ARPA-E, Tue Mar 1, 2011
Arati Prabhakar's Panel on Efficiency and Profitability

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California Energy Commission.

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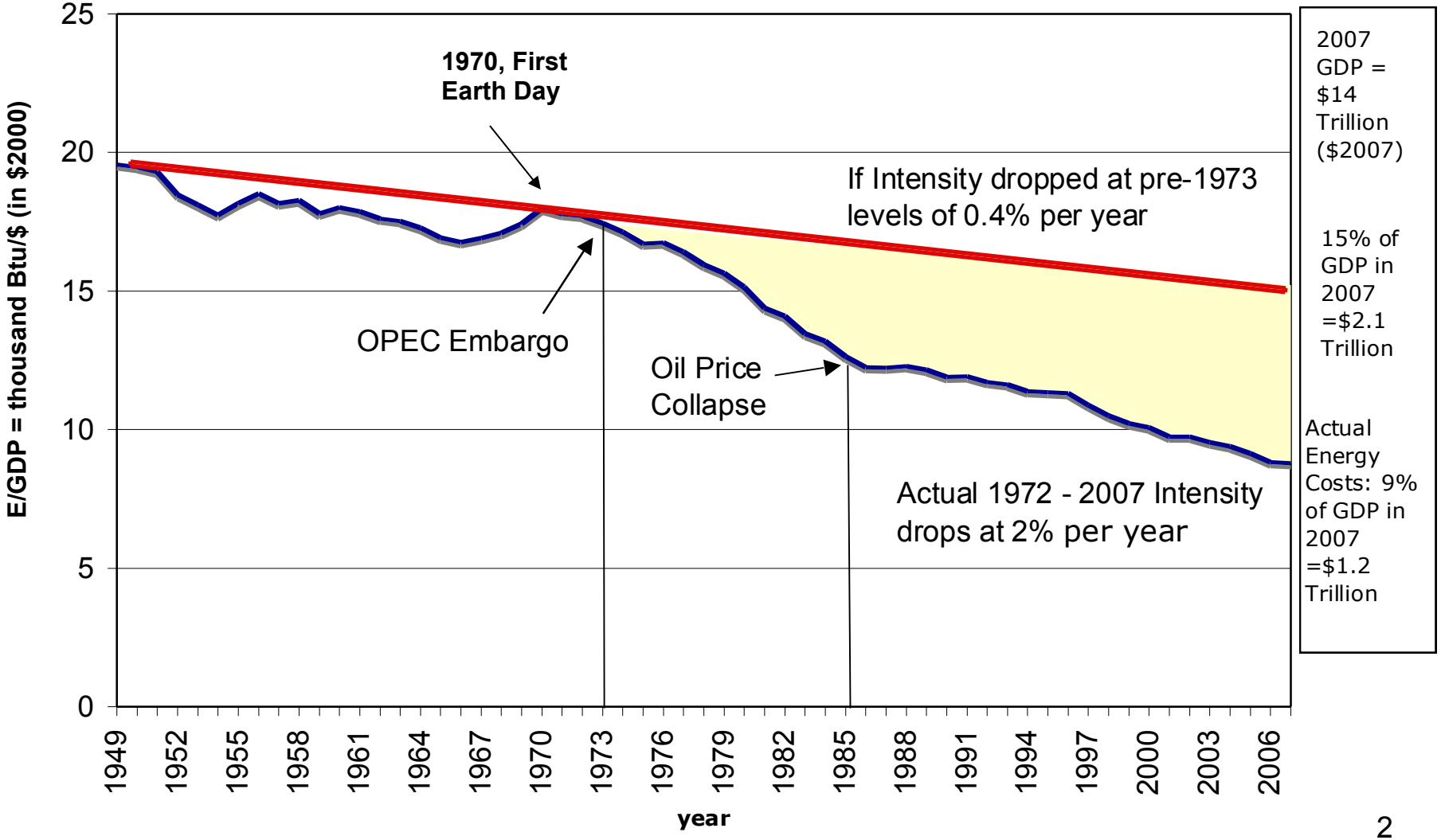
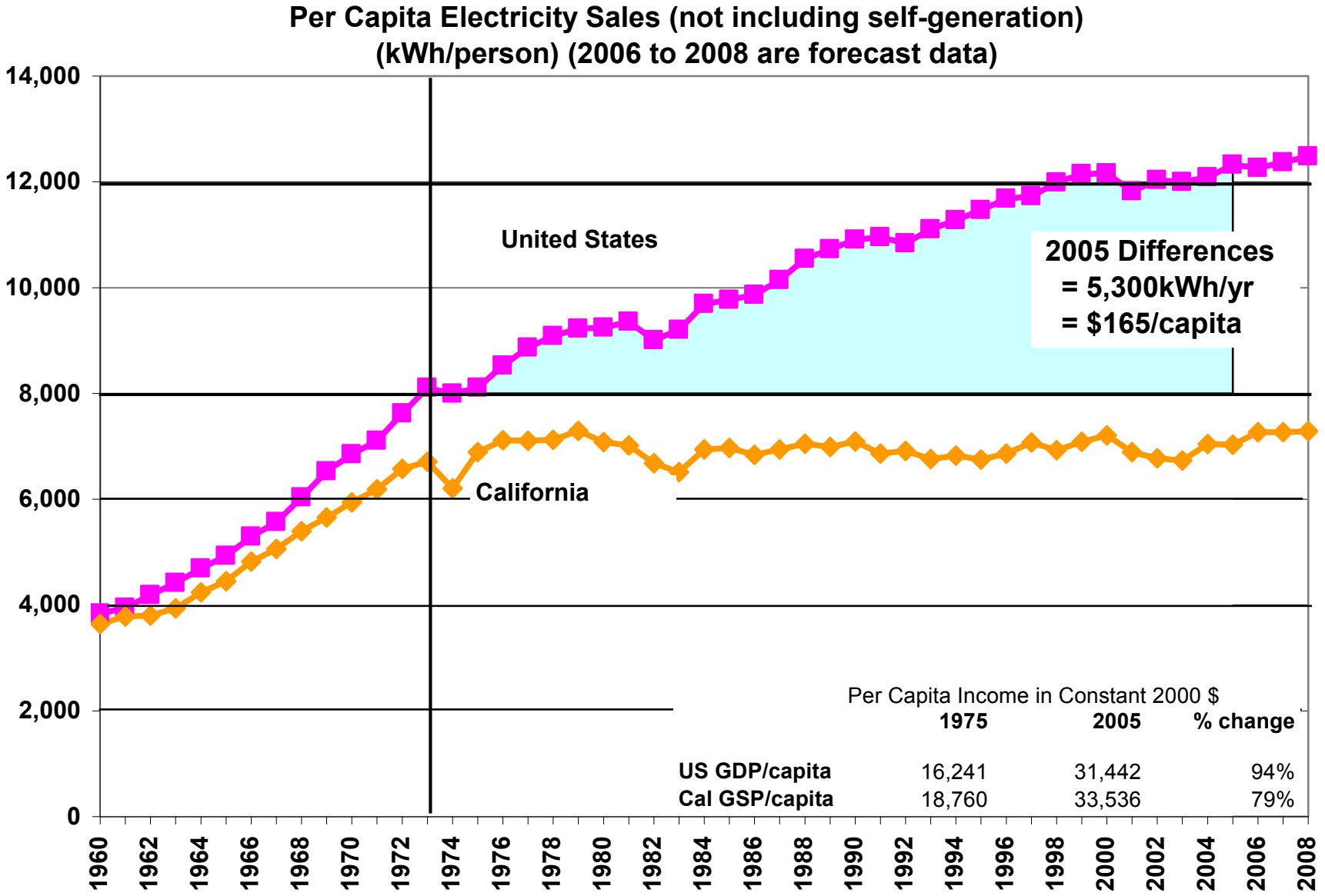
Presentation available at www.ArtRosenfeld.org

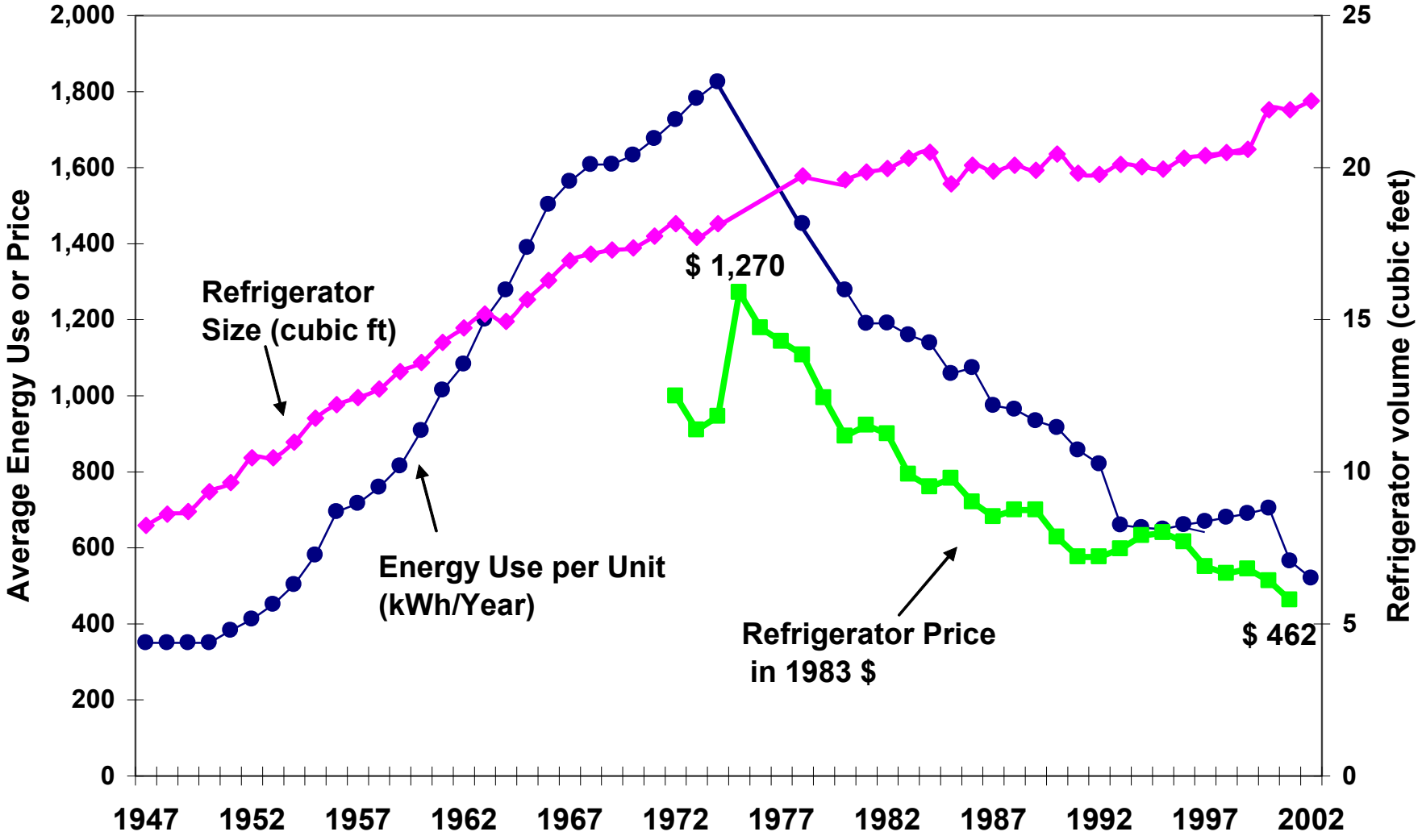
Energy Intensity (E/GDP) in the US 1949 - 2007



