicago, IL** Energy Conservation Code prescribes a minimum solar reflectance and thermal emittance for low-sloped roofs.
- **2004 Florida Building Code** prescribes cool materials for all roofs on non residential buildings that are essentially the same as those in ASHRAE Standard 90.1-2004.
- **Hawaii.** In 2001, 2002, and 2005, respectively, the counties of Honolulu, Kauai, and Maui adopted cool-roof credits for commercial and high-rise residential buildings based on ASHRAE Standard 90.1-1999.

# Cool Roofs Policies (Continued)

- **U.S. EPA ENERGY STAR™ Label.** Requires that low-sloped roofing products have initial and three-year-aged solar reflectances not less than 0.65 and 0.50, respectively. Steep-sloped roofing products must have initial and three-year-aged solar reflectances not less than 0.25 and 0.15, respectively.
- **LEED Green Building Rating System.** The Leadership in Energy and Environmental Design (LEED) Green Building Rating System assigns one rating point for the use of a cool roof in its Sustainable Sites Credit.
- **Cool Roof Rating Council.** The Cool Roof Rating Council was established in 1998 to “develop accurate and credible methods for evaluating and labeling the solar reflectance and thermal emittance (radiative properties) of roofing products and to disseminate the information to all interested parties.”

# California: Cool Roofs and Climate Targets



# Cool Roofs in Other Countries

- Cool roofs offer significant cooling energy savings in buildings with air conditioning and improve comfort in buildings without air conditioning.
- **Cool Roofs Codes and Standards.**
  - China
  - India
  - EU (EU-CRC)
  - Brazil (One Degree Less)
  - Australia
  - Taiwan
  - Middle East

# Cool Pavements

- Cool pavement technologies are diverse.
  - Solar reflectance of freshly installed asphalt pavement is  $\sim 0.05$
  - Aged asphalt pavements have a solar reflectance of  $0.10 - 0.18$
  - Light-color (low carbon content) concrete can have an initial solar reflectance of  $0.35 - 0.40$  that will age to about  $0.25 - 0.30$
  - We recommend using cool pavement materials to increase the solar reflectance of paved surfaced by  $\sim 0.15$
- Current pavement construction standards do not account for the solar reflectance of pavements. However, the maximum temperature of a pavement and the diurnal range of pavement temperature is an important consideration in design of a pavement.
- Laboratory tests have demonstrated that cooler pavements have a longer life time.
- **LEED Green Building Rating System** assigns one rating point for the use of cool pavements in its Sustainable Sites Credit.



# International CO<sub>2</sub> Market

- The value of a global cooling strategy in carbon equivalent terms is over \$800 billion, based on \$20/tonne CO<sub>2</sub>.
- Existing CO<sub>2</sub> markets do not allow trading of CO<sub>2</sub>-equivalent offsets for geo-engineering technologies, such as cool cities, that directly cool the earth and slow the rate of global warming.
- Current CO<sub>2</sub> market is based on measures that directly reduce the CO<sub>2</sub> emissions and require for such CO<sub>2</sub> reduction measures:
  - **Real.** Albedo-based CO<sub>2</sub> offsets do not represent a “real” reduction in greenhouse gas emissions
  - **Permanent.** In order to make the cooling effects of increasing urban albedo permanent, programs would need to be set to ensure that roofs and pavements are kept reflective in perpetuity
  - **Verifiable.** The Clean Development Mechanism (CDM), California Climate Action Registry (CCAR) and other registries have developed protocols for different types of measures
  - **Additional.** Offsets require a baseline in order to calculate the benefit

# International Activities

- European Union Cool Roof Council (EU-CRC)  
<http://coolroofs.univ-lr.fr/>
- Brazil 1-Degree Less  
[www.onedegreeless.org](http://www.onedegreeless.org)
- Building energy standards (Kuwait, India)
- Major Economies Forum (MEF) on Energy and Climate
- Copenhagen (IPCC)



## An action plan:

### An International Cool Cities Campaign

- We propose to organize the hundred largest cities in the temperate and tropical regions of the world to develop city-specific implementation programs to install cool roofing and pavement materials
- Initial acceptance from a few large cities: New York City (USA), Taipei (Taiwan), São Paulo (Brazil), Delhi (India), Hyderabad (India), Los Angeles (USA), Osaka (Japan), and Tokyo (Japan)

# Cool Cities Mandate

- Develop a collaborative research and implementation program to regionally analyze the effect of cool city technologies; assist the stakeholders in developing countries to develop customized and regional technologies and programs; develop an international center with regional offices in many cities around the world
- Conduct basic and applied research to develop, demonstrate, and manufacture advanced building envelope and pavement materials
- Develop techniques to monitor the implementation programs
- Analyze the effect of cool cities on air quality
- Work with IPCC and other international bodies to develop regional equivalencies between cool cities measures and CO<sub>2</sub> emission reduction; work with international agencies to incorporate the effect of cool cities in the CO<sub>2</sub> emission market exchange.

# Research Elements for 100 Cool Cities

- What needs to be done? An initial list
  - Perform detailed analysis (Energy and AQ impacts)
  - Develop a detailed land use database
  - 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