Ten Years at the Calif. Energy Commission
&
White Roofs to Cool your Building, your City and (this is new !) Cool the World
Haas Executive Education Program Berkeley, CA. April 6, 2011

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California Energy Commission.

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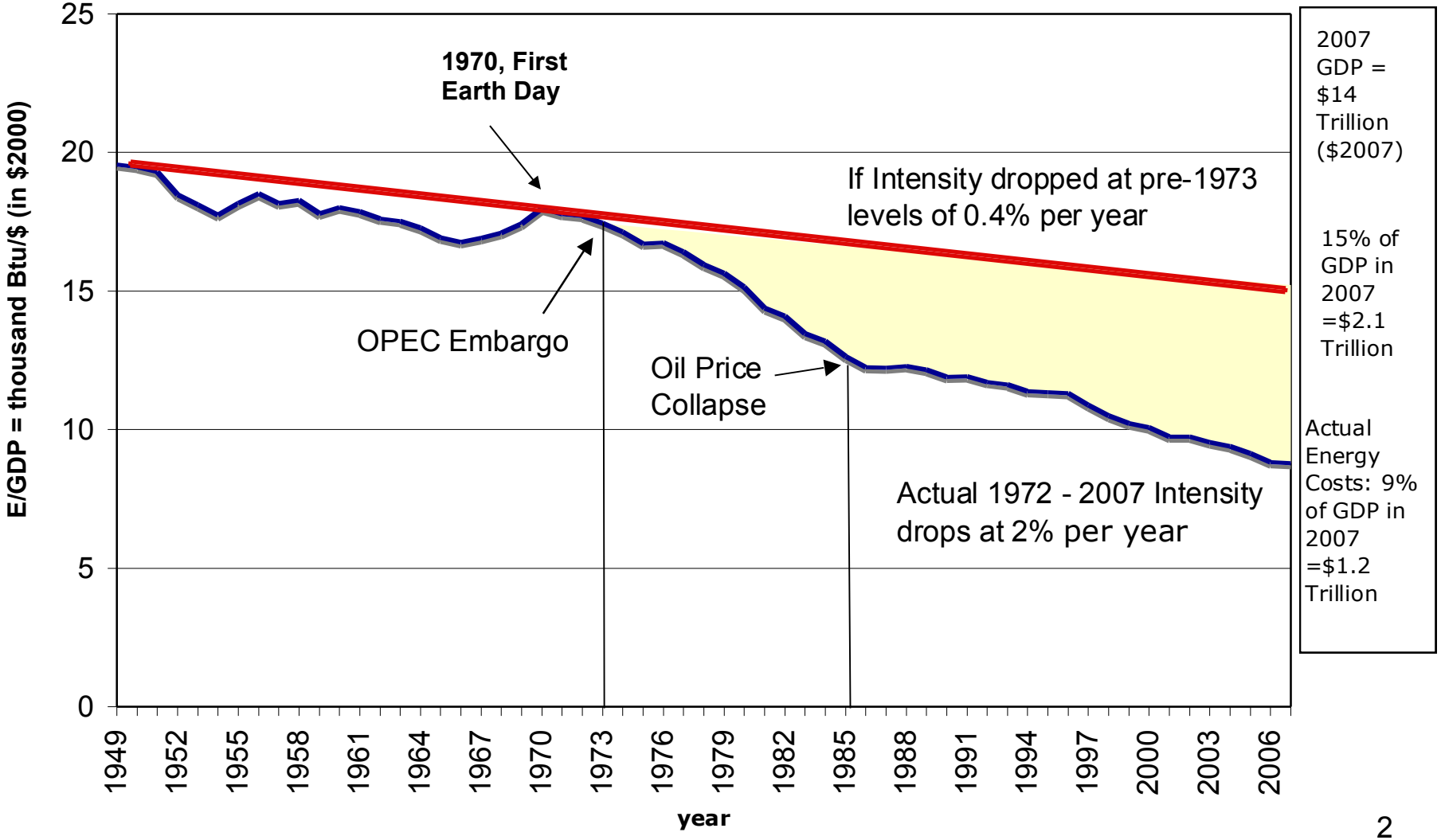
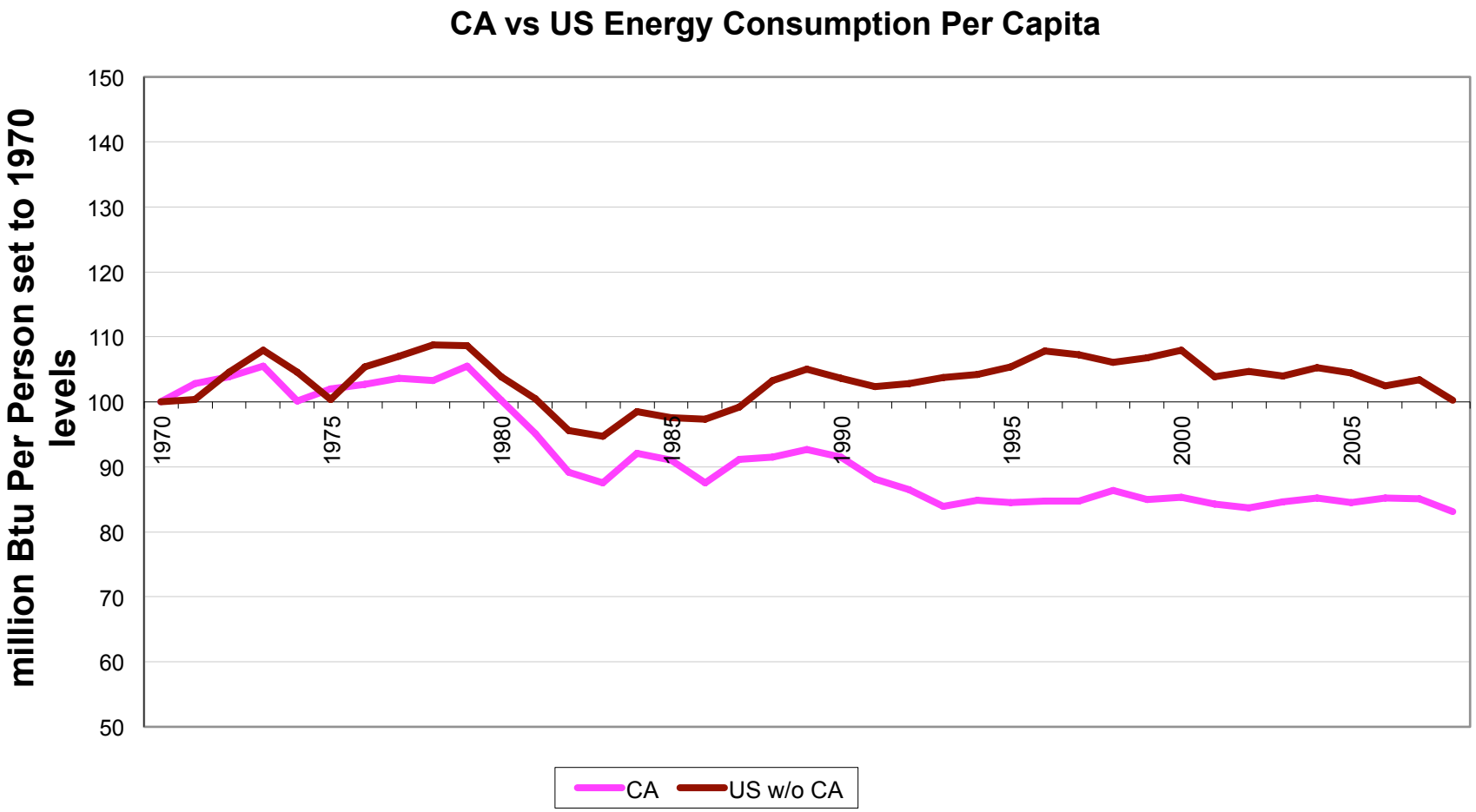
Presentation available at www.ArtRosenfeld.org