ArtRosenfeld@gmail.com or PatMcAuliffe@sbcglobal.net

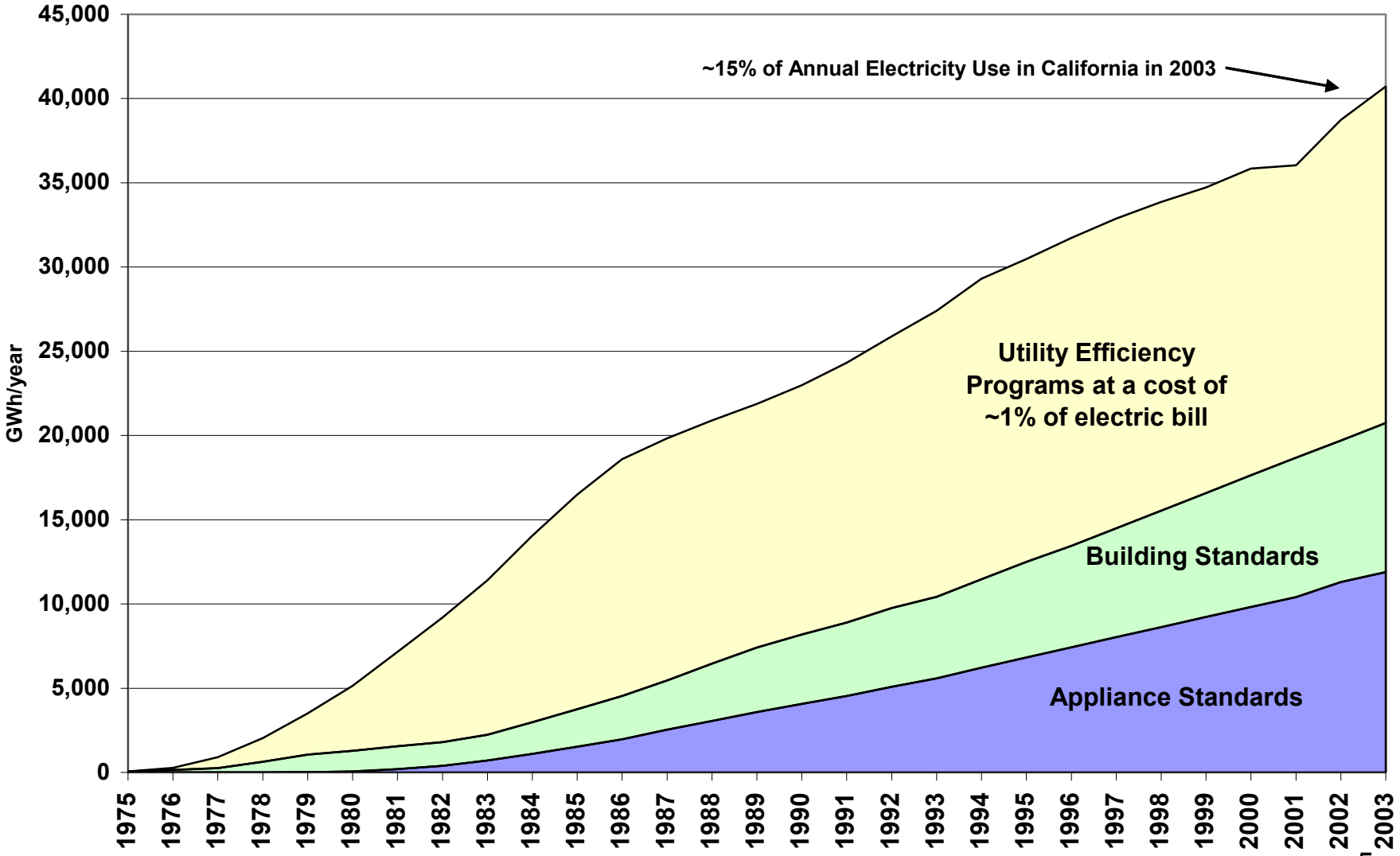

Per Capita Electricity Sales (not including self-generation)
(kWh/person) (2006 to 2008 are forecast data)
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
United States
California
2005 Differences
= 5,300kWh/yr
= $165/capita
Per Capita Income in Constant 2000 $
1975
2005
% change
US GDP/capita 16,241 31,442 94%
Cal GSP/capita 18,760 33,536 79%
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008

New United States Refrigerator Use v. Time and Retail Prices



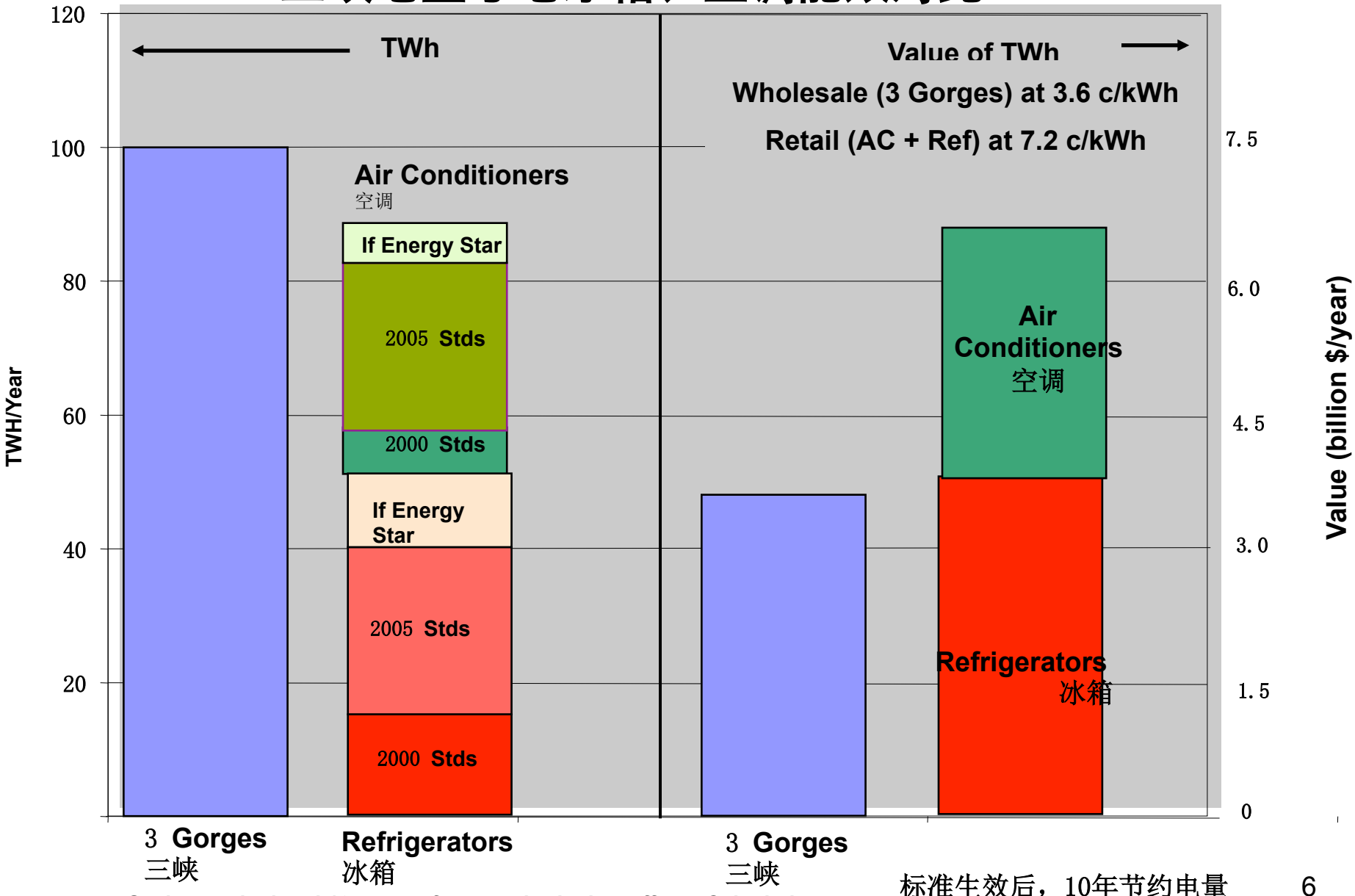
Source: David Goldstein, NRDC, SF

Annual Energy Savings from Efficiency Programs and Standards



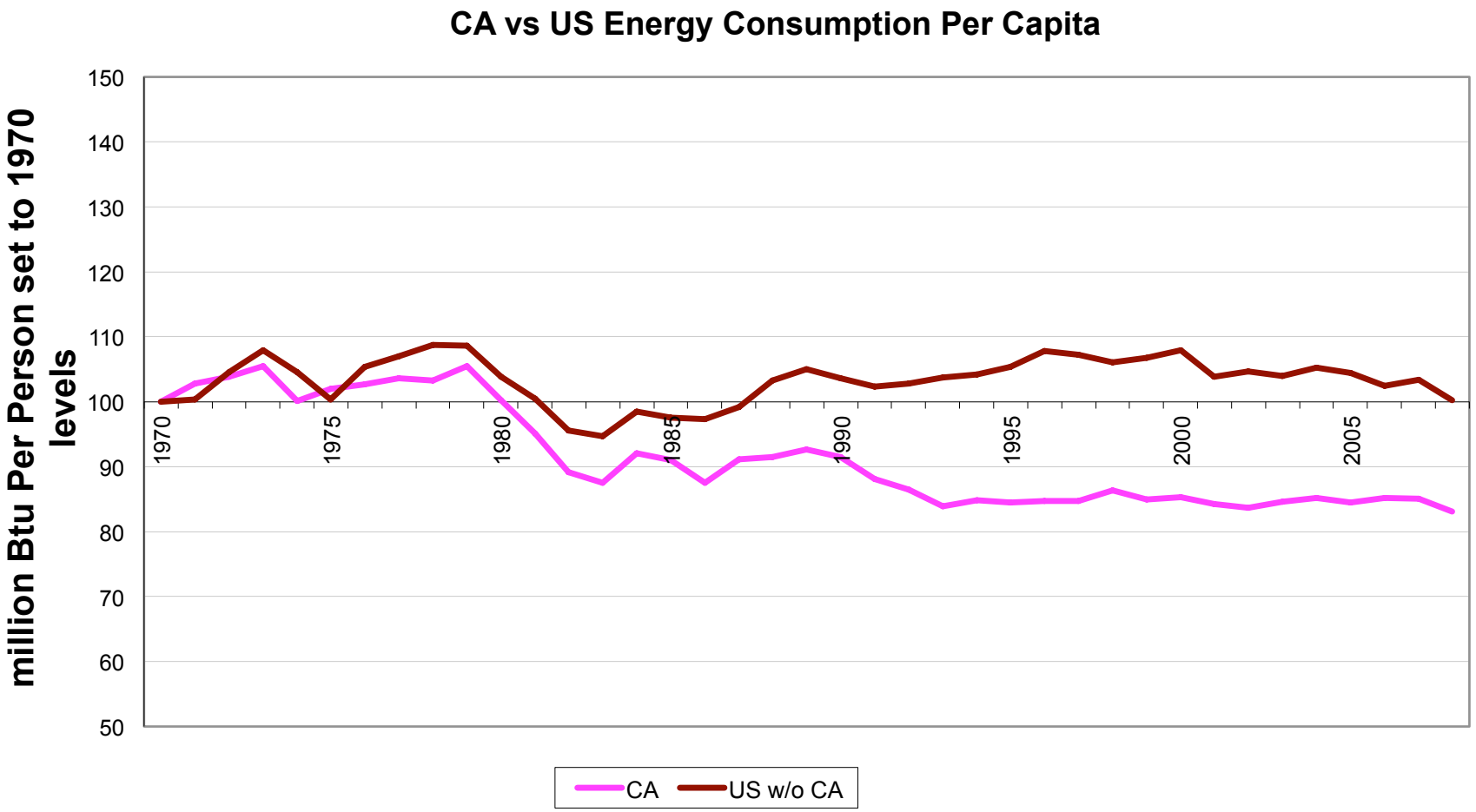
Comparison of 3 Gorges to Refrigerator and AC Efficiency Improvements

