

# Urban Heat Islands

**Toronto, Canada**

**May 2, 2002**

**Arthur H. Rosenfeld, Commissioner**

**California Energy Commission**

**(916) 654-4930**

**[ARosenfe@Energy.State.CA.US](mailto:ARosenfe@Energy.State.CA.US)**





# For Technical Information Contact:

Hashem Akbari

Heat Island Group Leader

Lawrence Berkeley National Laboratory

Tel: 510-486-4287, E\_mail: [h\\_akbari@lbl.gov](mailto:h_akbari@lbl.gov)

Web: [eetd.lbl.gov/heatisland](http://eetd.lbl.gov/heatisland)



# Temperature Trends in Downtown Los Angeles



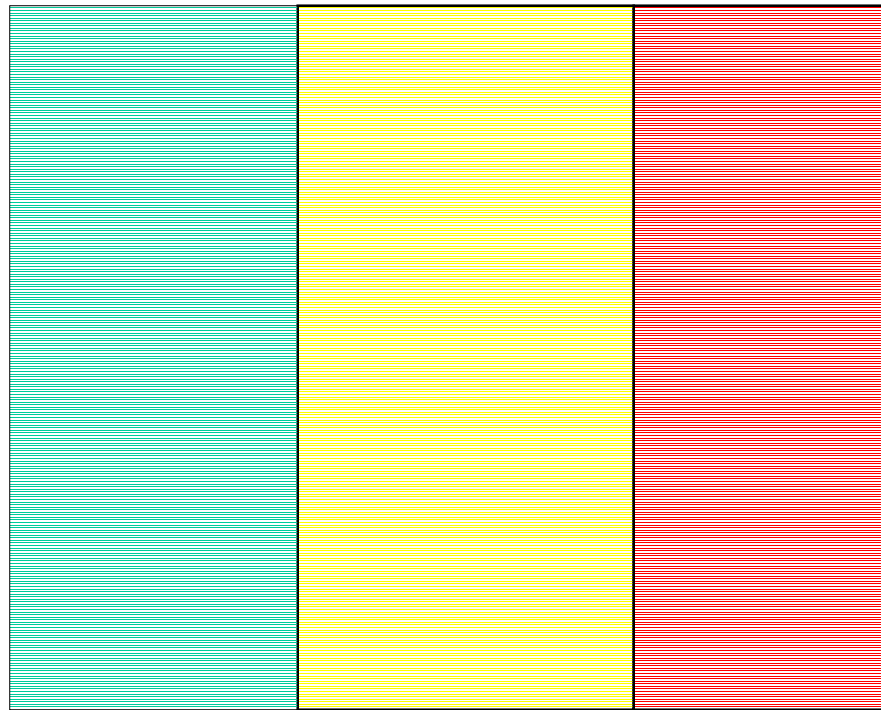
# Measured Temperature Trends in Selected Cities (3-8 Decades)