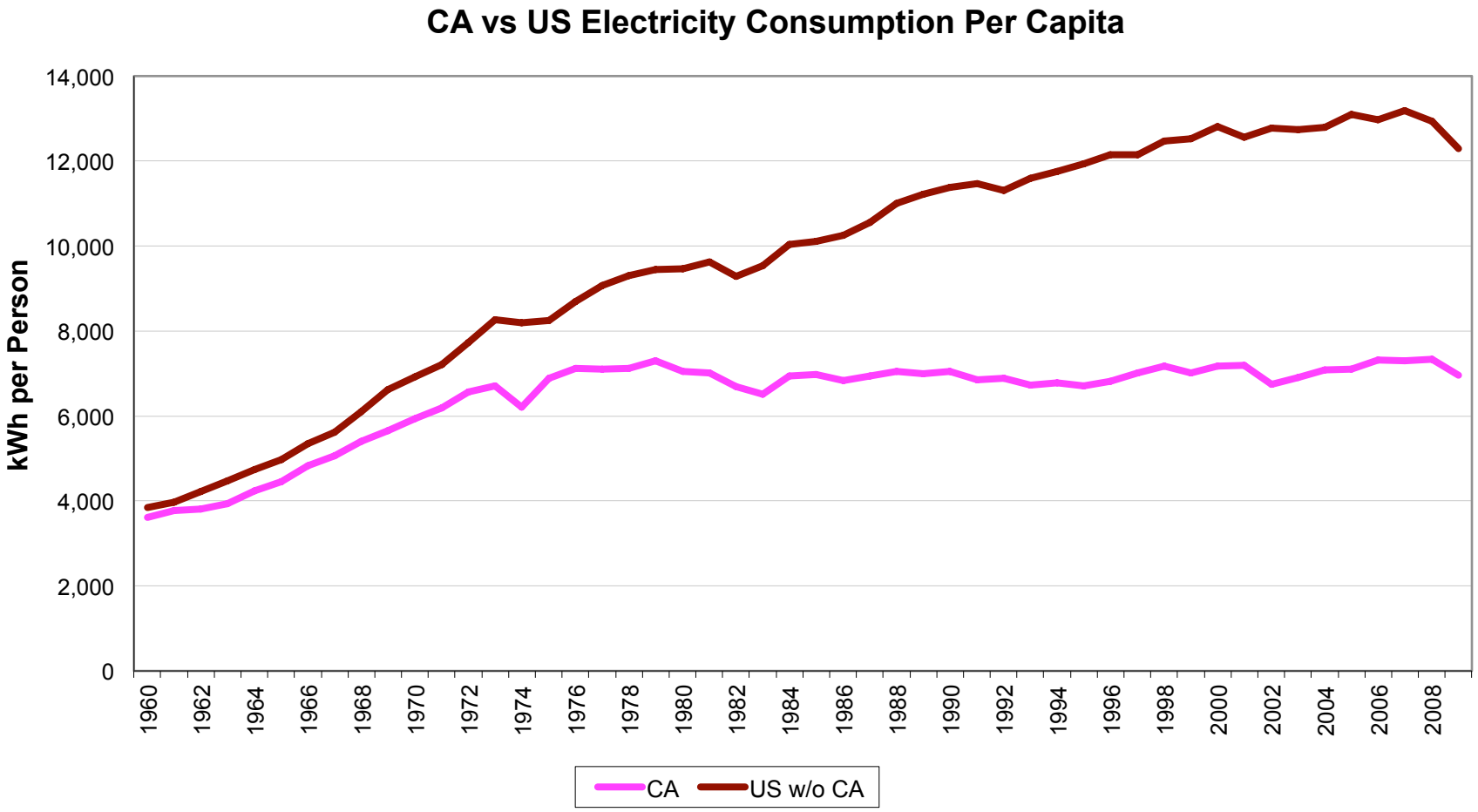
File Name Haas ExecEduc 4-6-11

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

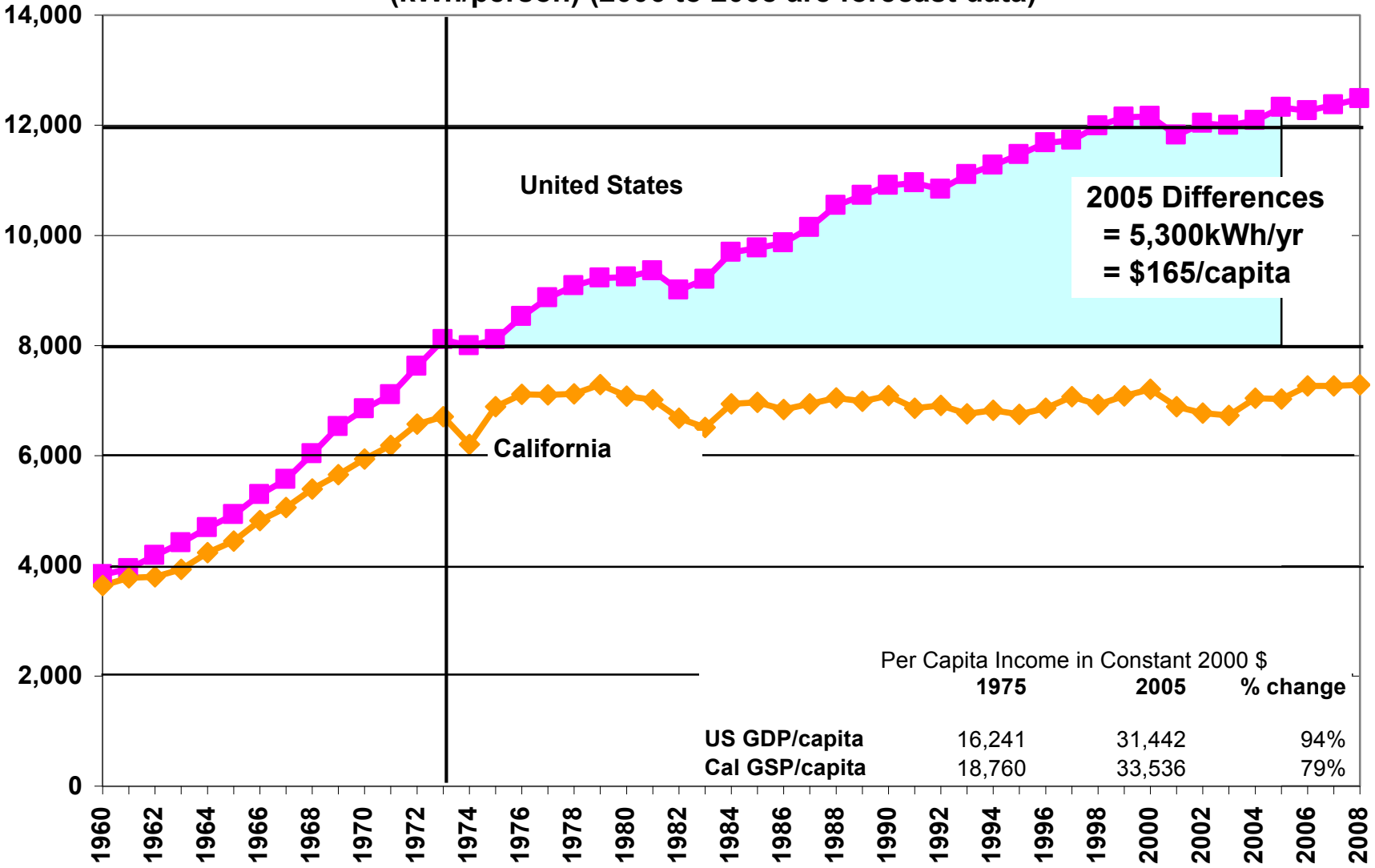


ArtRosenfeld@gmail.com or PatMcAuliffe@sbcglobal.net


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

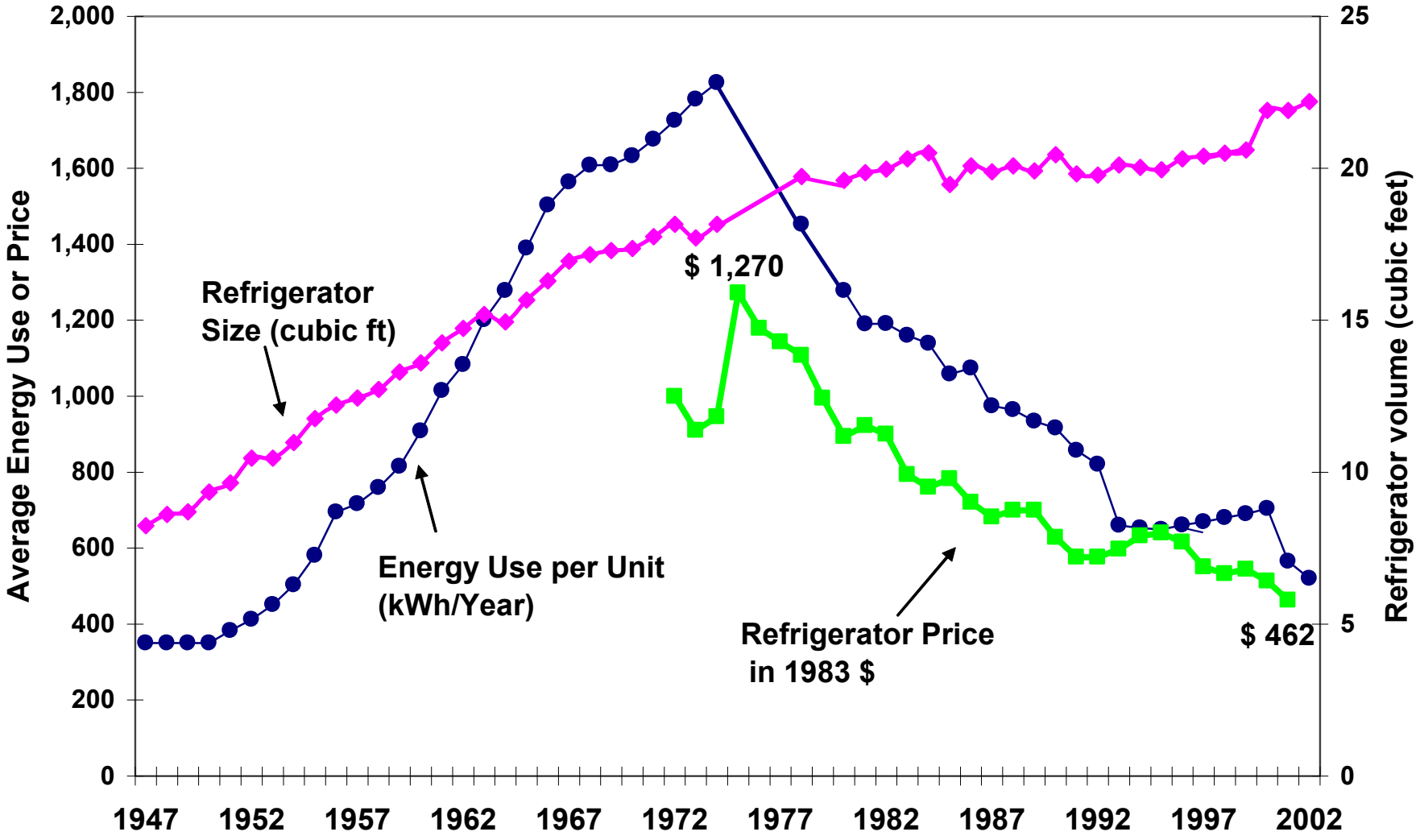
Per Capita Electricity Sales (not including self-generation) (kWh/person) (2006 to 2008 are forecast data)



Per Capita Income in Constant 2000 $

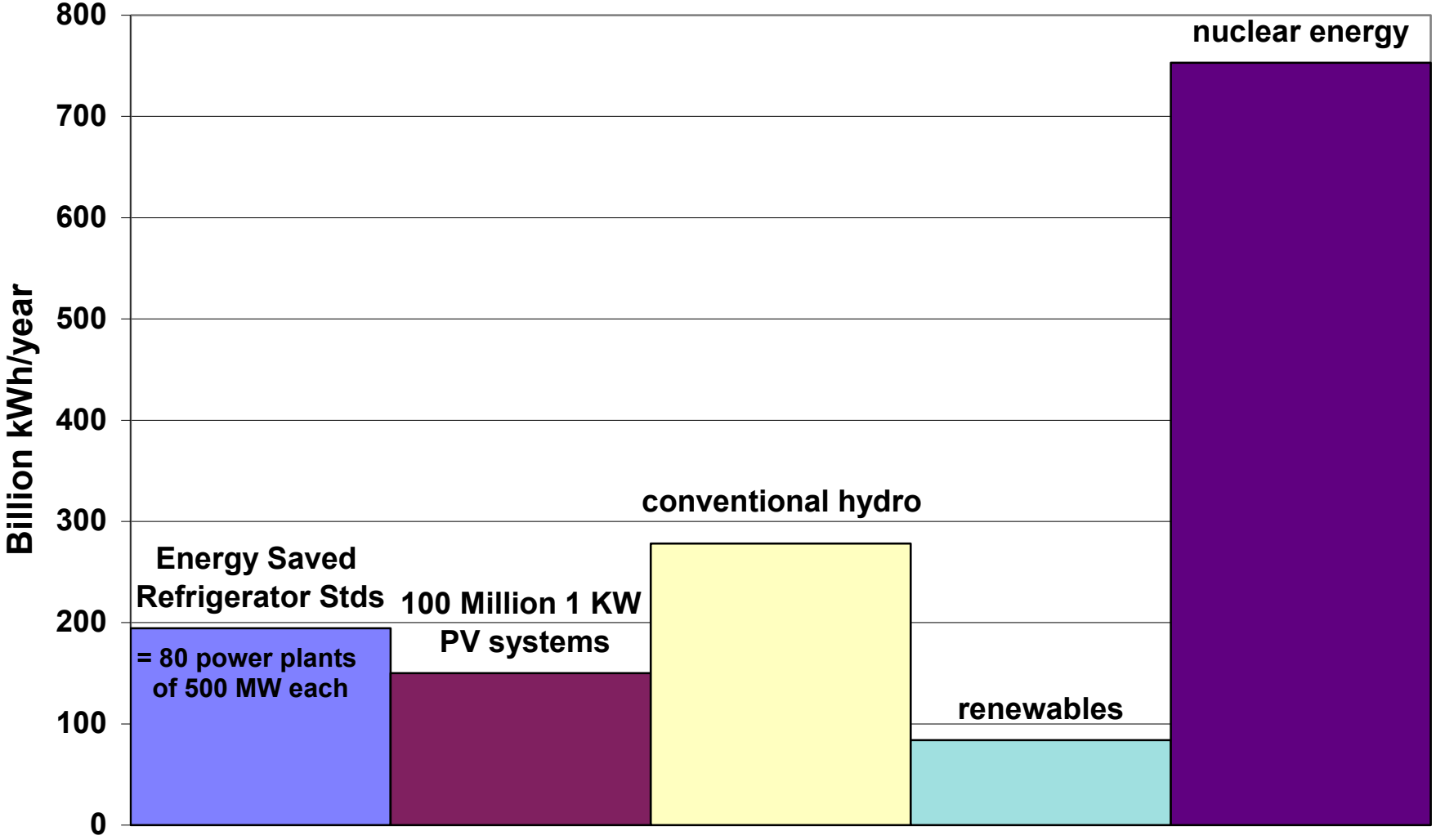
	1975	2005	% change
US GDP/capita	16,241	31,442	94%
Cal GSP/capita	18,760	33,536	79%