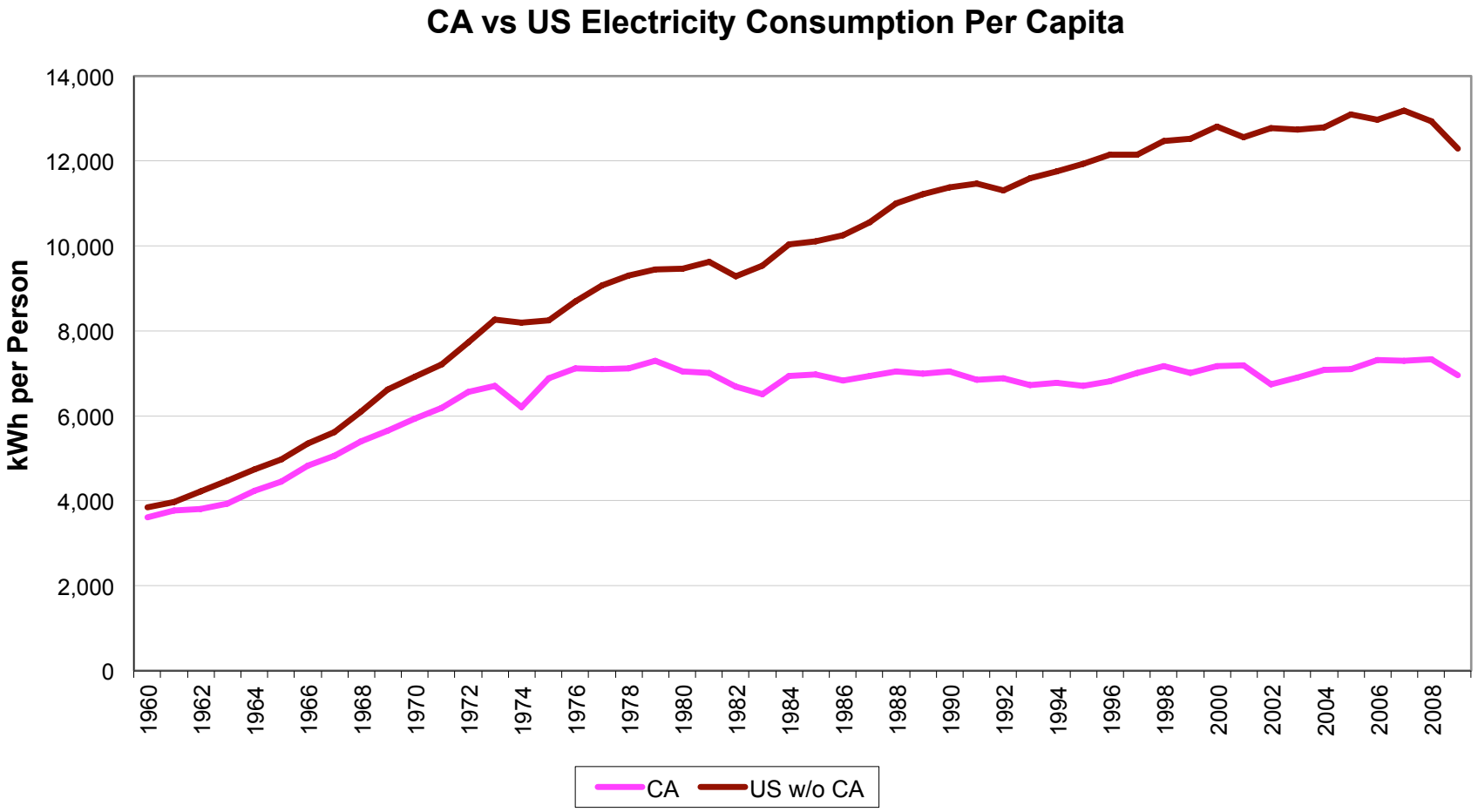
三峡电量与电冰箱、空调能效对比



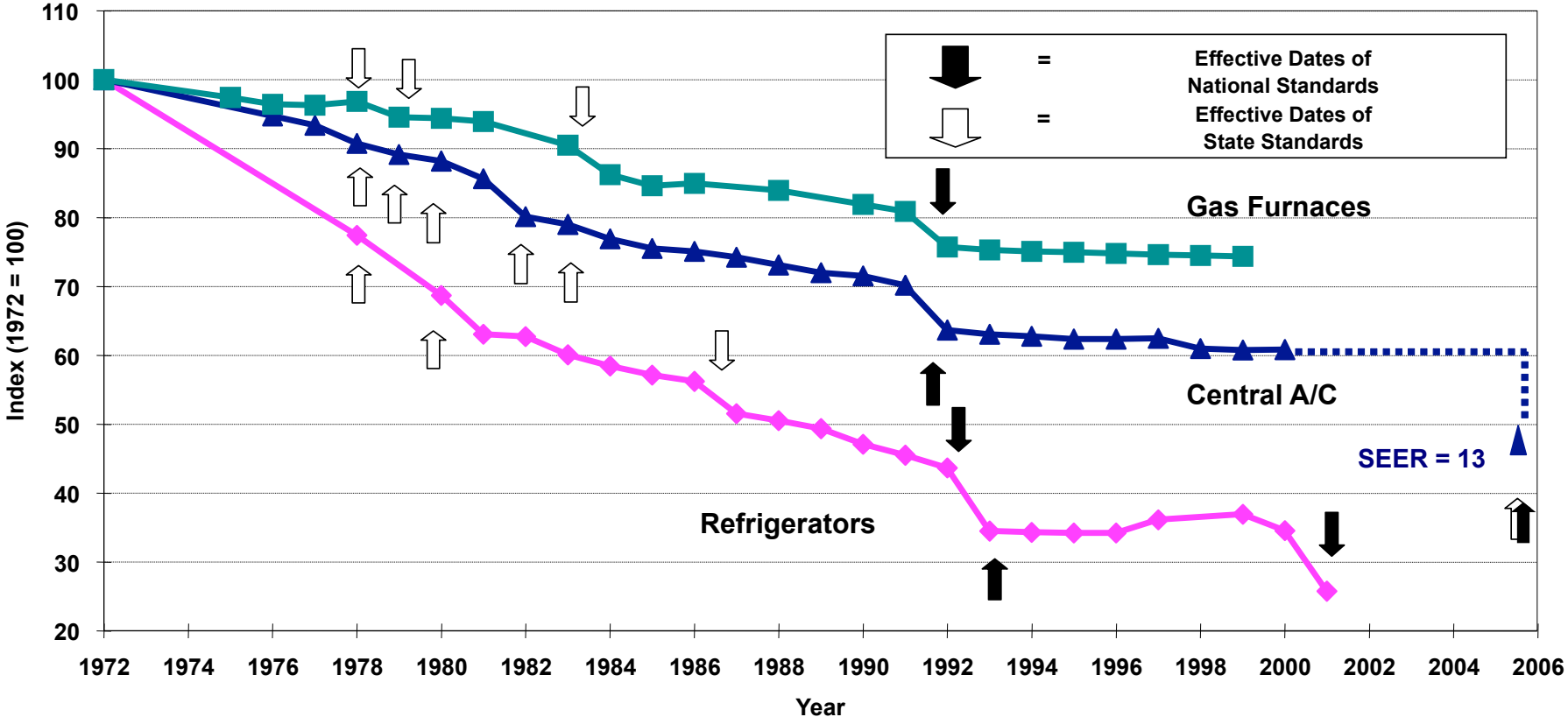
Savings calculated 10 years after standard takes effect. Calculations provided by David Fridley, LBNL

标准生效后，10年节约电量


CA vs US Energy Consumption Per Capita
million Btu Per Person set to 1970 levels
150
140
130
120
110
100
90
80
70
60
50
1970
1975
1980
1985
1990
1995
2000
2005
CA
US w/o CA


CA vs US Electricity Consumption Per Capita
kWh per Person
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
CA
US w/o CA

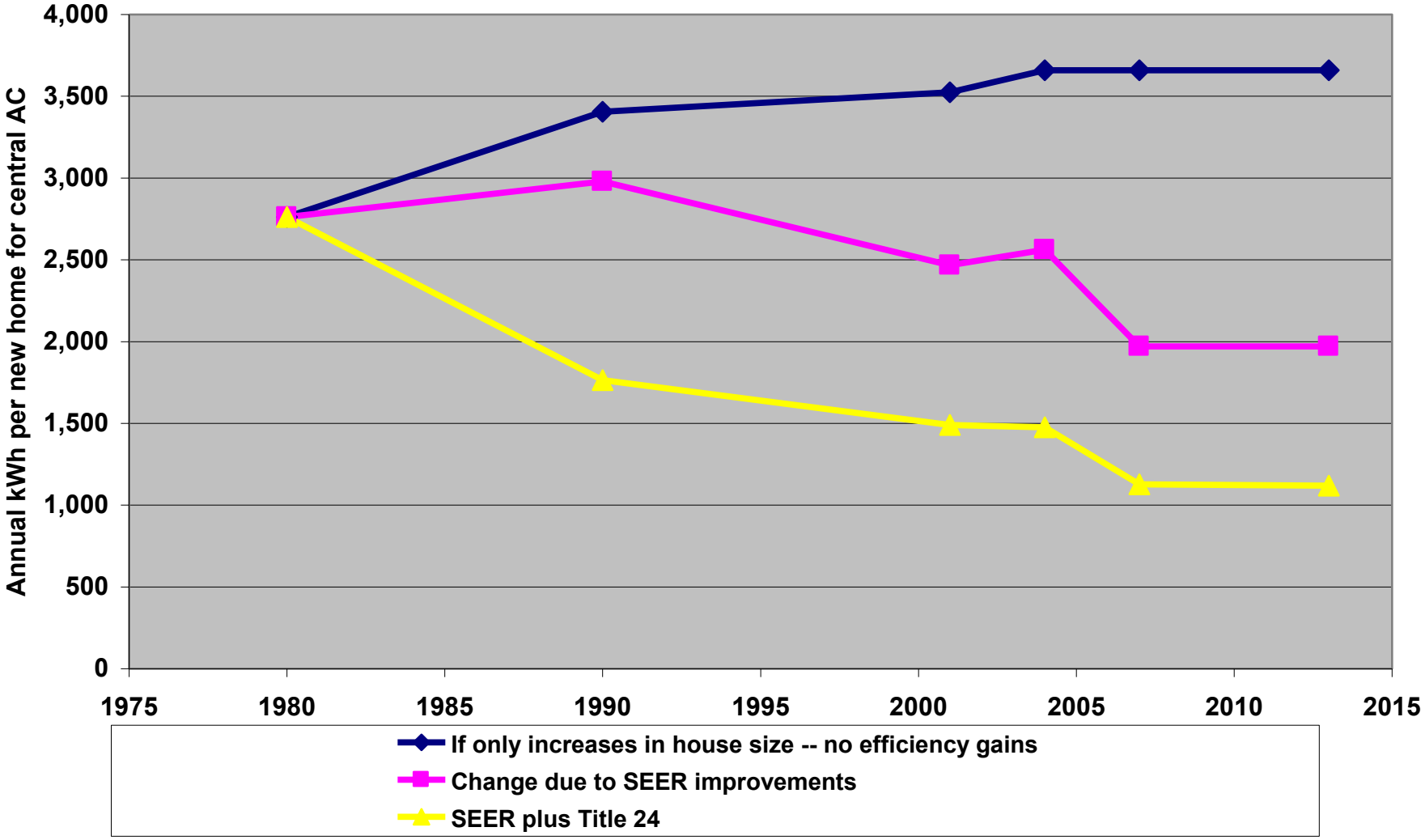
Impact of Standards on Efficiency of 3 Appliances