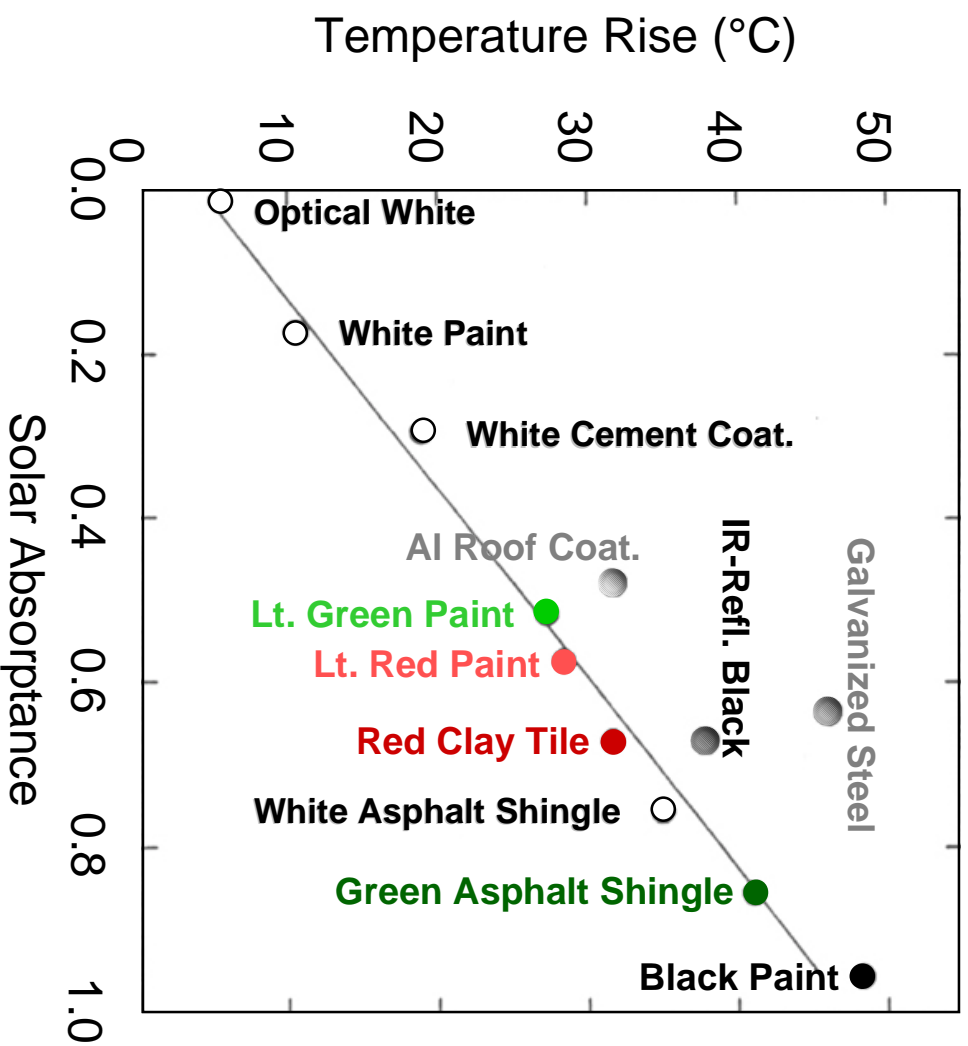
← IPCC  
Trend of  
Global  
Warming



# Effect of Temperature Rise on Peak Ozone Concentration



# Temperature Rise of Various Materials in Sunlight



# White Roofs and Trees: Measured Cooling Savings

## ◆ Roofs

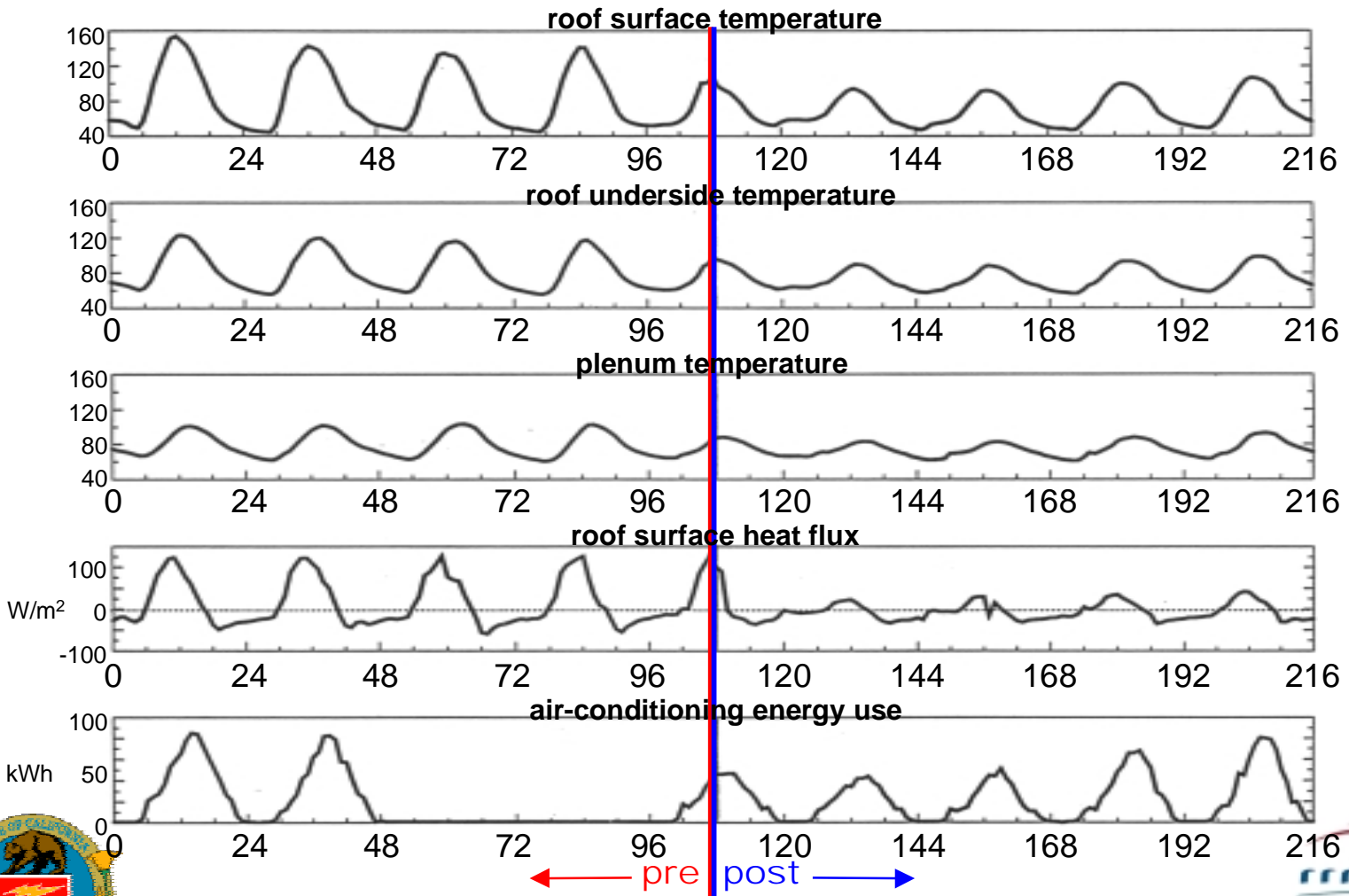
- *Sacramento*: 80% in a house; 35% in two school bungalows
- *Florida*: 10%-43% in several houses, average 19%
- *Recent Demonstrations*: 5%–20% in several commercial buildings in California and Florida

## ◆ Trees

- *Sacramento*: 30% in two houses
- *Florida*: 45% in a trailer office



# Demonstration of Cool Roofs in 3 Commercial Buildings Monitored Hourly Data: Gilroy



## Demonstration of Cool Roofs in 3 Commercial Buildings Air-Conditioning Savings

	Monitored kWh/day		Normalized post kWh/day for <b>pre</b> $T_{out}$	Estimated savings	
	<b>pre</b>	<b>post</b>		$\Delta$ kWh/day	%
<b>Davis</b>	1094	915	896 $\pm$ 15	198 $\pm$ 15	18 $\pm$ 1
<b>Gilroy</b>	675	658	589 $\pm$ 7	86 $\pm$ 7	13 $\pm$ 1
<b>San Jose</b>	713	730	700 $\pm$ 6	13 $\pm$ 6	2 $\pm$ 1