New United States Refrigerator Use v. Time and Retail Prices



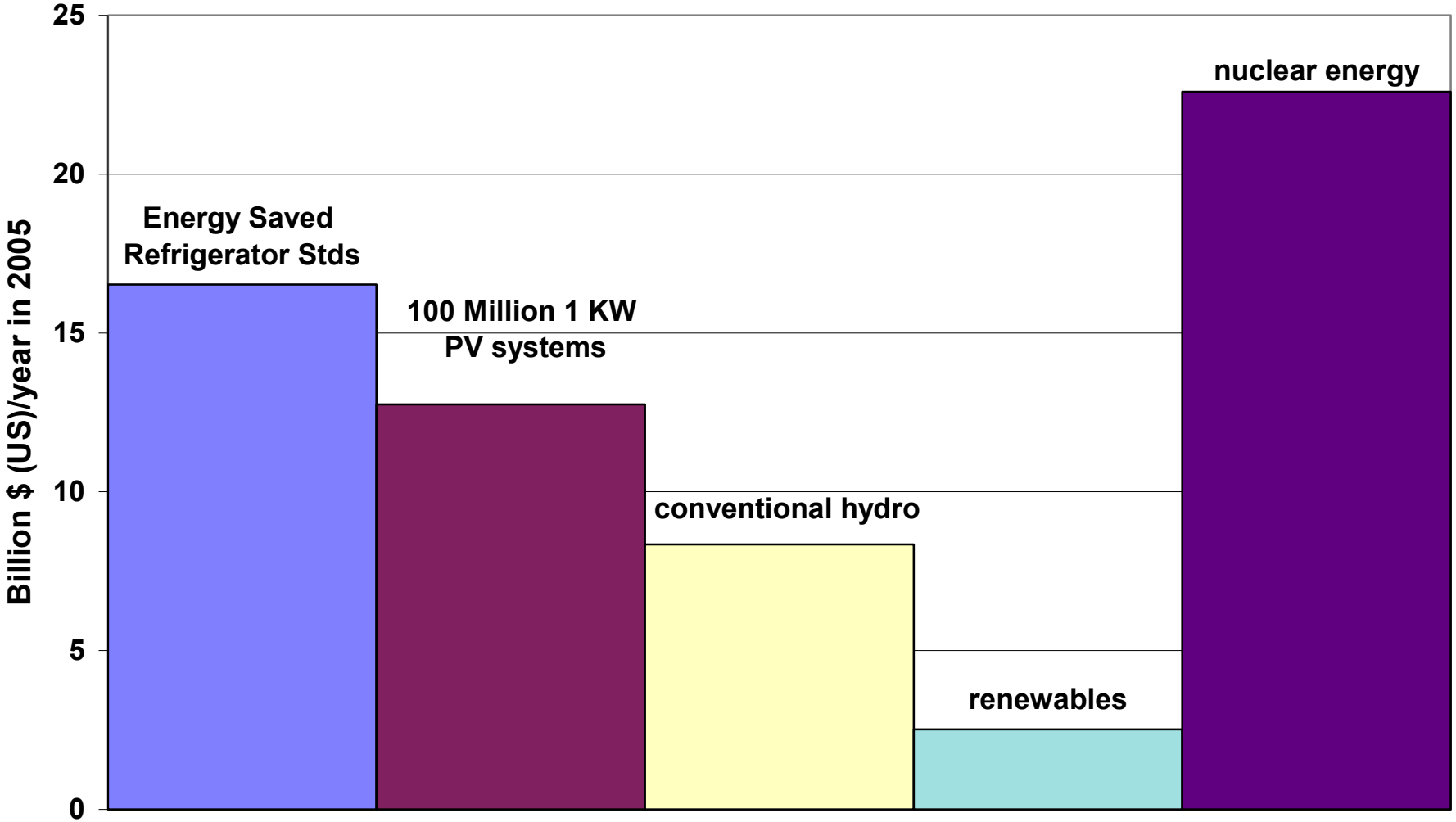
Source: David Goldstein, NRDC, SF

Annual Energy Saved vs. Several Sources of Supply In the United States

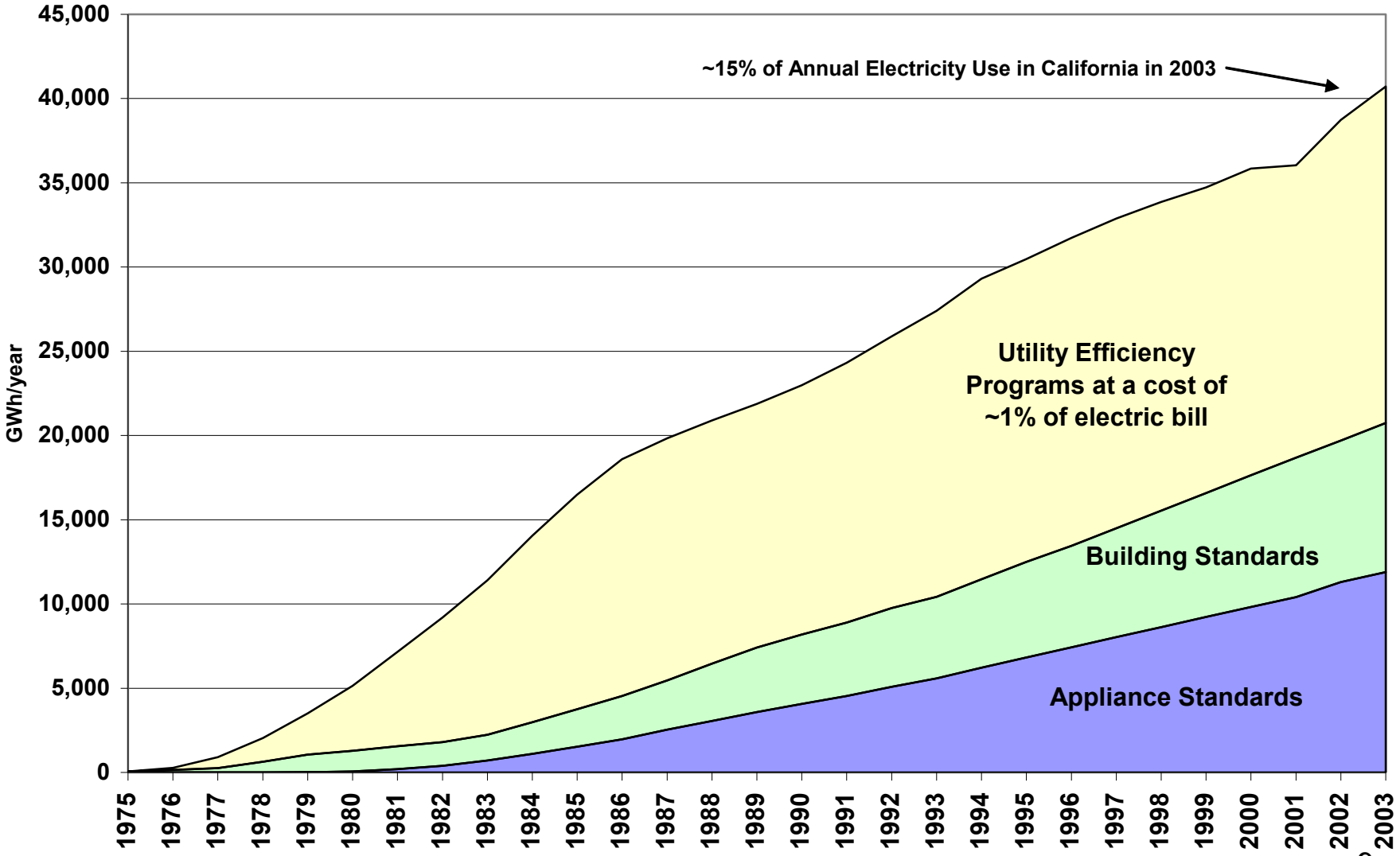


In the United States

Value of Energy to be Saved (at 8.5 cents/kWh, retail price) vs. Several Sources of Supply in 2005 (at 3 cents/kWh, wholesale price)

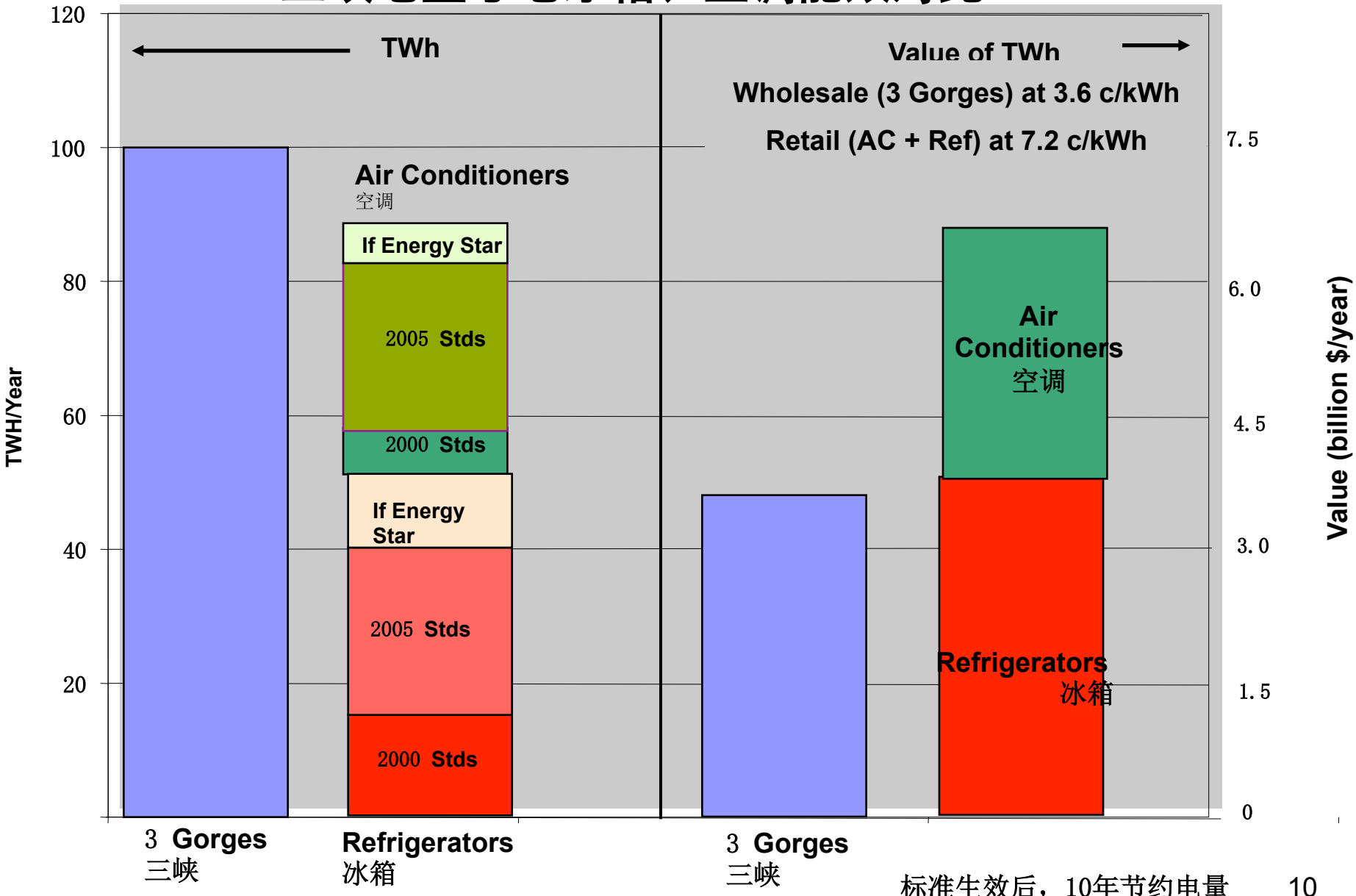


Annual Energy Savings from Efficiency Programs and Standards



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

Two Energy Agencies in California

- The California Public Utilities Commission (CPUC) was formed in 1890 to regulate natural monopolies, like railroads, and later electric and gas utilities.
- The California Energy Commission (CEC) was formed in 1974 to regulate the environmental side of energy production and use.
- Now the two agencies work very closely, particularly to delay climate change.
- The Investor-Owned Utilities, under the guidance of the CPUC, spend “Public Goods Charge” money (rate-payer money) to do everything they can that is cost effective to beat existing standards.
- The Publicly-Owned utilities (20% of the power), under loose supervision by the CEC, do the same.