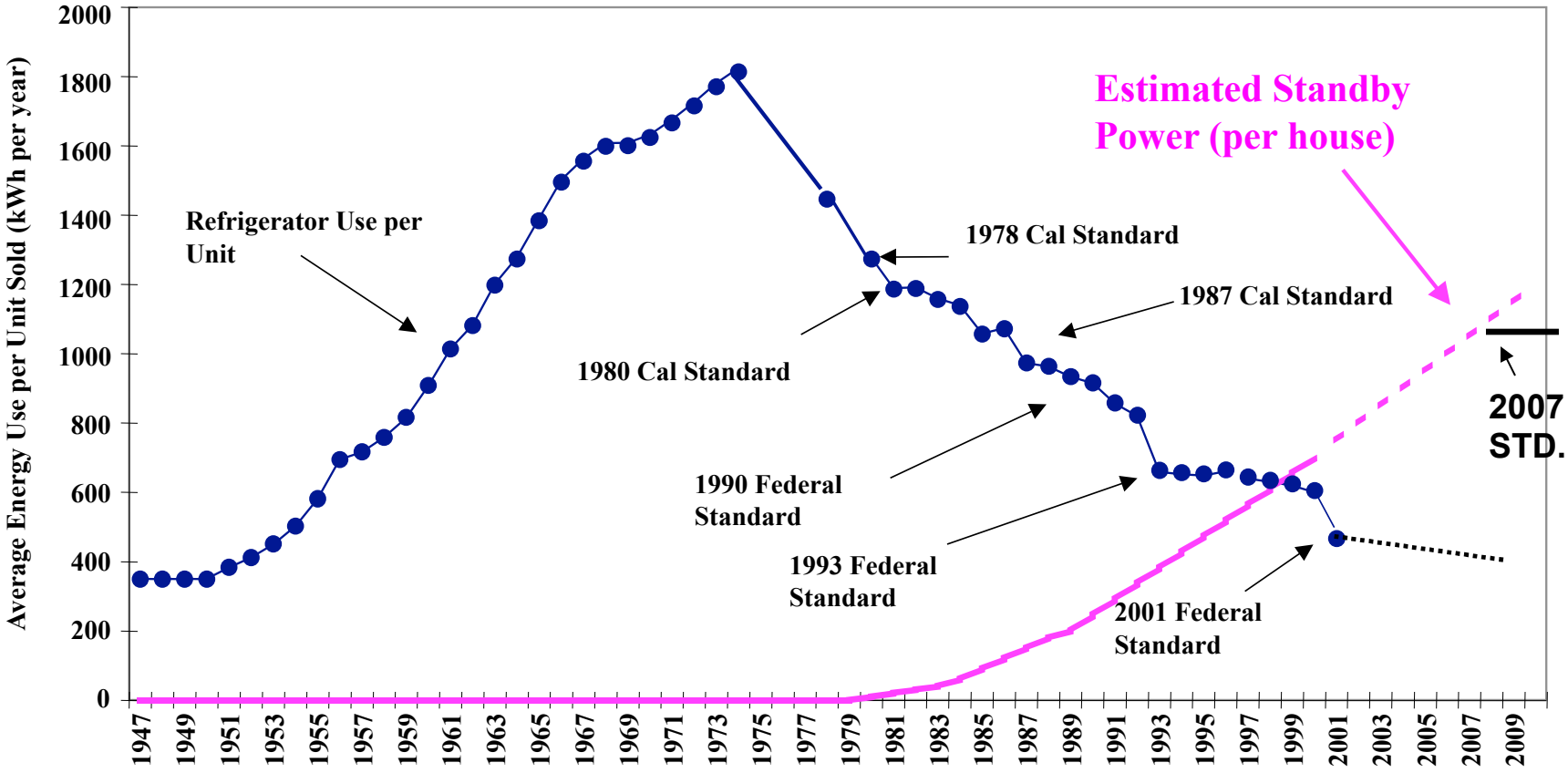
Source: S. Nadel, ACEEE,

in ECEEE 2003 Summer Study, www.eceee.org

Air Conditioning Energy Use in Single Family Homes in PG&E
The effect of AC Standards (SEER) and Title 24 standards

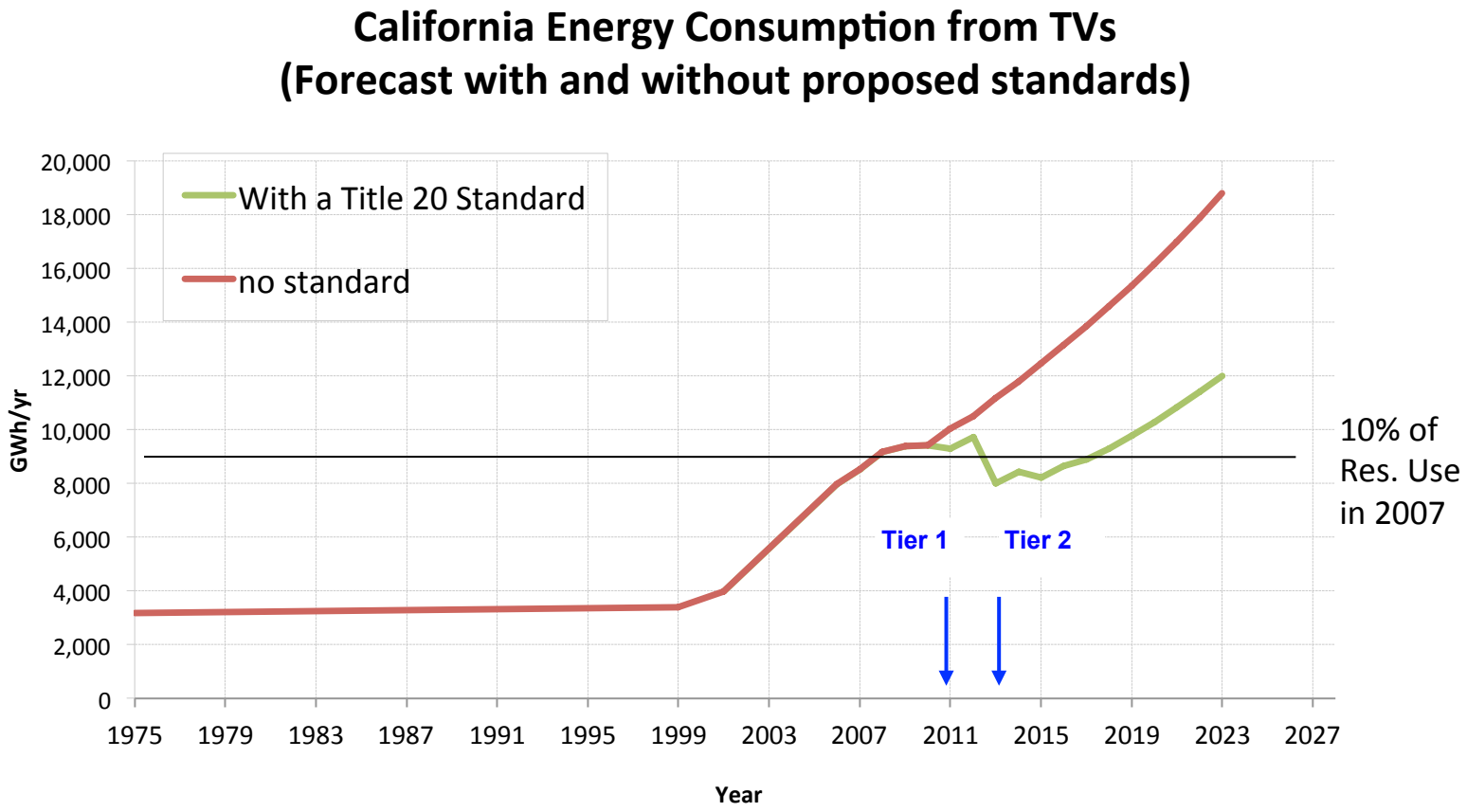


United States Refrigerator Use, repeated, to compare with Estimated Household Standby Use v. Time