# Simulated Air Temperature Difference: Adding 11 M Trees Los Angeles, 3 p.m., August 28

Los Angeles \*  
\* LAX

\* Burbank  
\* Ontario  
\* Anaheim \* Riverside  
\* Irvine

Temperature difference (°C)

-3.5      -3.0      -2.5      -2.0  
-1.5      -1.0      -0.5

11



# Mitigation Measures: Light-Colored Surfaces and Trees

## ❖ Direct Effect

- ❖ **Light-colored roofs** reflect solar radiation; reduce air-conditioning use
- ❖ **Trees** that shade buildings reduce air-conditioning use

## ❖ Indirect Effect

- ❖ Light-colored surfaces in a neighborhood alter surface energy balance; result in lower ambient temperature
- ❖ Vegetation in a neighborhood reduces ambient temperature through **evapo-transpiration**

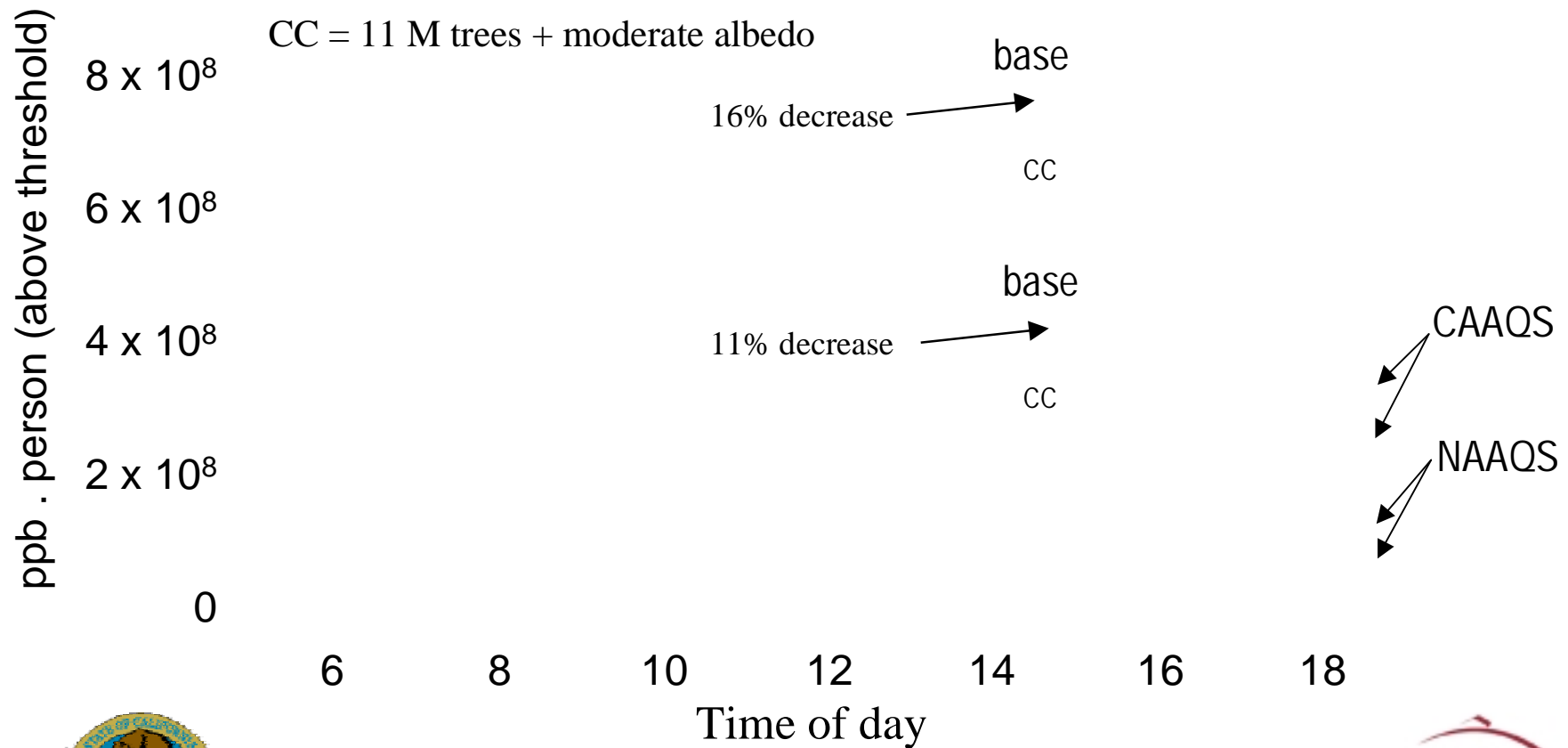


# Simulated Meteorology and Air-quality Impacts in LA



# Simulated Population-Weighted Exceedence Exposure to Ozone

Los Angeles, August 28



# Potential National Savings from Changing Roof Reflectivity



# Cool benefits in LA

(\$ Millions/Year)

Source	Cool Roofs	Trees	Pavements	Total
Building Savings	46	58	0	104
Cooler Urban Air	21	35	15	71
Improved Human Health (from reduced ozone)	104	180	76	360
<b>Total</b>	<b>171</b>	<b>273</b>	<b>91</b>	<b>535</b>

**National Savings extrapolat to ~ 5 B/yr**

Source: Rosenfeld, et.al., Energy and Buildings 28(1998) 51-62



# The Cool Roof Rating Council

## **Mission: Develop methods for evaluating and labeling reflective roofing products**

- ❖ Initial meetings between manufacturers: Gaithersburg, February and July 1994
- ❖ Initial formation of CRRC: Berkeley, September 1997; 2 meetings per year thereafter
- ❖ Incorporation of CRRC: June 1998
- ❖ CRRC organizational committees: Education/outreach; technical/research; rating, codes, and standards; membership