California Energy Commission Responsibilities

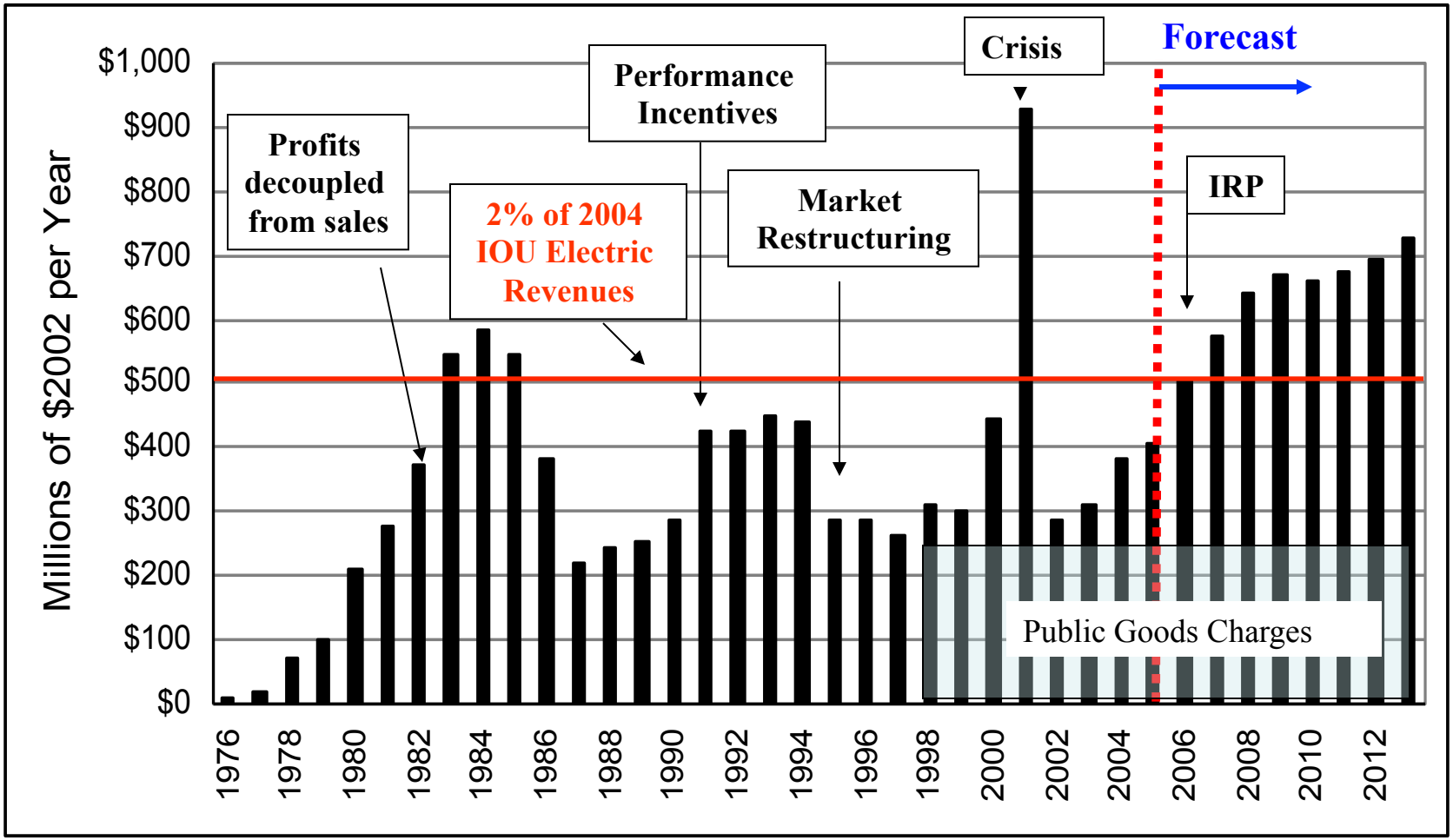
Both Regulation and R&D

- California Building and Appliance Standards
  - Started 1977
  - Updated every few years
- Siting Thermal Power Plants Larger than 50 MW
- Forecasting Supply and Demand (electricity and fuels)
- Research and Development
  - ~ $80 million per year
- CPUC & CEC are collaborating to introduce communicating electric meters and thermostats that are programmable to respond to time-dependent electric tariffs.

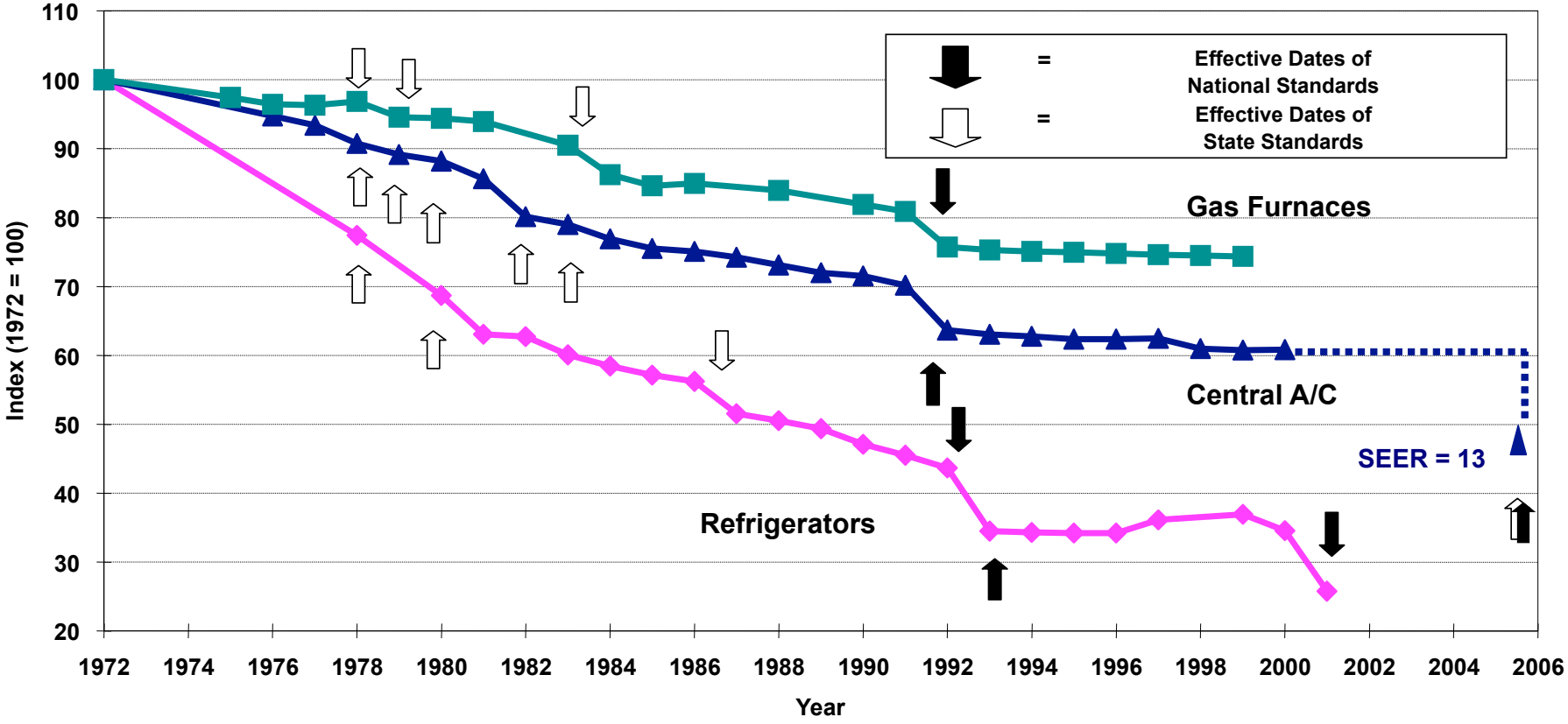
California's Energy Action Plan

- California's Energy Agencies first adopted an Energy Action Plan in 2003. Central to this is the State's preferred "Loading Order" for resource expansion.
  1. Energy efficiency and Demand Response
  2. Renewable Generation,
  3. Increased development of affordable & reliable conventional generation
  4. Transmission expansion to support all of California's energy goals.
- The Energy Action Plan has been updated since 2003 and provides overall policy direction to the various state agencies involved with the energy sectors

California IOU's Investment in Energy Efficiency



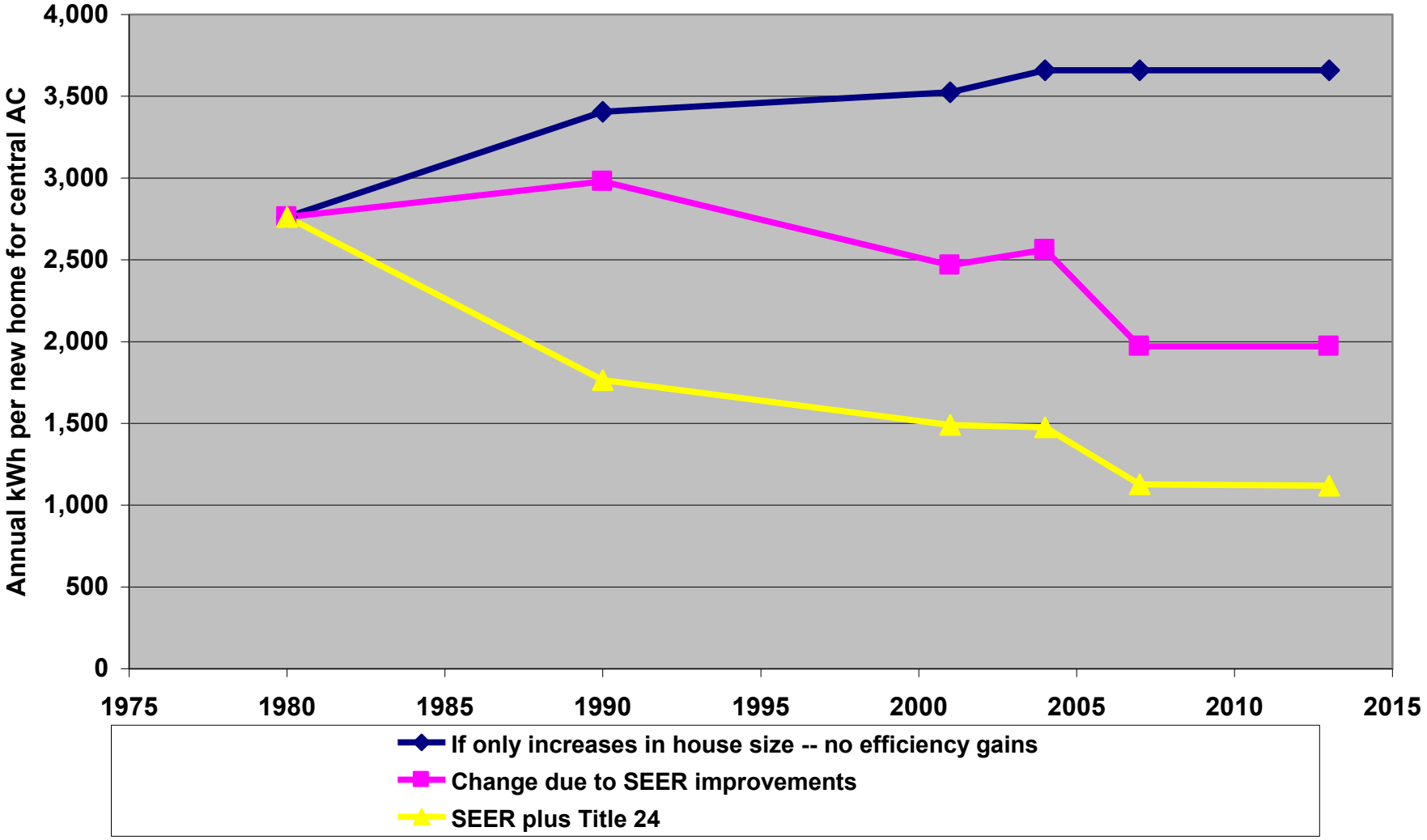
Impact of Standards on Efficiency of 3 Appliances