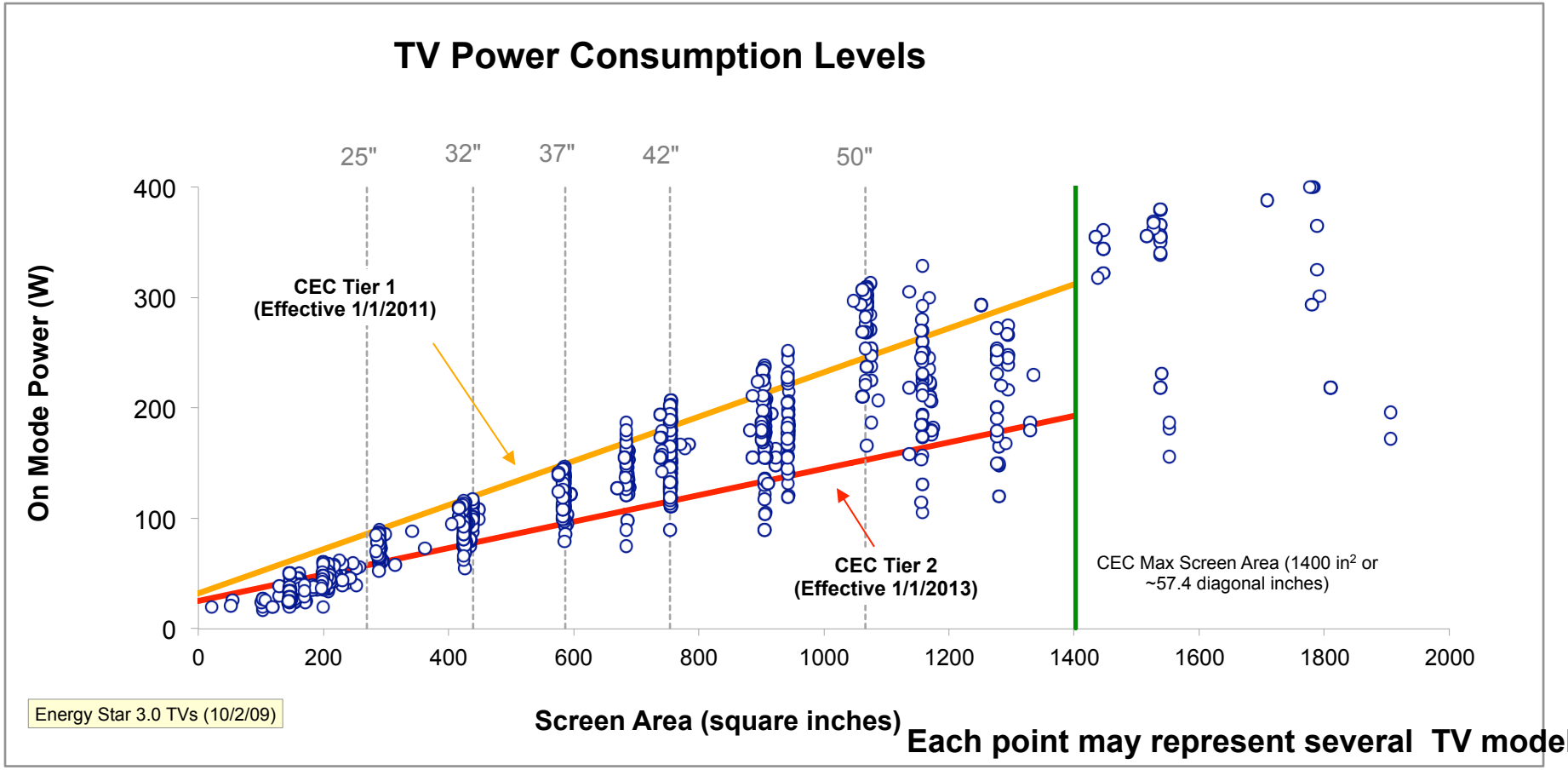


Televisions Represent Significant Energy Use

The residential energy consumption due to televisions rapidly increased from 3-4% in 1990s to 8-10% in 2008. Television energy will grow up to 18% by 2023 without regulations. The projected growth does not include the residential energy use by cable boxes, DVD players, internet boxes, Blue Ray, game consoles etc.



Technically Feasible Standards



***Consumers can expect to save between $ 50 - $ 250 over the life of their TV**

***A 50 inch plasma can consume as little as 307 kWh/yr and as much as 903 kWh/yr**

General Purpose Lighting – Proposed Regulations (cont.)

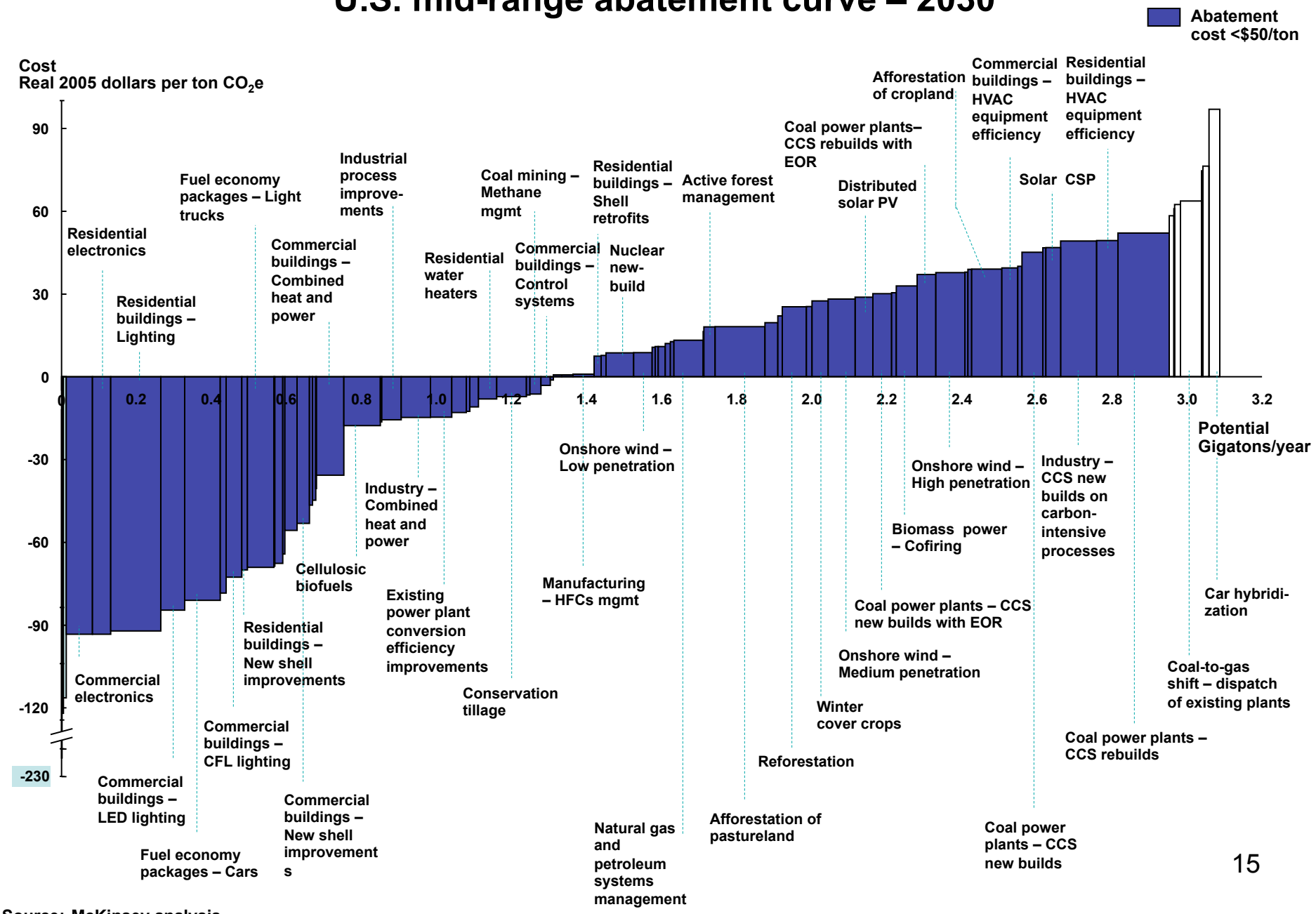
Proposed Table K-8: Standards for State-regulated General Services Incandescent Lamps -Tier I

Rated Lumens Range	Maximum rated Wattage	Minimum Rated Life Time	Proposed California Effective Date
1490-2600 Lumens	100→72 Watts	1,000 hours	Jan, 1, 2011
1050-1489Lumens	75→53 Watts	1,000 hours	Jan 1, 2012
750-1049 Lumens	60→43 Watts	1,000 hours	Jan 1, 2013
310-749 Lumens	40→29 Watts	1,000 hours	Jan 1, 2013

Proposed Table K-9: Standards for State-regulated General Services Lamps -Tier II

Lumens Range	Maximum Lamp Efficacy	Minimum Rated Life Time	Proposed California Effective Date
All	45 lumens per watt	1,000 hours	Jan, 1, 2018

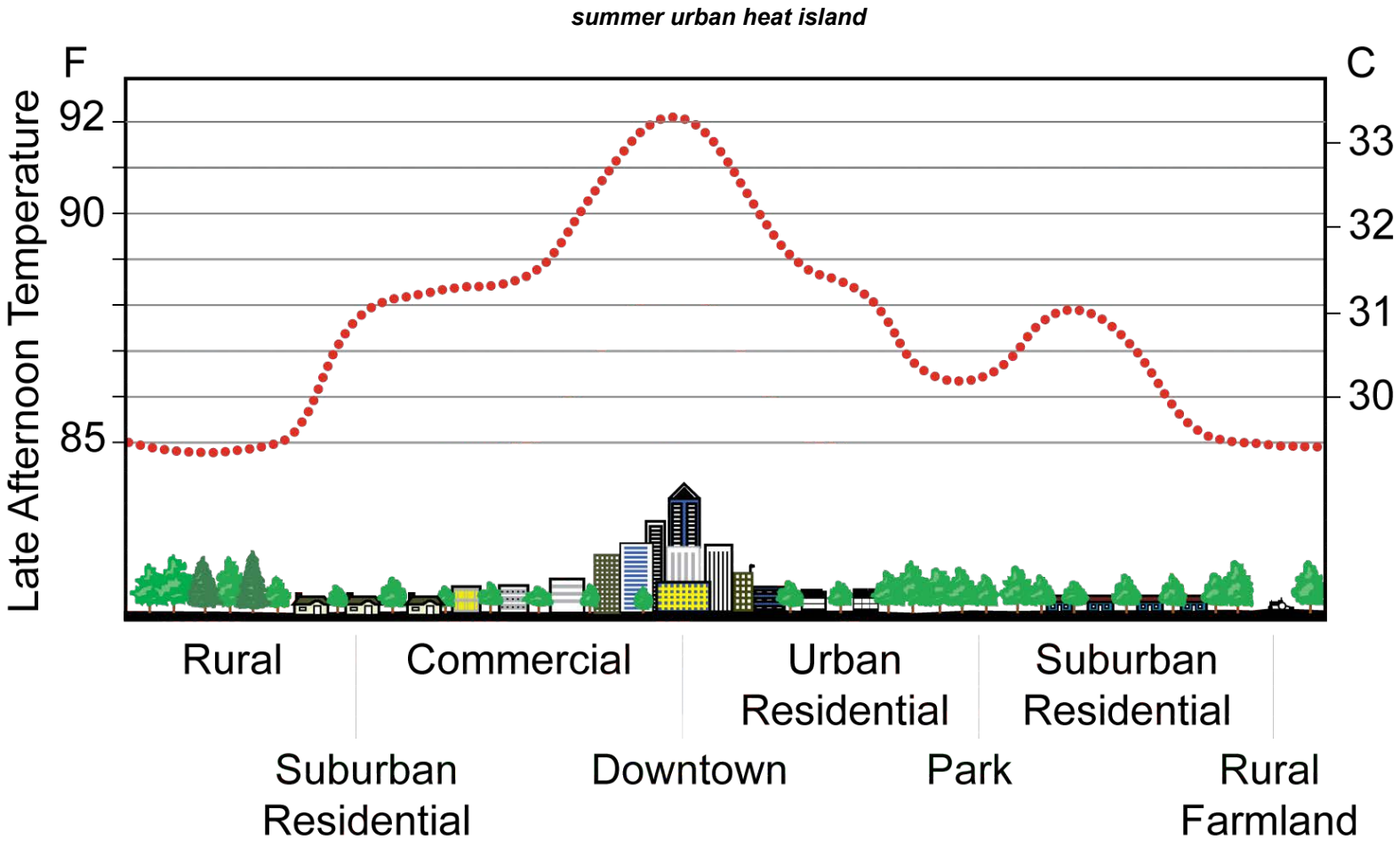
U.S. mid-range abatement curve – 2030



Source: McKinsey analysis

White roofs to cool your buildings, your cities, and (this is new) to cool the earth.