# White Roofs for California

- ❖ One Time Incentive -- \$20 Million
  - at \$0.15 to \$0.20 per square foot
- ❖ Annual Public Goods Charge Incentive -- \$ 2-3 Million
- ❖ Texas and other states will soon also have PGCs
- ❖ New California Power Authority wants to lend money for the entire cost of a re-roof (only, of course, if white)



# California Title 24

## New Building Performance Standards

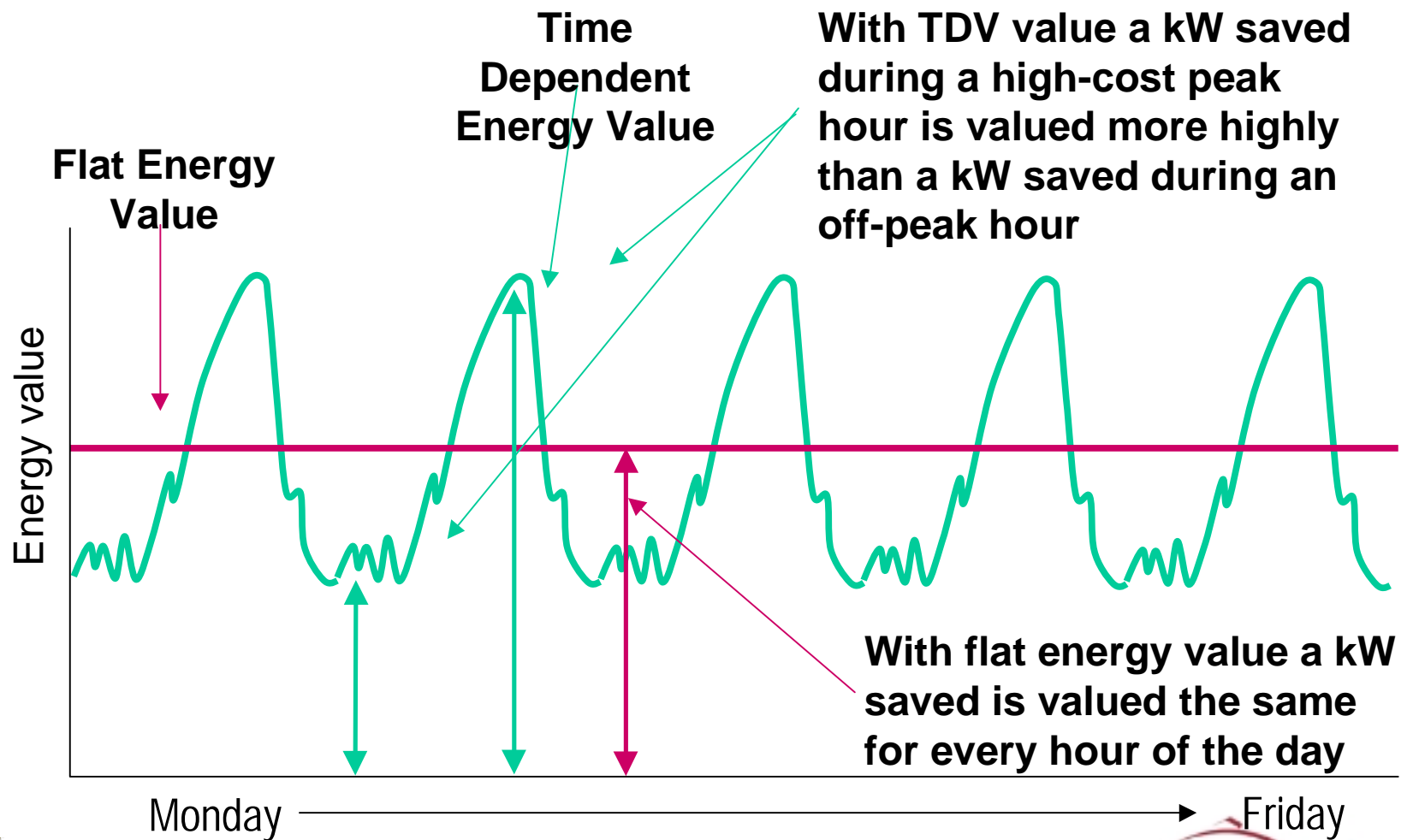
- ❖ 2001 to 2005-- **credits** white and cool colored roofs
- ❖ 2003/2005 will **require** cool flat roofs.
  - Will introduce time-dependent valuation of electricity, doubles the importance of air conditioning.
  - Note: ASHRAE 90.1 and 90.2 and Florida and Georgia already credit white roofs.

### Related Transportation Issues of Interest

- ❖ Buses already have white roofs; state fleet should purchase only white cars.