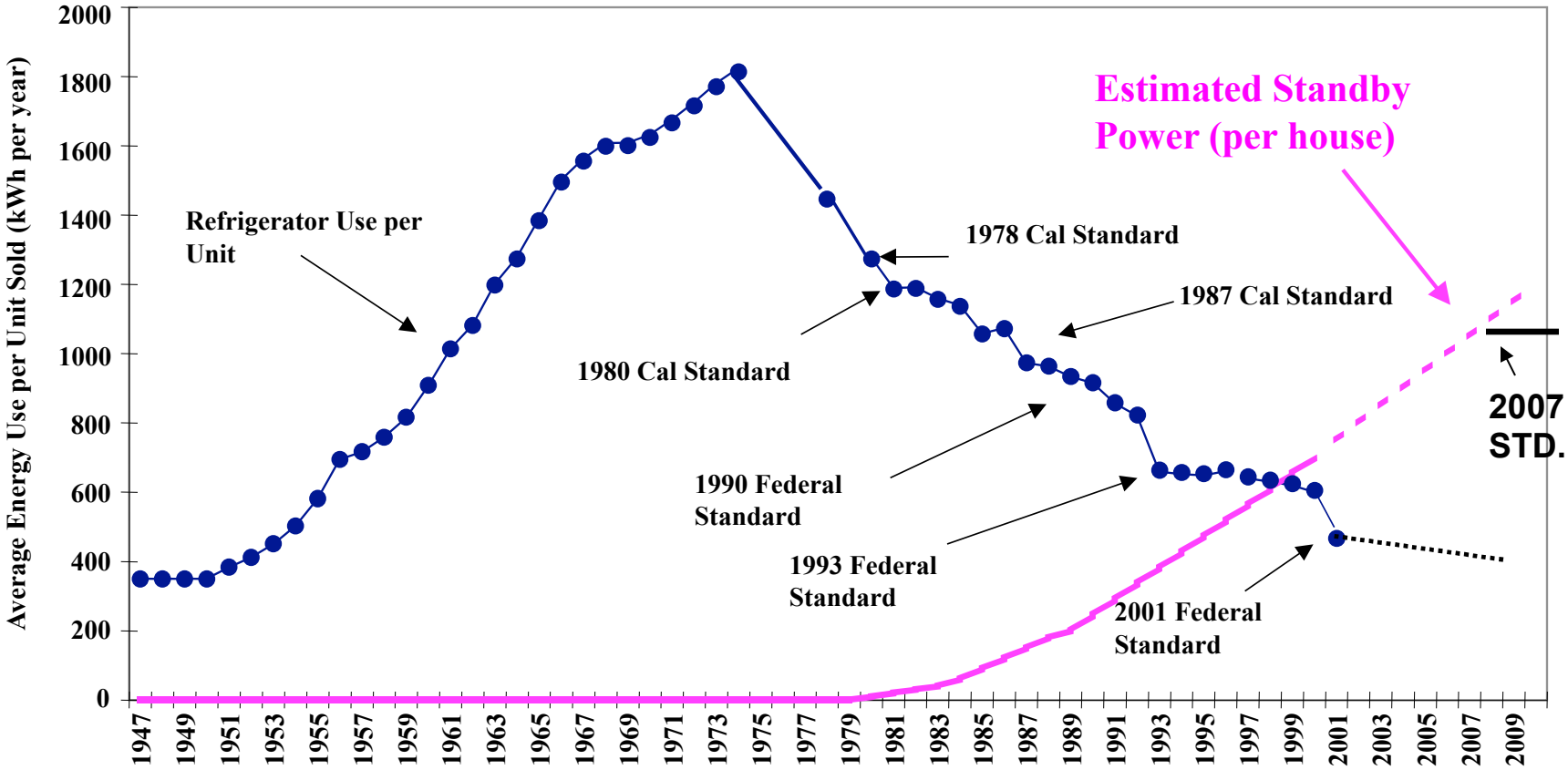
Source: S. Nadel, ACEEE,

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

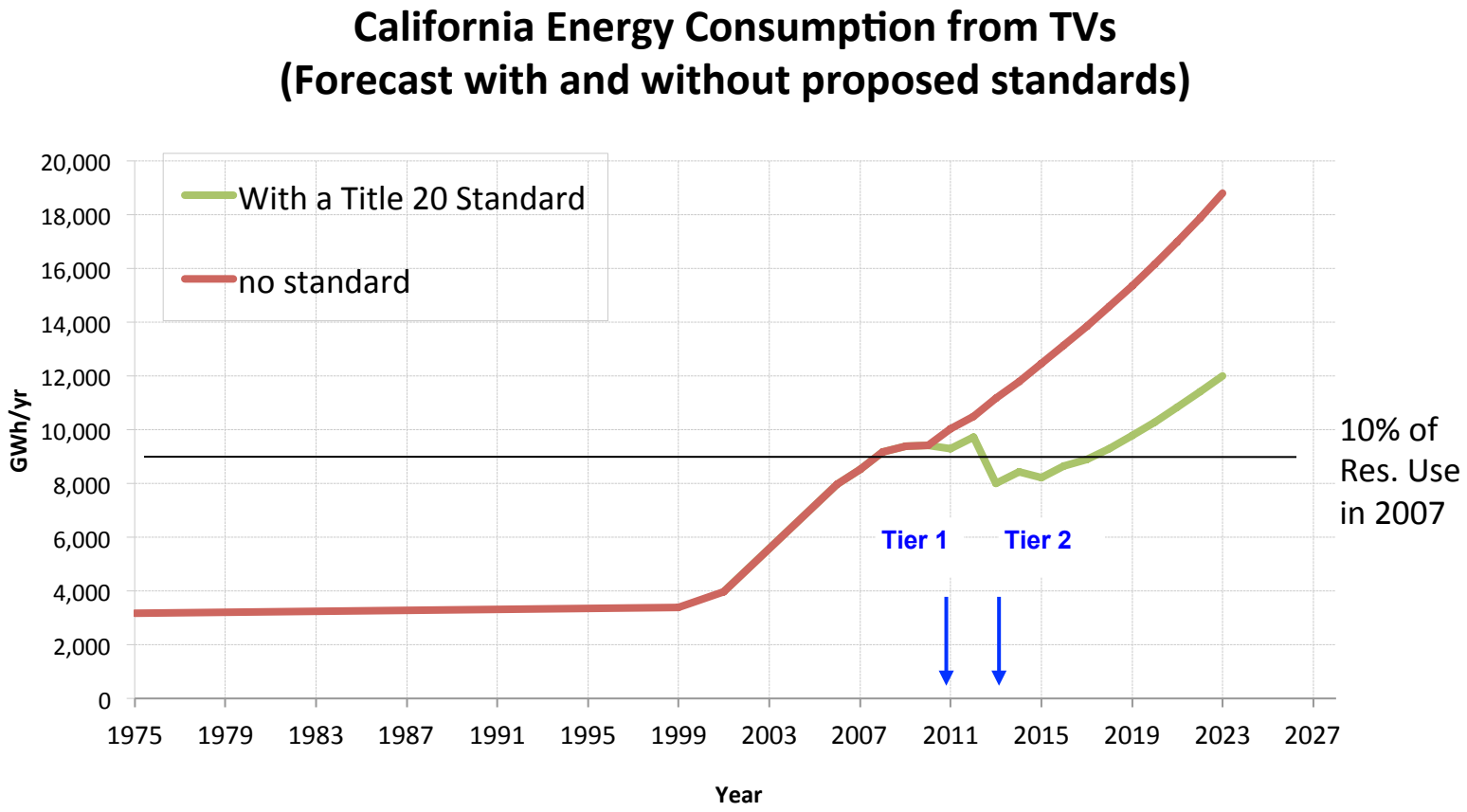


United States Refrigerator Use, repeated, to compare with Estimated Household Standby Use v. Time

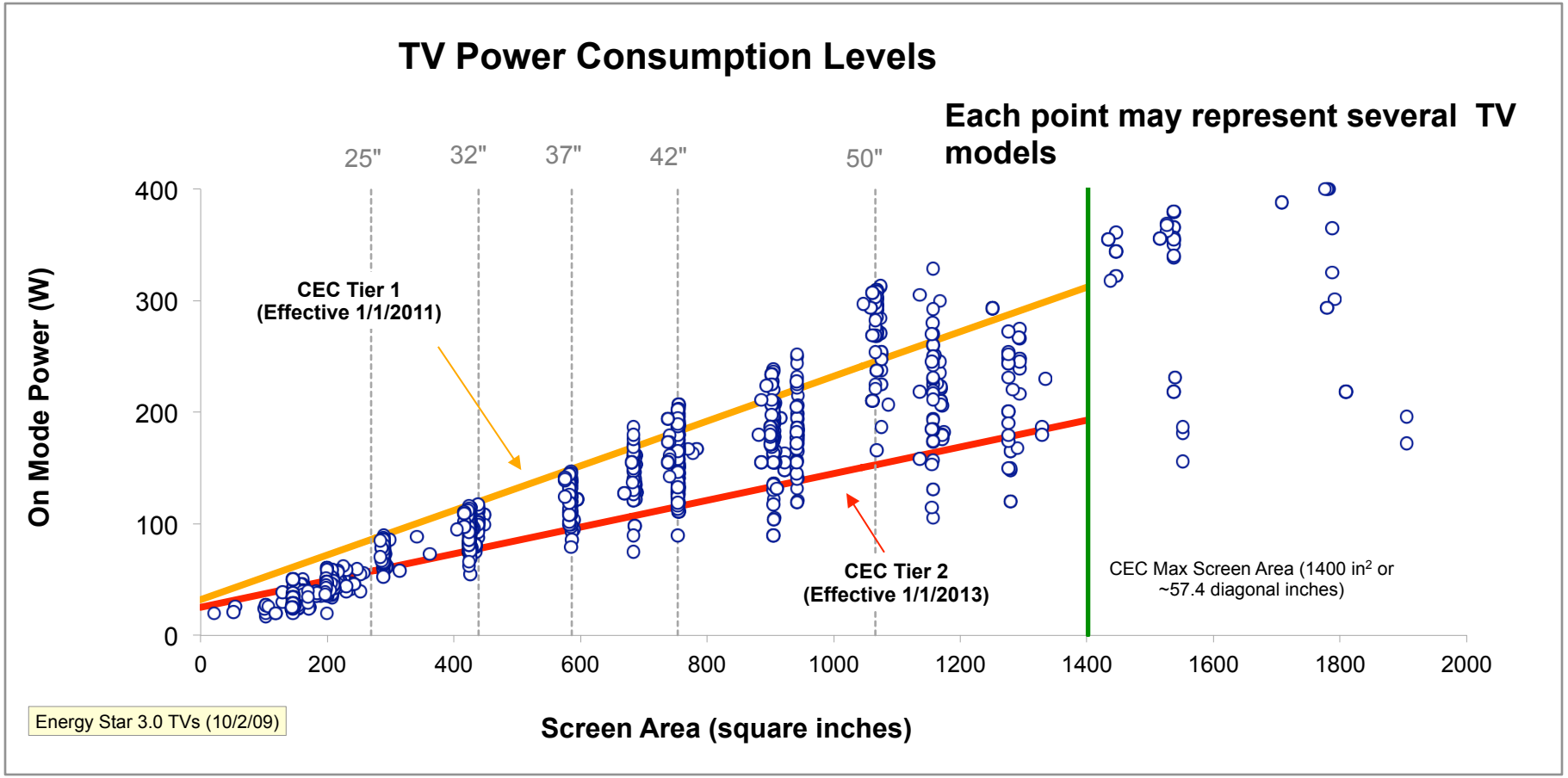


Televisions Represent Significant Energy Use

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.)