Summer in the city



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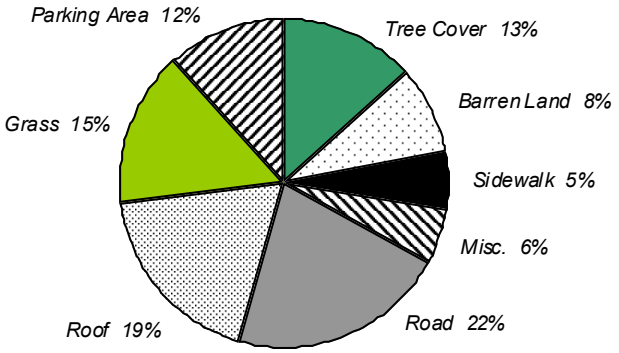
Bird's eye view of urban land use

18

~ 1 km^2

The surface of Sacramento, CA is about

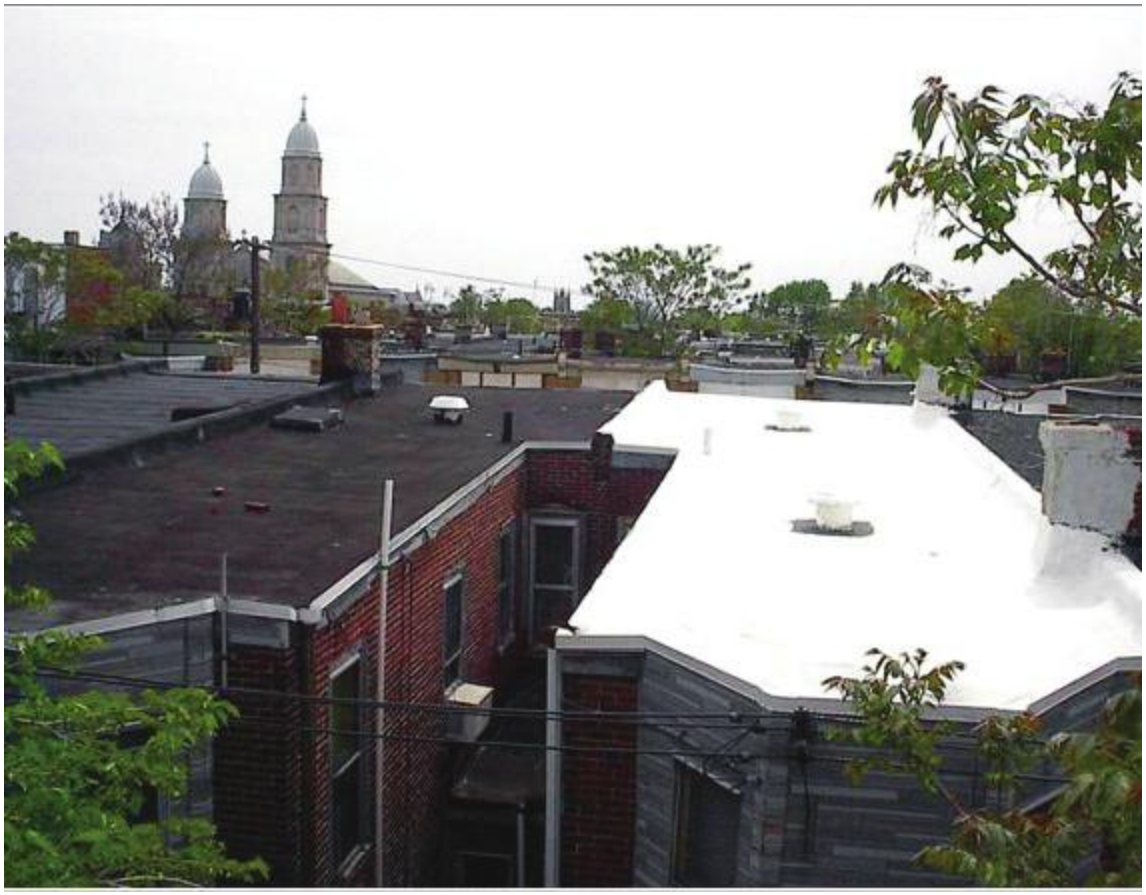
- **20% roofs**
- **30% vegetation**
- **40% pavement**



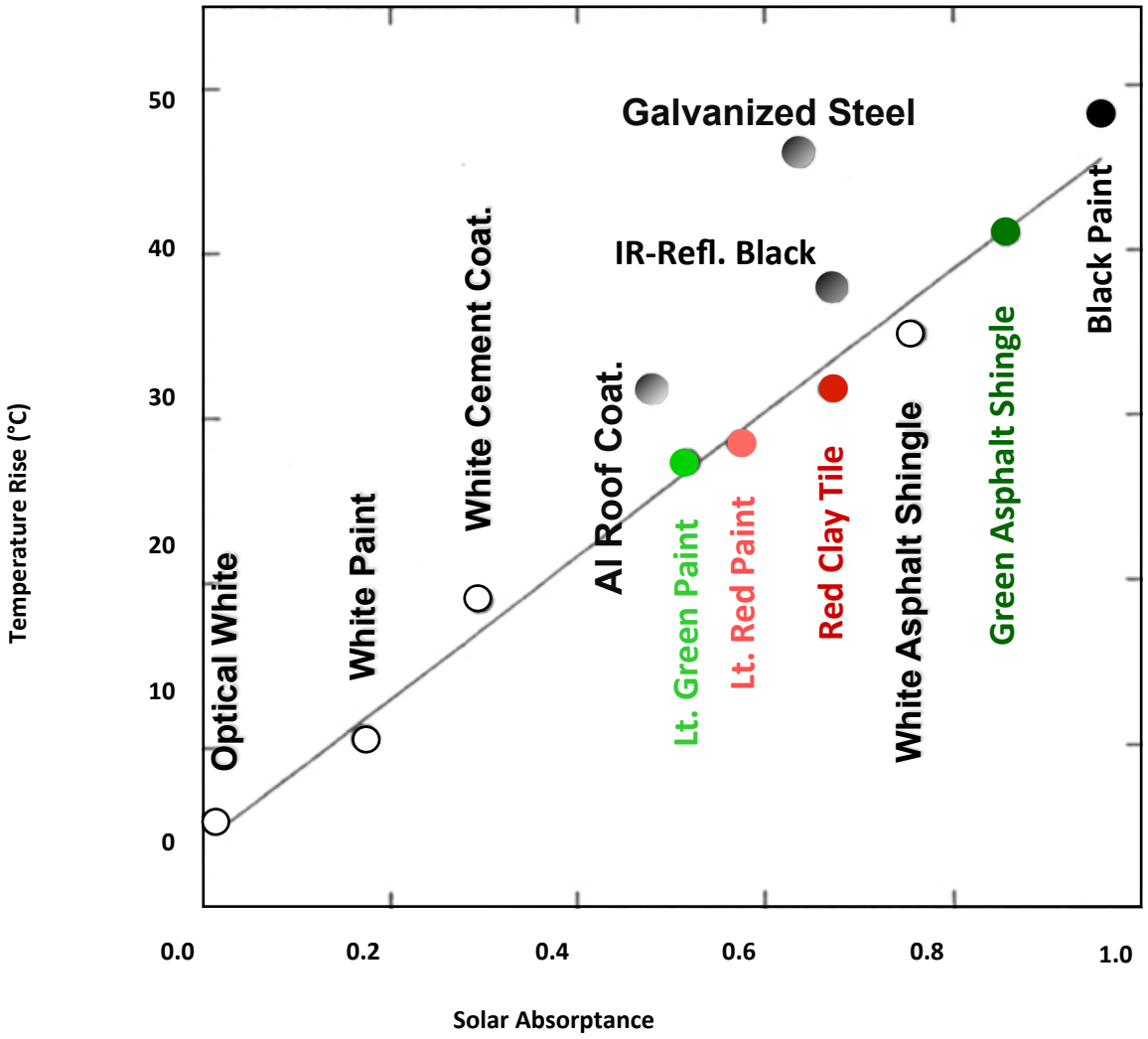
Area by Land-Cover Category Above the Canopy

Chicago Heat Wave 1995, 739 Deaths

Virtually all of the deaths occurred on the top floors of buildings with black roofs



Reflective roofs stay cooler in the sun



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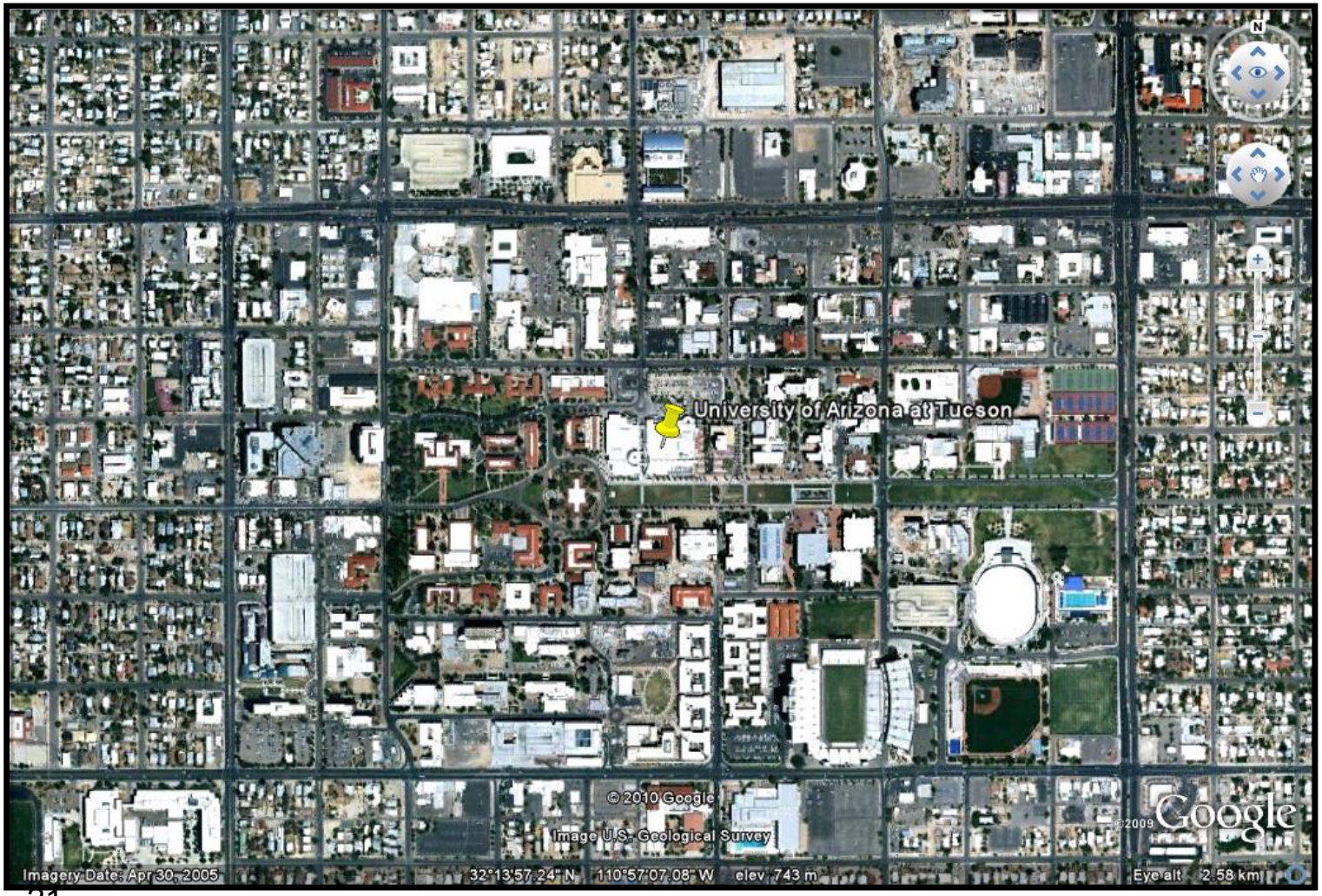
White roofs are popular in Tucson, AZ