# How TDV Works (electricity)



# R&D

## **Underway**

- ❖ Cool Colored Roofs, particularly shingles
- ❖ Service Life of Cooler Roofs

## **Planned**

- ❖ Service Life of Cooler Pavements



# General Comments

## State Implementation Plans (SIP)

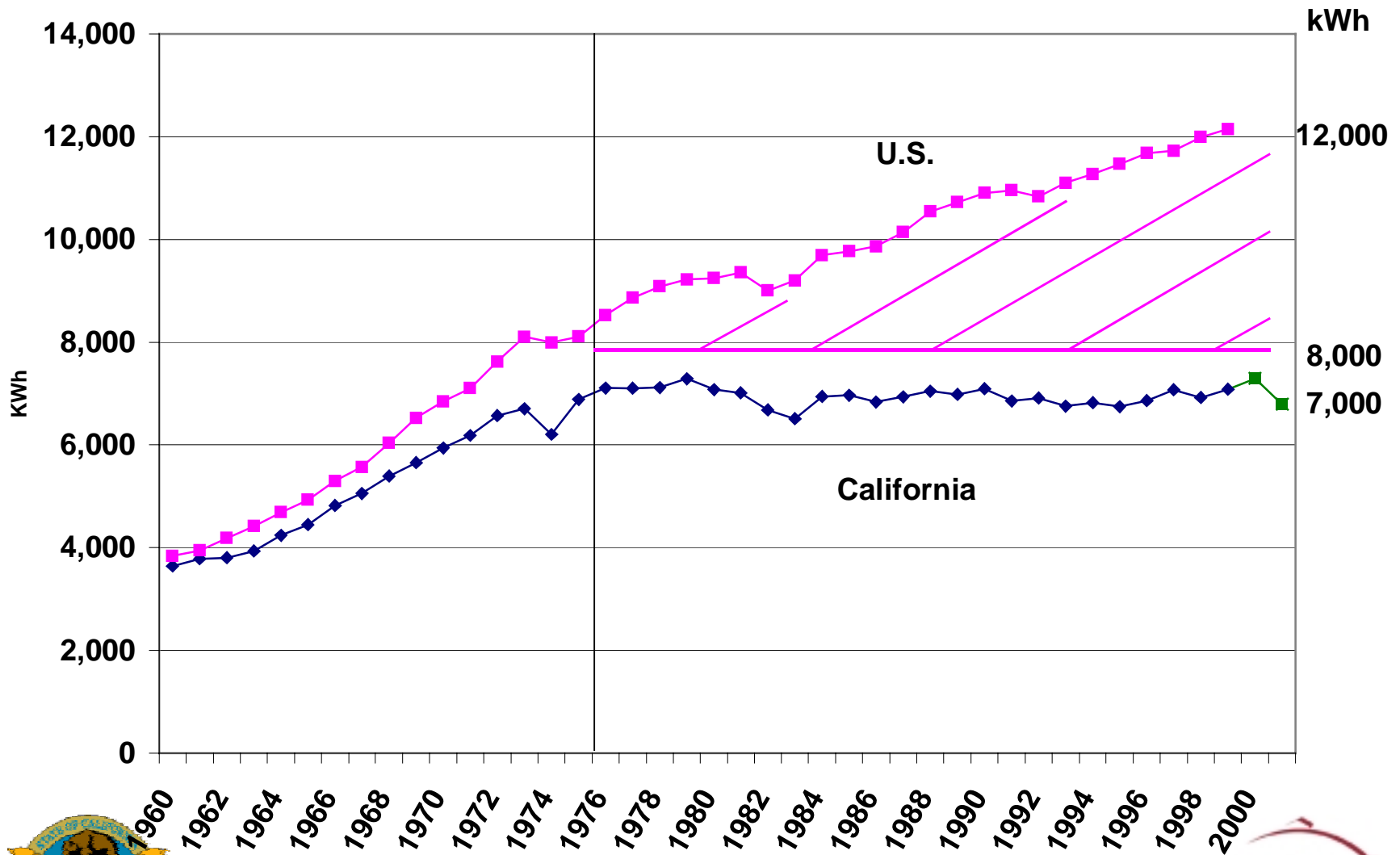
- ❖ California is waiting for Houston which is a cliff-hanger

## Trees

- ❖ Shaded Buildings always save A/C, **BUT**
  - In LA, modeled cooling ratios were Roofs:Pavement:Tress = 1:1:2
  - In Soggy South, evapo-transportation drops by ~50%
  - So Roofs:Pavement:Tress = 1:1:1