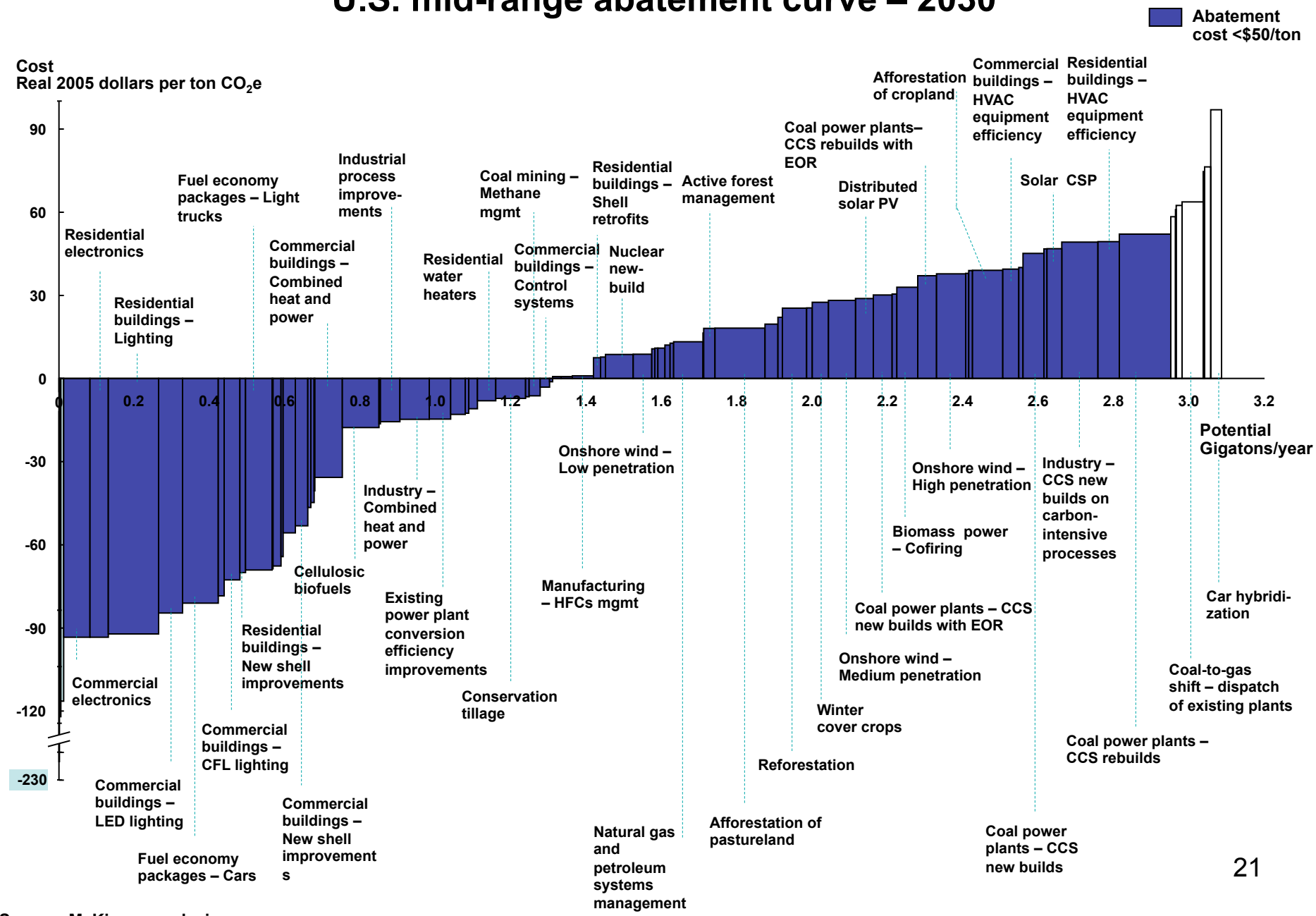
Proposed Table K-8: Standards for State-regulated General Services Incandescent Lamps -Tier I

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

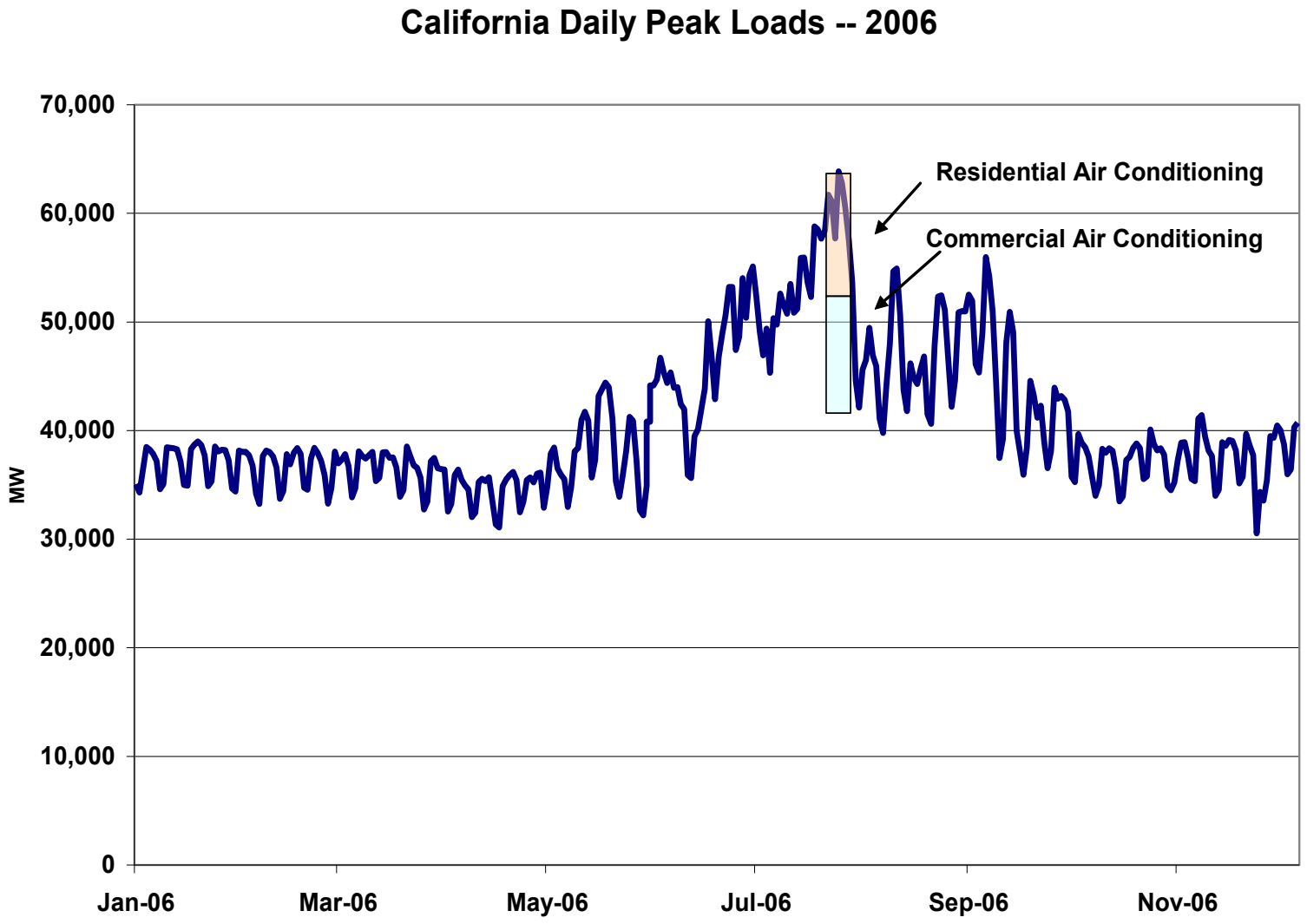
U.S. mid-range abatement curve – 2030



Source: McKinsey analysis

Demand Response

California is a Summer Peaking Area



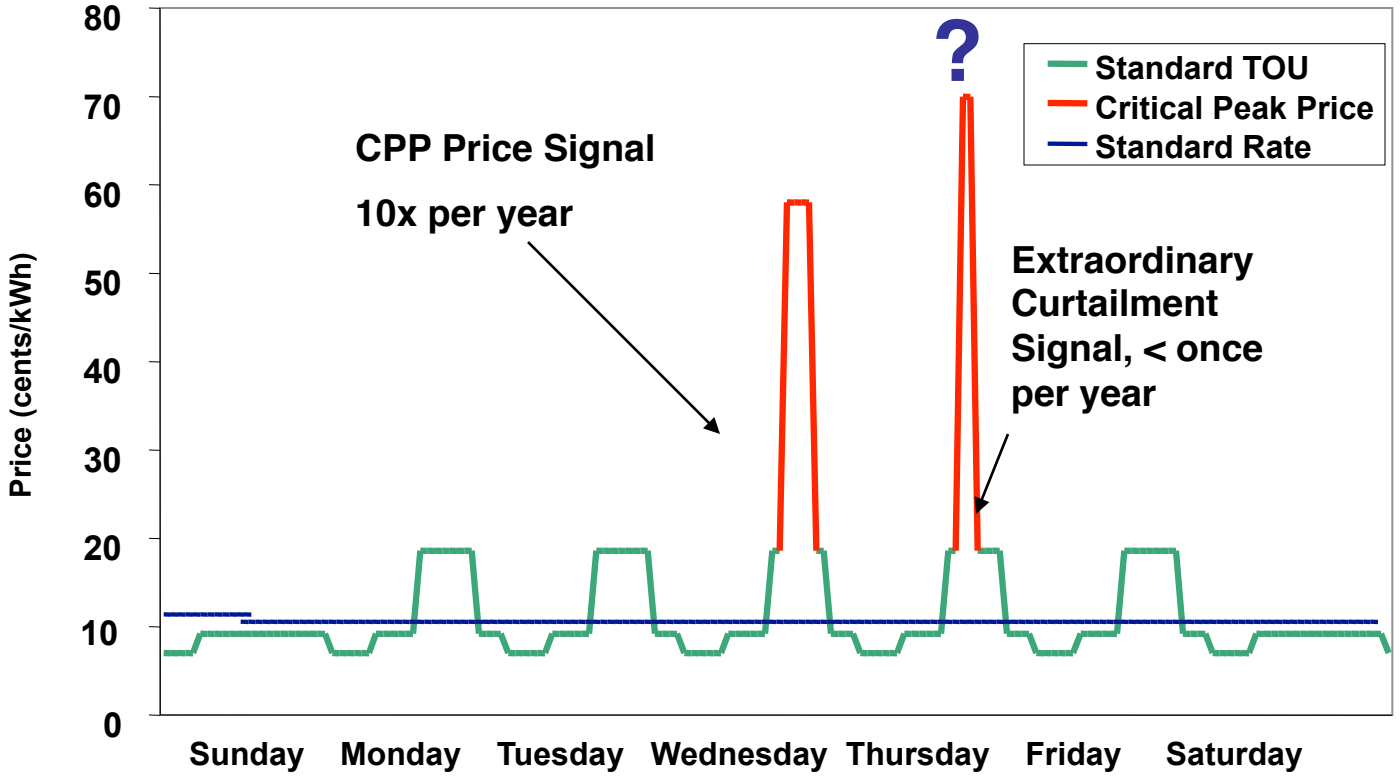
Three Necessary Components for Demand Response and Utility Modernization