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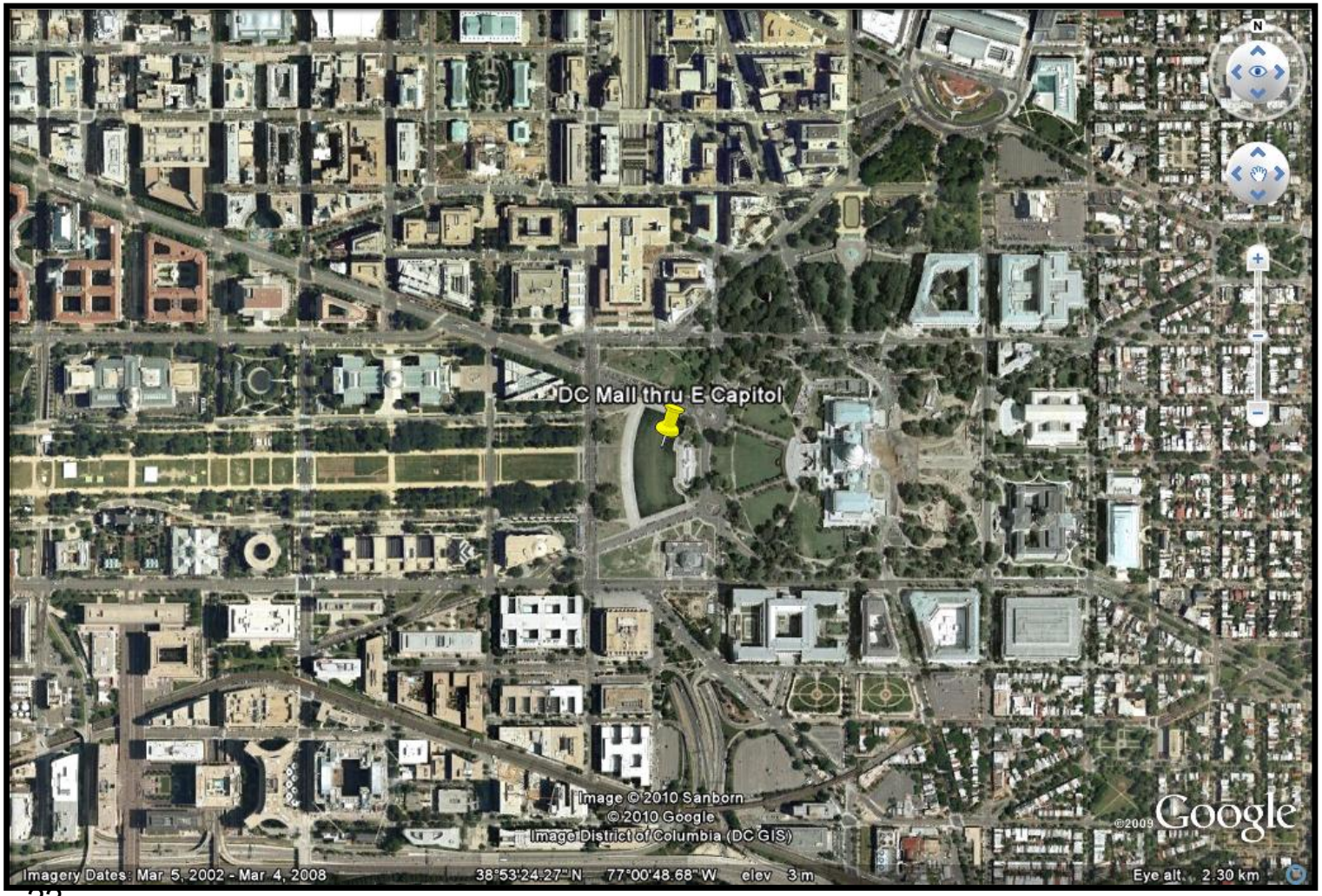
Washington, DC (Federal) has problems



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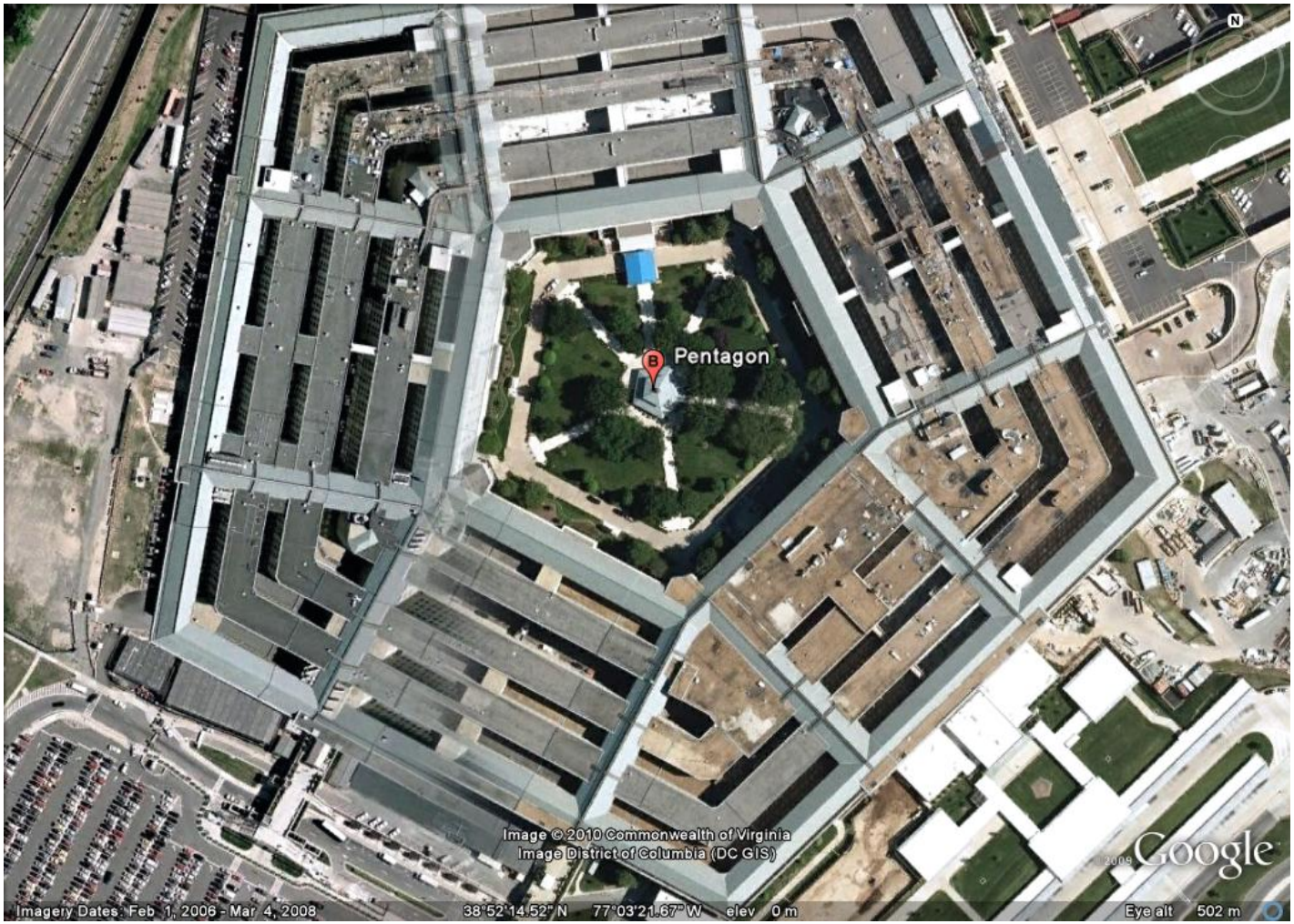
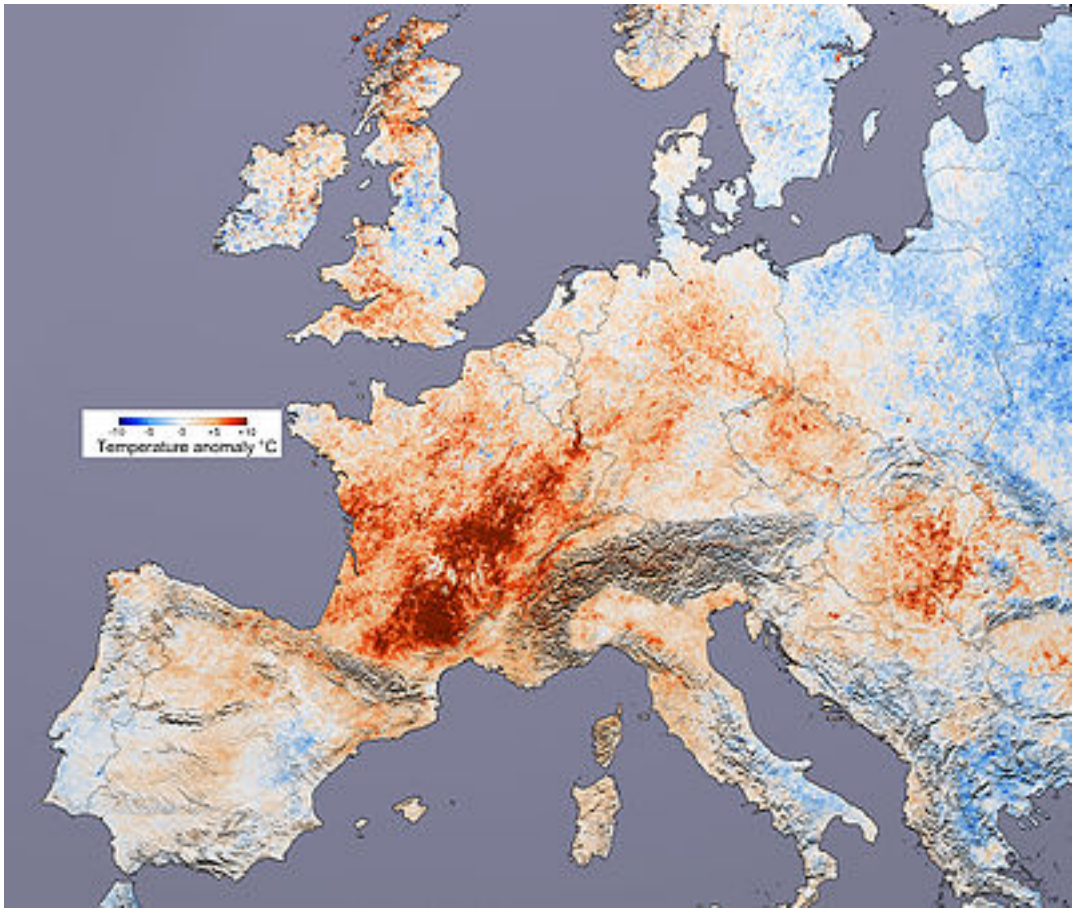
Pentagon


Pentagon
Image © 2010 Commonwealth of Virginia
Image District of Columbia (DC GIS)
Imagery Dates: Feb 1, 2006 - Mar 4, 2008
38°52'14.52" N 77°03'21.67" W elev 0 m
Eye alt 502 m
Google