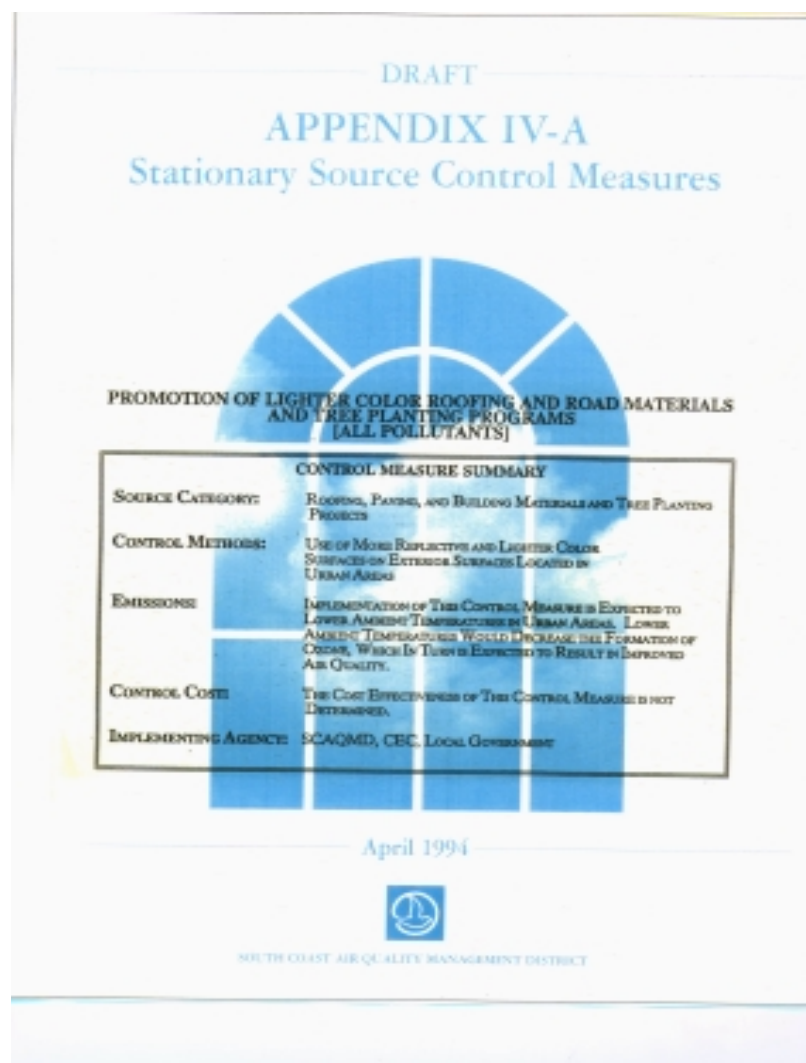


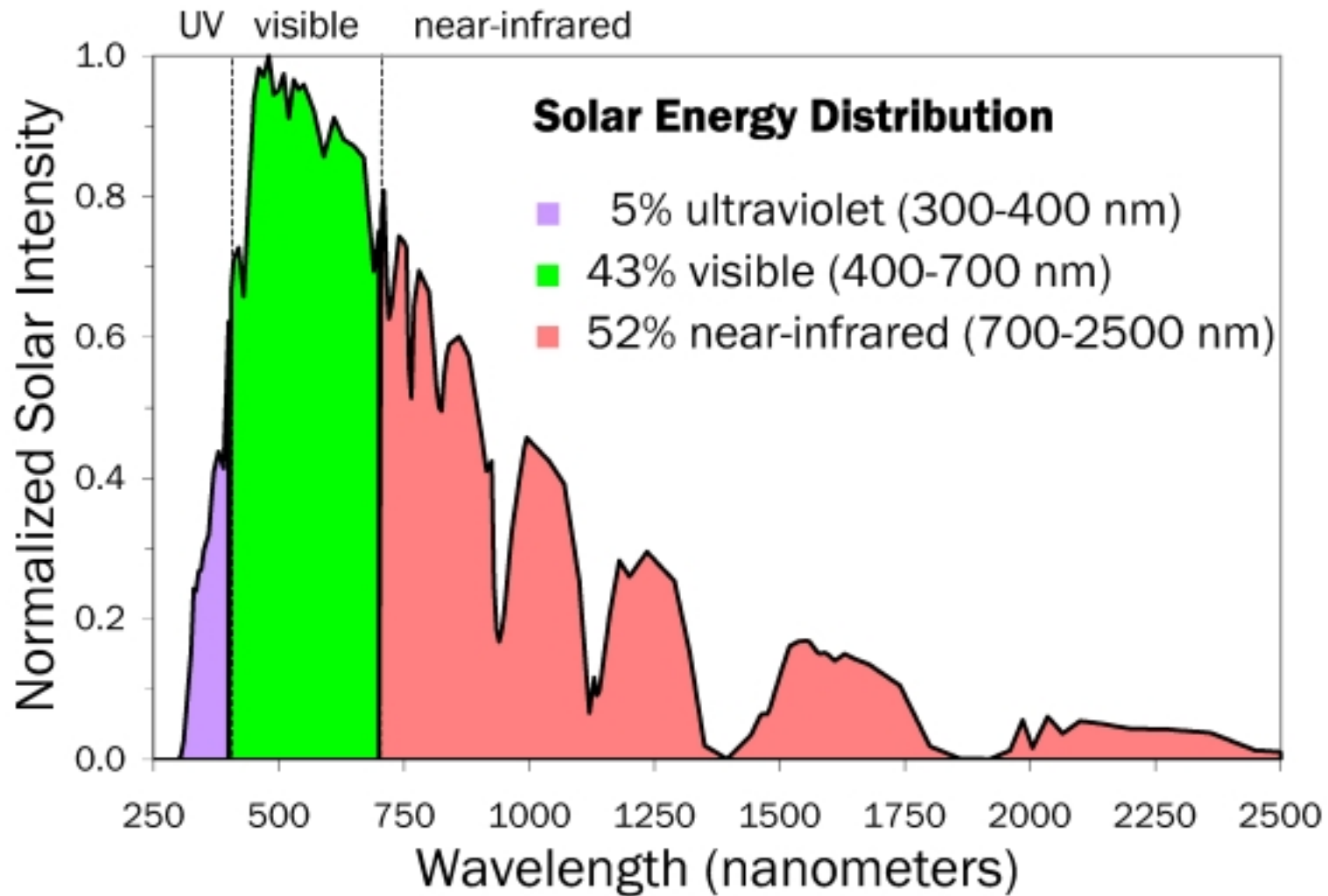
**Total Electricity Use, per capita, 1960 - 2001  
(estimated for California in 2000 and 2001)**



# Guidelines for Air-Quality Management Plans

- ❖ South Coast AQMD
- ❖ S.F. Bay Area AQMD
- ❖ TNRCC, all list Heat Island Measures, but with no numbers.