- Advanced Metering Infrastructure
  - Digital meters with communication
- Dynamic Tariffs
  - Enable customers to be able to respond to hourly prices
  - The structure of these tariffs is critically important as customers are hoping to reduce total energy costs
- Automated Response Technology at customer locations
  - Enable residential and small commercial customers to respond to price automatically
  - Larger customers with energy management systems linked to pricing signals over the internet or through other communication channels
- When coupled with energy efficiency programs and policies, the result can be a reduction in total consumption as well as peak period consumption

Critical Peak Pricing (CPP) with additional curtailment option

Potential Annual Customer Savings:

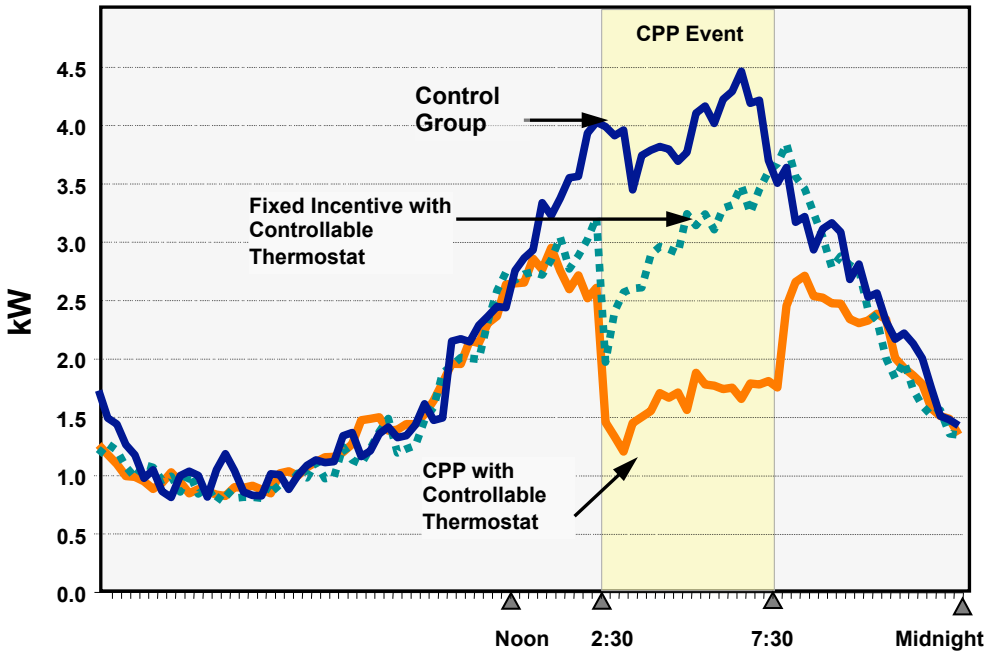
10 afternoons x 4 hours x 1kw = 40 kWh at 70 cents/kWh = ~$30/year



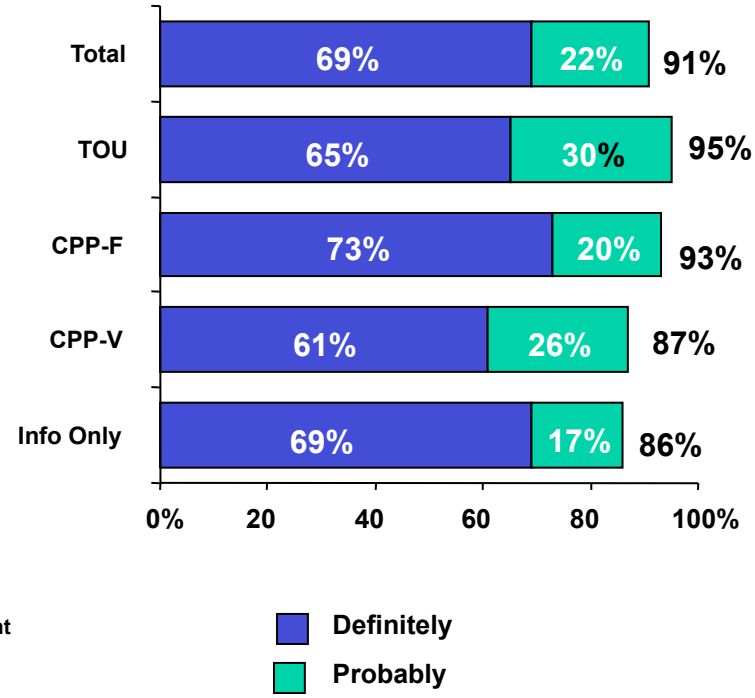
Key Results from Residential Pilot

- 12% average load reduction for CPP rate alone
- Up to 40% with rate + enabling tech
- Most participants preferred the pilot rates

Average Residential Response to Critical Peak Pricing

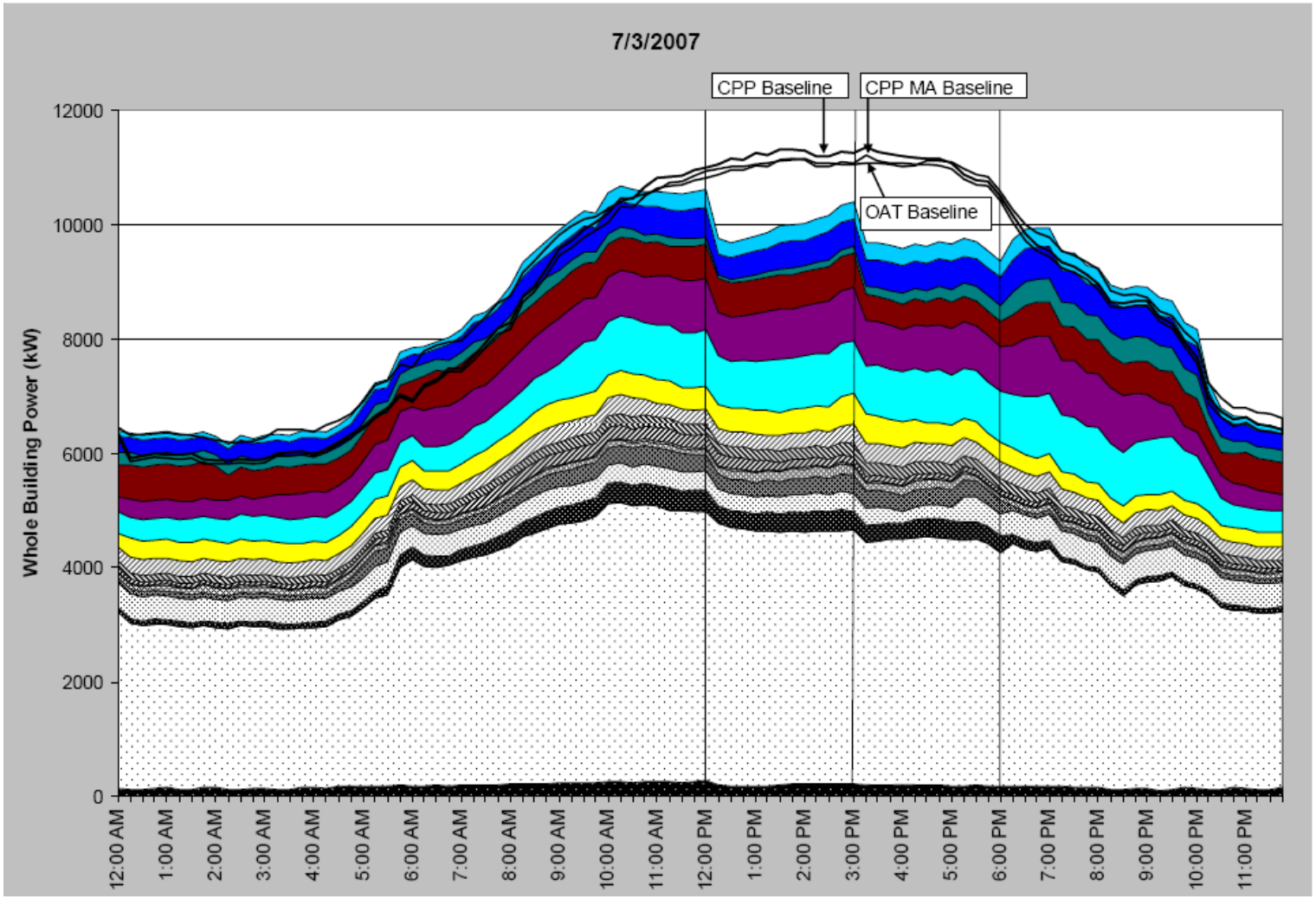


Should dynamic rates be offered to all customers?