Cooling our planet

European Heat Wave 2003, 30,000 Deaths
France July 2010, Few Deaths



White roofs, cool-colored roofs save money

OLD

flat, white

pitched, white

NEW

pitched, cool & colored

White roofs around the world

…in Santorini, Greece

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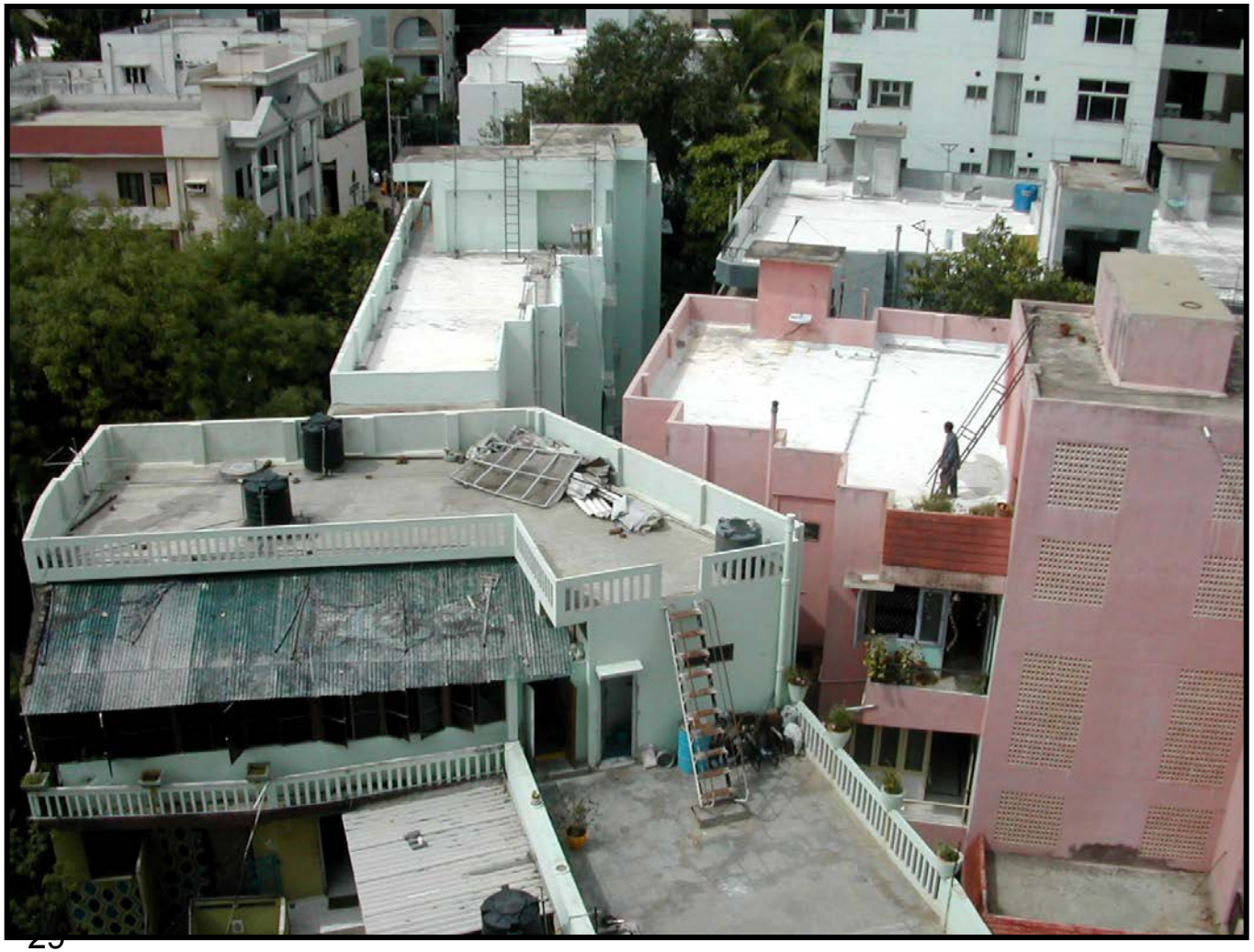
…in Hyderabad, India



…and widely in the state of Gujarat, India.

Walmart store in northern California

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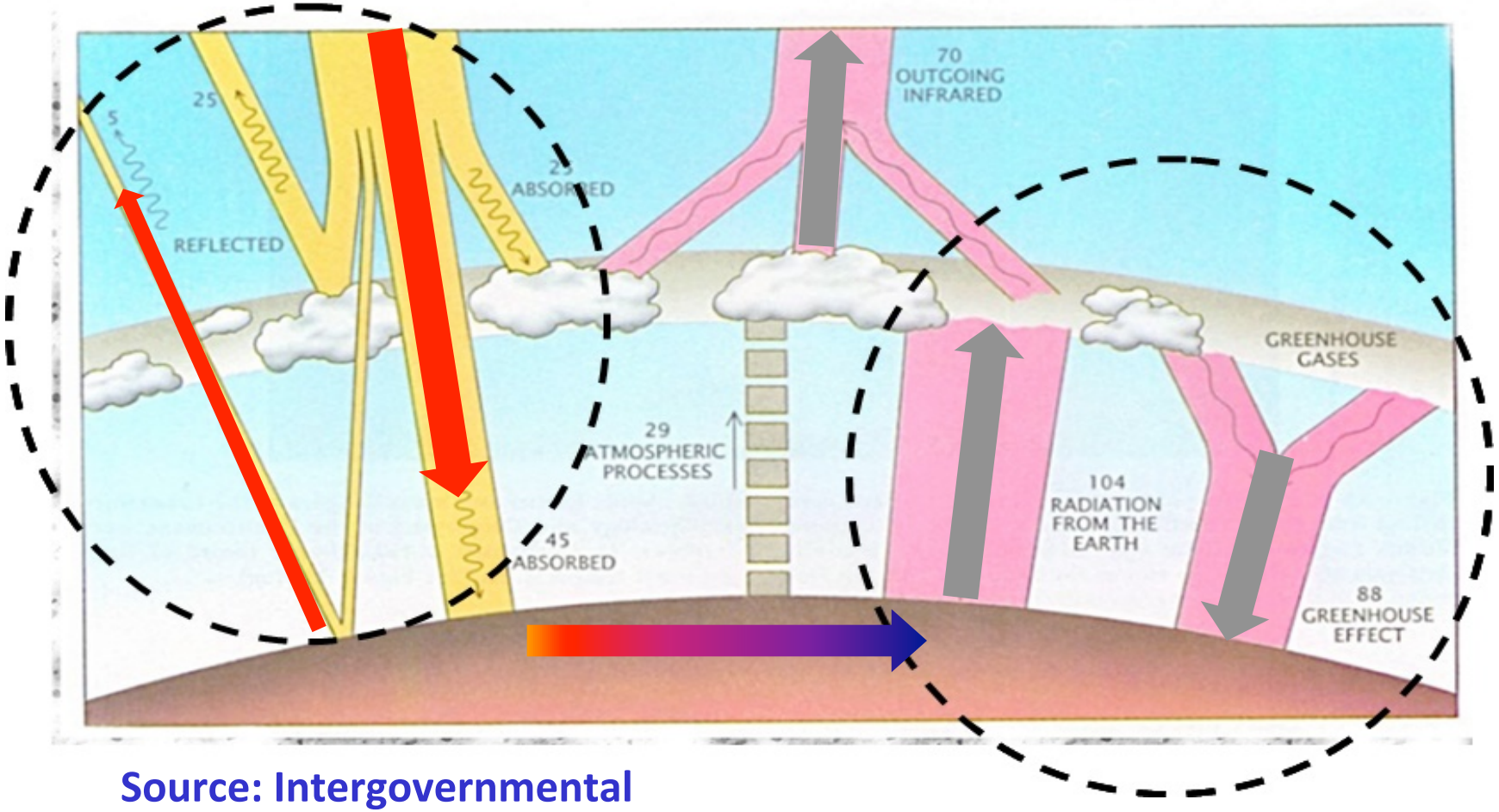
Congratulations to UC Davis

31

Solar-reflective surfaces cool the globe via “negative radiative forcing”



Source: Intergovernmental Panel on Climate Change (IPCC)

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GLOBAL COOLING: making 100 m^2 (1000 ft^2) of gray roofing white offsets the **emission** of 10 t of CO_2

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How much CO_2 equivalent is offset if we whiten all eligible urban flat roofs world-wide? (i/ii)

- Answer: **24 Gigatonnes (Gt)**
  - 2/3 of a year's worldwide emission
  - Gigatonne = billion metric tons

- If implemented over 20 years (the life of a roof or a program) this is ≈ 1.2 Gt/year.

How much CO_2 equivalent is offset if we whiten all eligible urban flat roofs world-wide? (ii/ii)

- Offset is equivalent to **taking 300 million cars off the road for 20 years**.
  - There are about 600 million passenger cars world wide, and they each emit ≈ 4 t CO_2/ year.

LAWRENCE BERKELEY NATIONAL LABORATORY PRESENTS:
SCIENCE AT THE THEATER

COOL CITIES, COOL PLANET

What to do now

Progress in energy efficiency standards

- In 2005, California's "Title 24" energy efficiency standards prescribed white surfaces for low-sloped roofs on commercial buildings. Several hot states are following.
- In 2008, California prescribed "cool colored" surfaces for steep residential roofs in its 5 hottest climate zones.
- **Other U.S. states & all countries with hot summers should follow.**

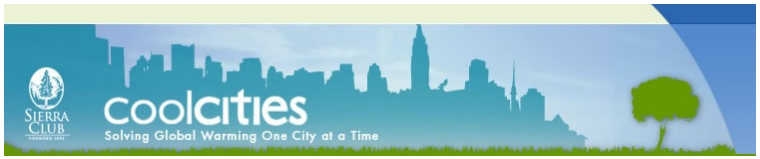
Recent cool roof progress (2005 – 2011)

- 2005
  - California Title 24 – “Flat roofs shall be white” (15 out of 16 climate zones). Walmart adopts white roofs for ALL stores.
  - EPA ENERGY STAR lists Cool Roof Materials
- 2010
  - June 1st, 2010 – Memo from U.S. Energy Secretary Steven Chu calls for all DOE Buildings to have white roofs, if cost-effective
  - June 16th, 2010 – Marine Corp follows suit, Pentagon following slowly
  - June 19th, 2010 – *RetroFIT Philly* announces winner of “coolest block” contest to white-coat black roofs of row houses.
- 2011
  - 100 Cool Cities launched – see www.WhiteRoofsAlliance.org
  - Spring 2011 – US will launch, at G20 Energy Ministers meeting, a voluntary Cool Roofs initiative and may even offer technical assistance to developing countries who join early.

To come 2012…

- Model codes will be modified to prescribe “flat roofs shall be white”
  - ASHRAE for commercial buildings
  - EECC for residential buildings
- But states and cities have to adopt model codes

Global Cool Cities Alliance could unite many initiatives and trade associations



American Council for an Energy-Efficient Economy

THE CLIMATE GROUP

Resources on the web

- **Art Rosenfeld's website**
  - ArtRosenfeld.org
- **Cool Colors Project**
  - CoolColors.LBL.gov
- **Heat Island Group**
  - HeatIsland.LBL.gov
- **Cool Communities Project**
  - CoolCommunities.LBL.gov
- **Roof Savings Calculator**
  - RoofCalc.com
- **Global Cool Cities Alliance**
  - GlobalCoolCitiesAlliance.org
- **Cool Roof Rating Council**
  - CoolRoofs.org
- **Cool California**
  - CoolCalifornia.org
- **EPA Heat Islands**
  - epa.gov/heatisland
- **Energy Star Cool Roofs**
  - EnergyStar.gov