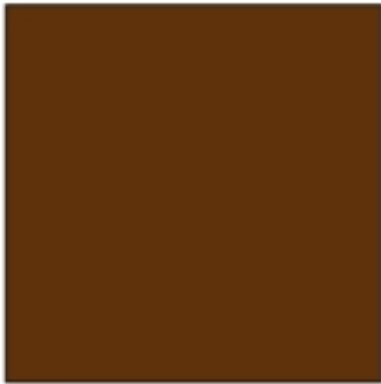




brown  
metal  
panel

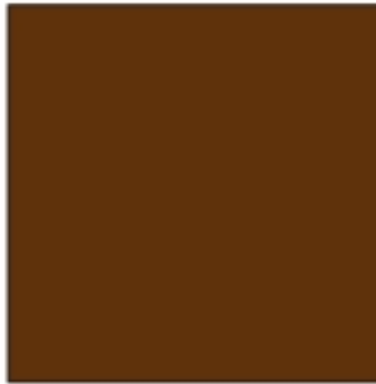
COURTESY  
BASF CORPORATION

**cool**

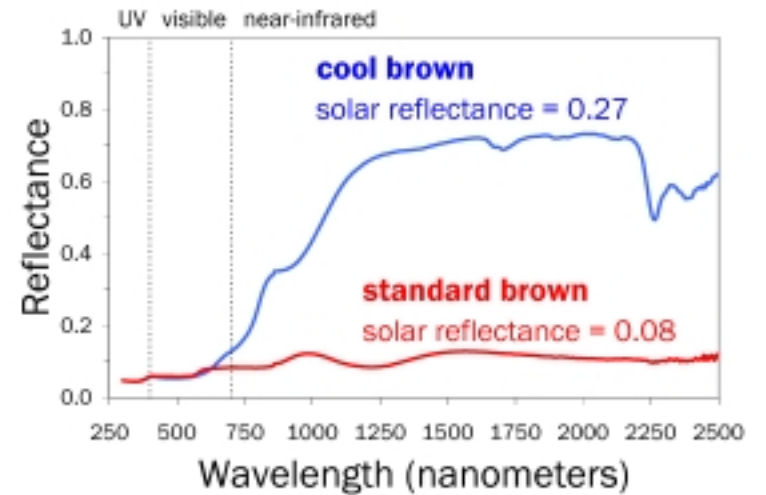


**solar reflectance = 0.27**  
thermal emittance = 0.85  
roof temp - air temp = 36°C (65°F)

**standard**



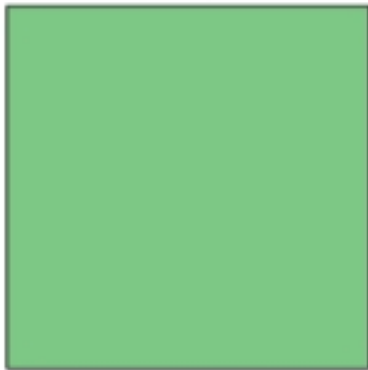
**solar reflectance = 0.08**  
thermal emittance = 0.85  
roof temp - air temp = 45°C (81°F)



green  
metal  
panel

COURTESY  
BASF CORPORATION

**cool**

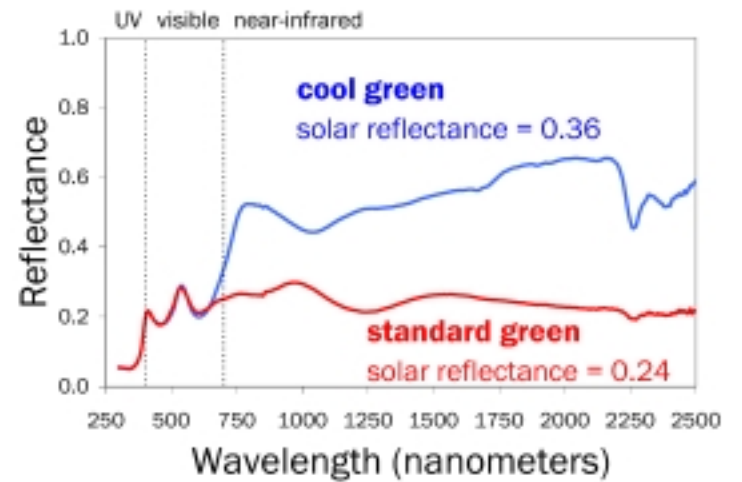


**solar reflectance = 0.36**  
thermal emittance = 0.85  
roof temp - air temp = 31°C (56°F)

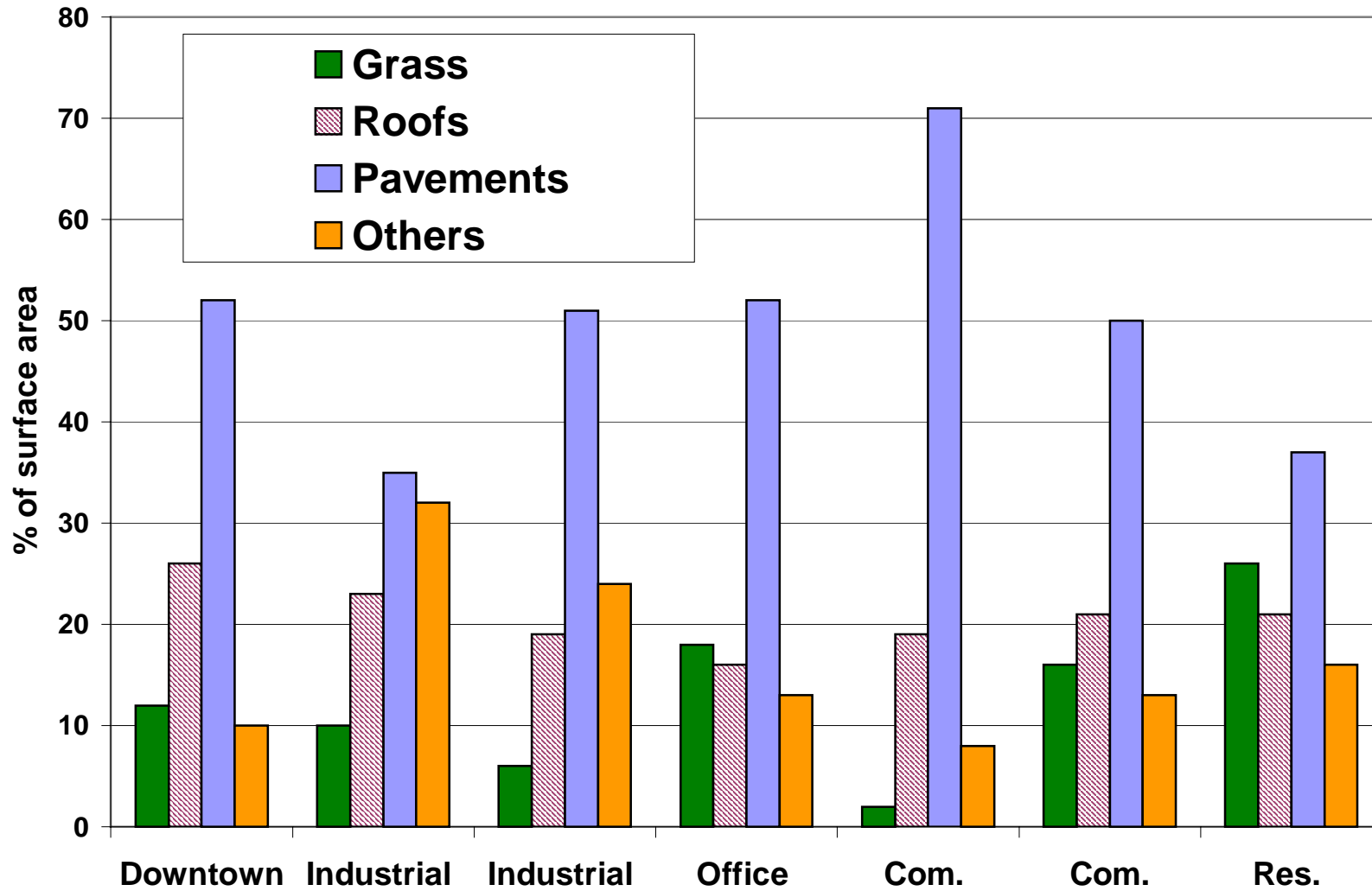
**standard**



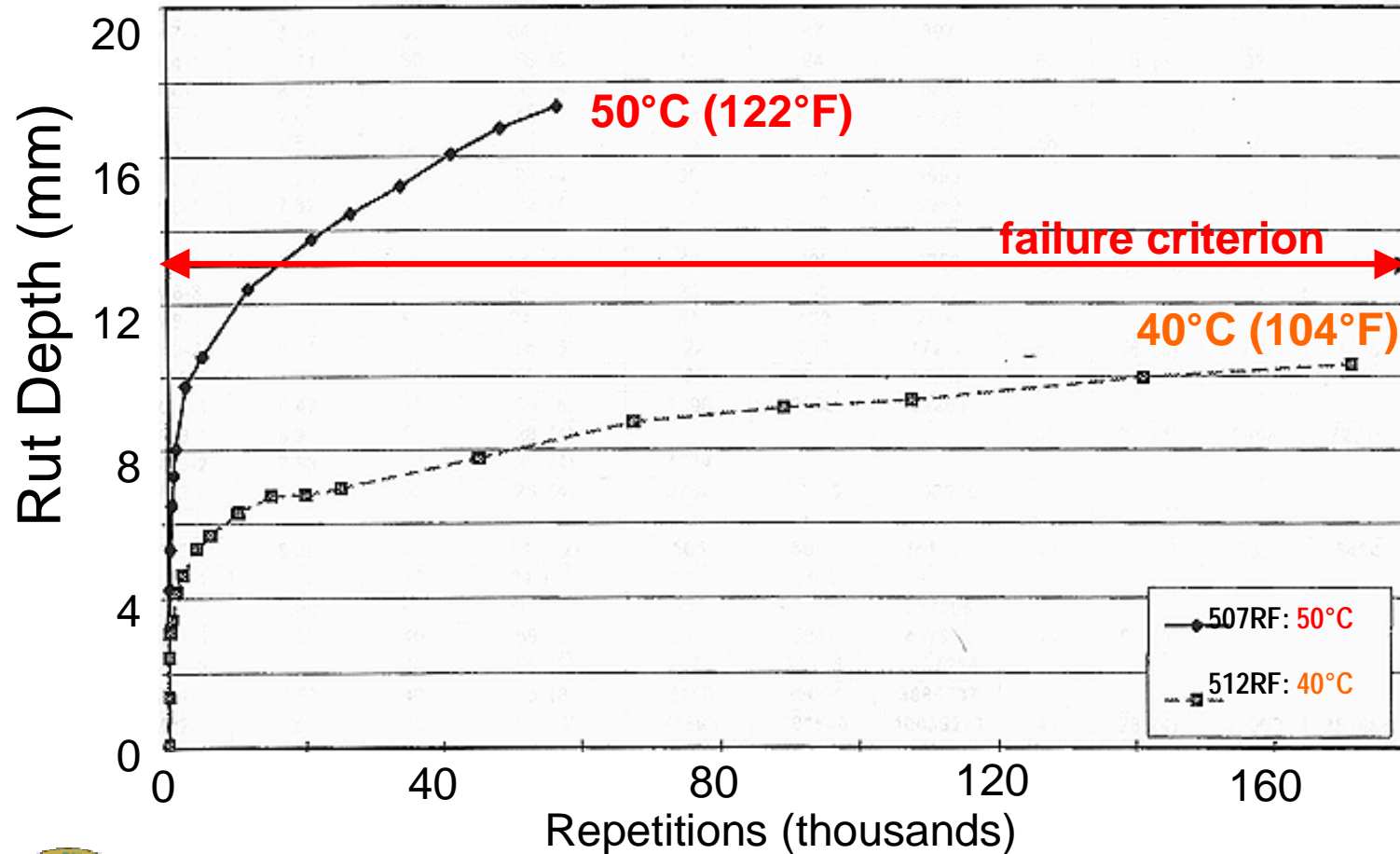
**solar reflectance = 0.24**  
thermal emittance = 0.85  
roof temp - air temp = 38°C (68°F)



## Under the Canopy Fabric of Sacramento, CA



# Temperature Effect on Rutting



Source: Dr. John Harvey, UC B Civil Engineering, Inst. Transpo. Studies