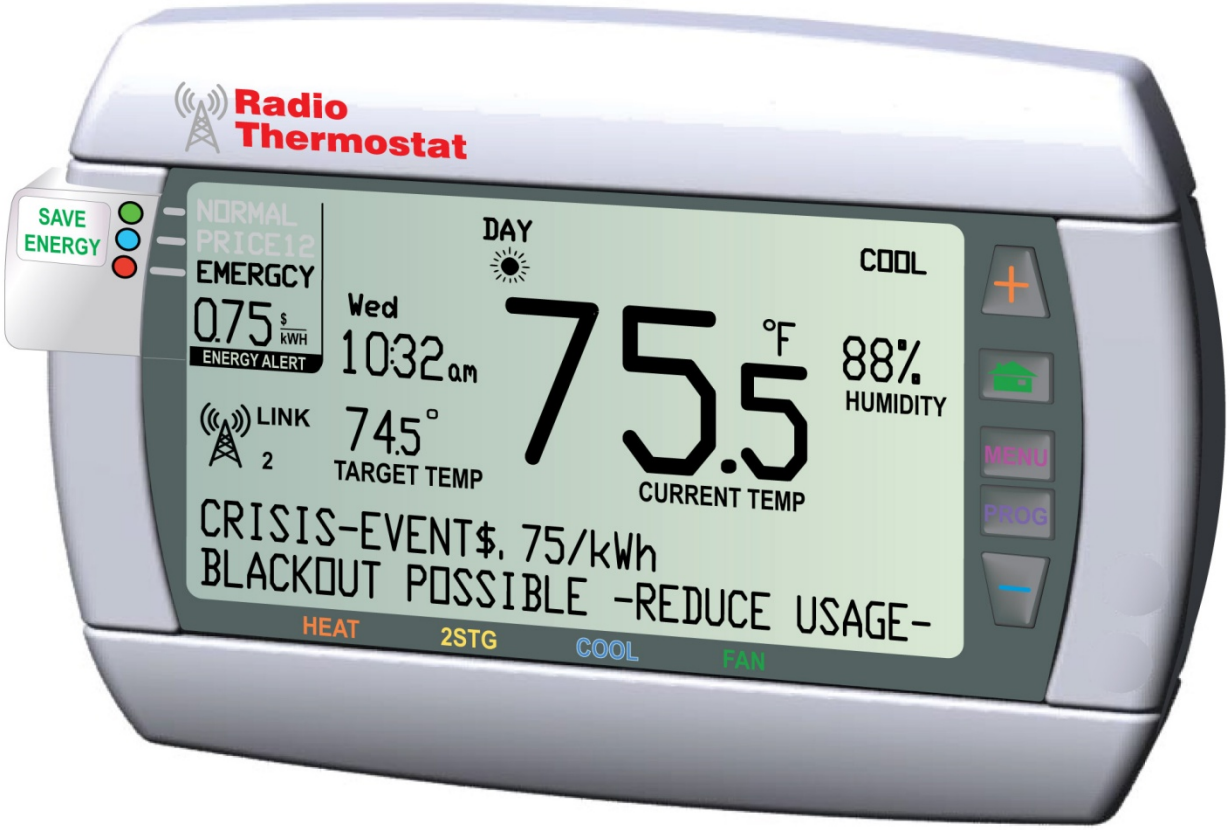
Automated Demand Response

Commercial Customers



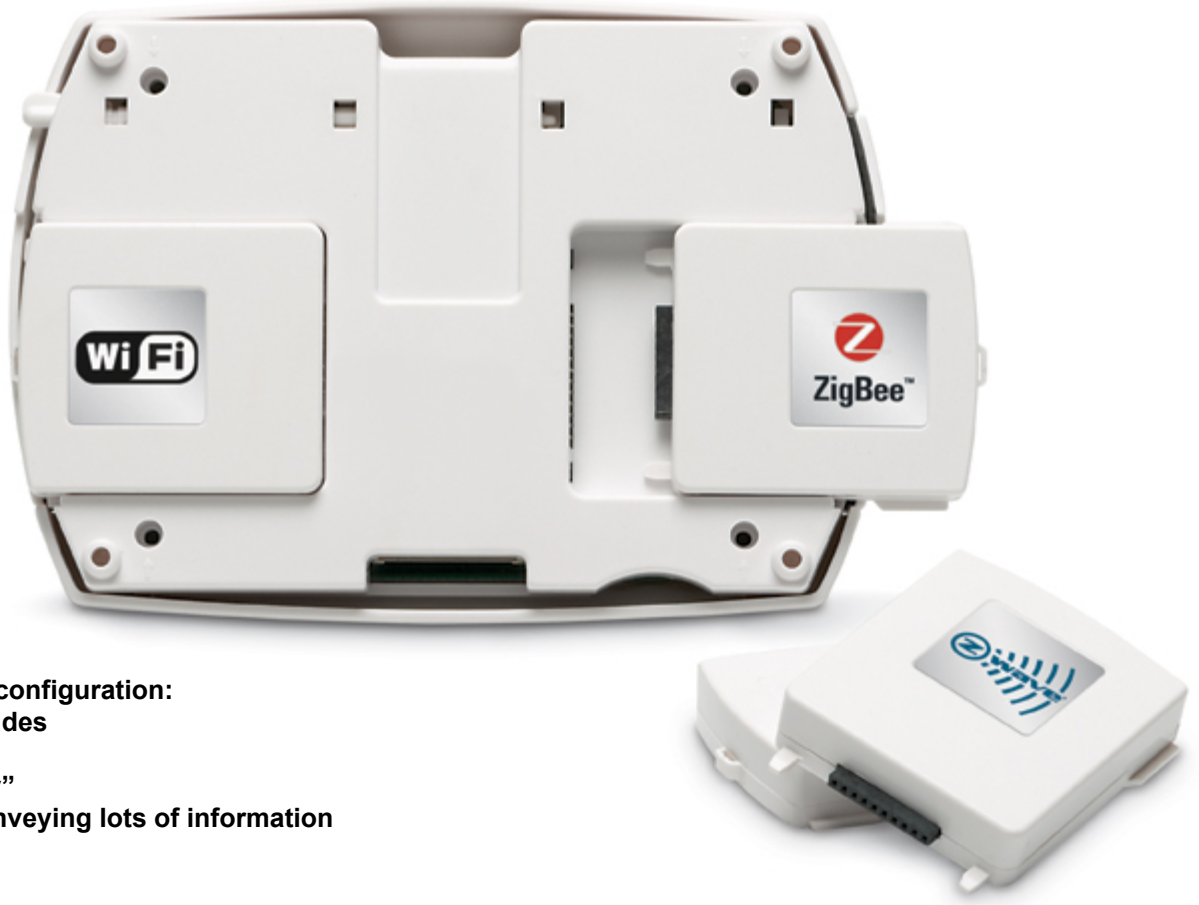
*Source: Demand Response Research Center, Global Energy Partners

PCT With U-SNAP Interface (front)



Source: Tim Simons, Golden Power

PCT With U-SNAP Interface (rear)

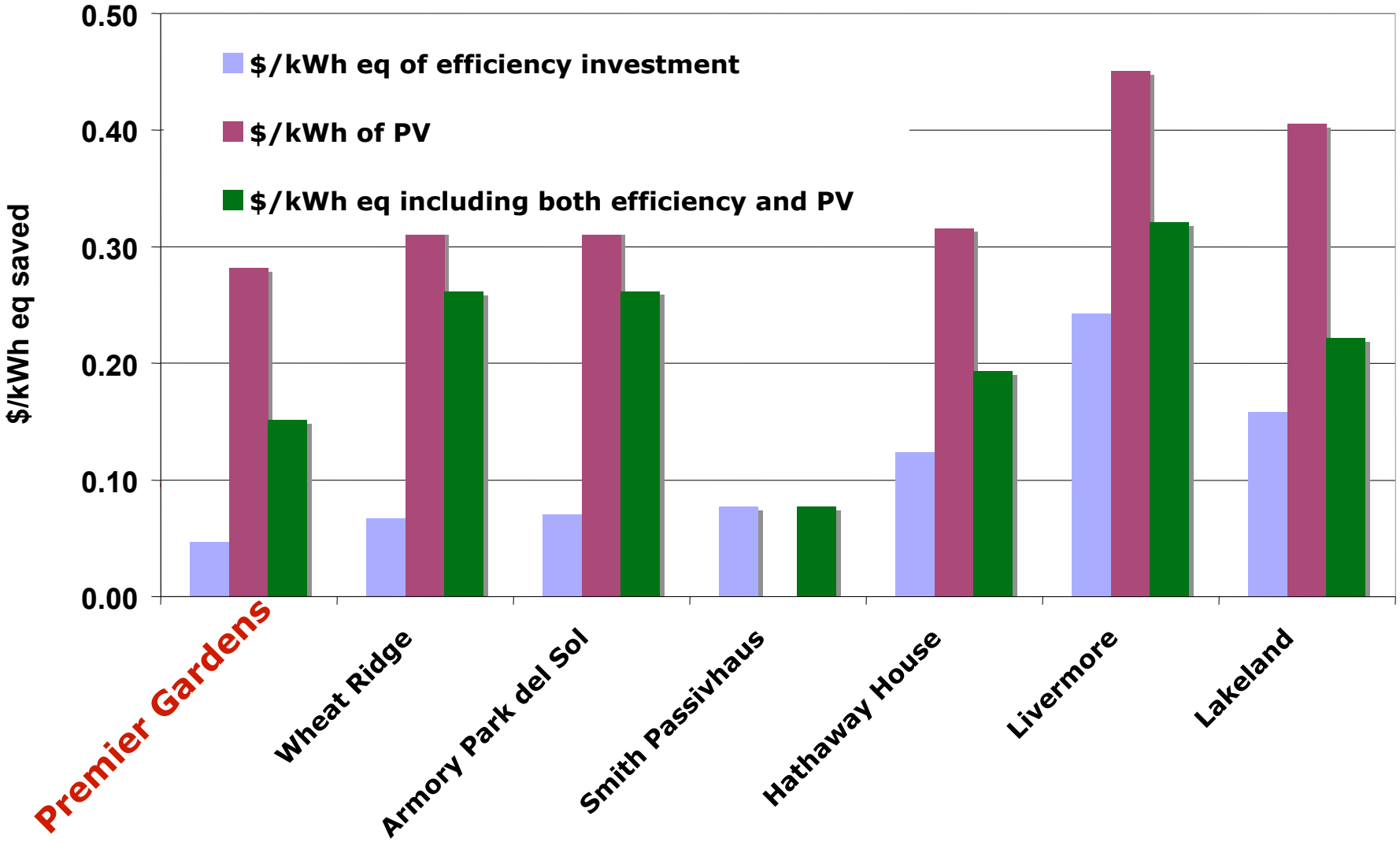


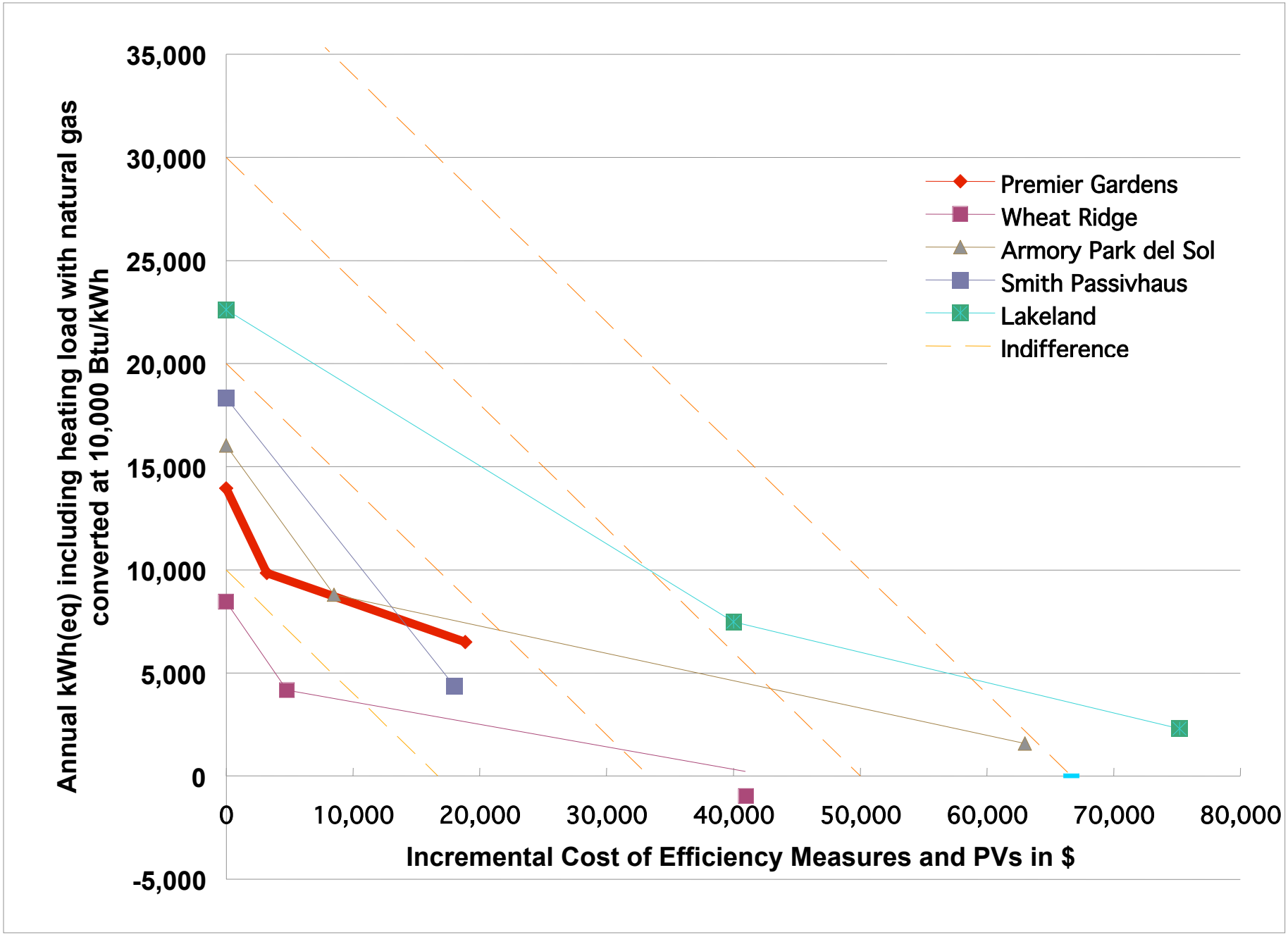
Advantages of this configuration:

1. **Customer decides**
2. **Flexible**
3. **“plug and play”**
4. **Capable of conveying lots of information**

Source: Tim Simons, Golden Power

- Source for following two Slides:
  - Lester Lave and Maxine Savitz. Relative Costs for 95 new production homes at Premier Gardens in Sacramento; Figs 2.12&13. Real Prospects for Energy Efficiency in the US; National Academy Press (2010), www.nap.edu

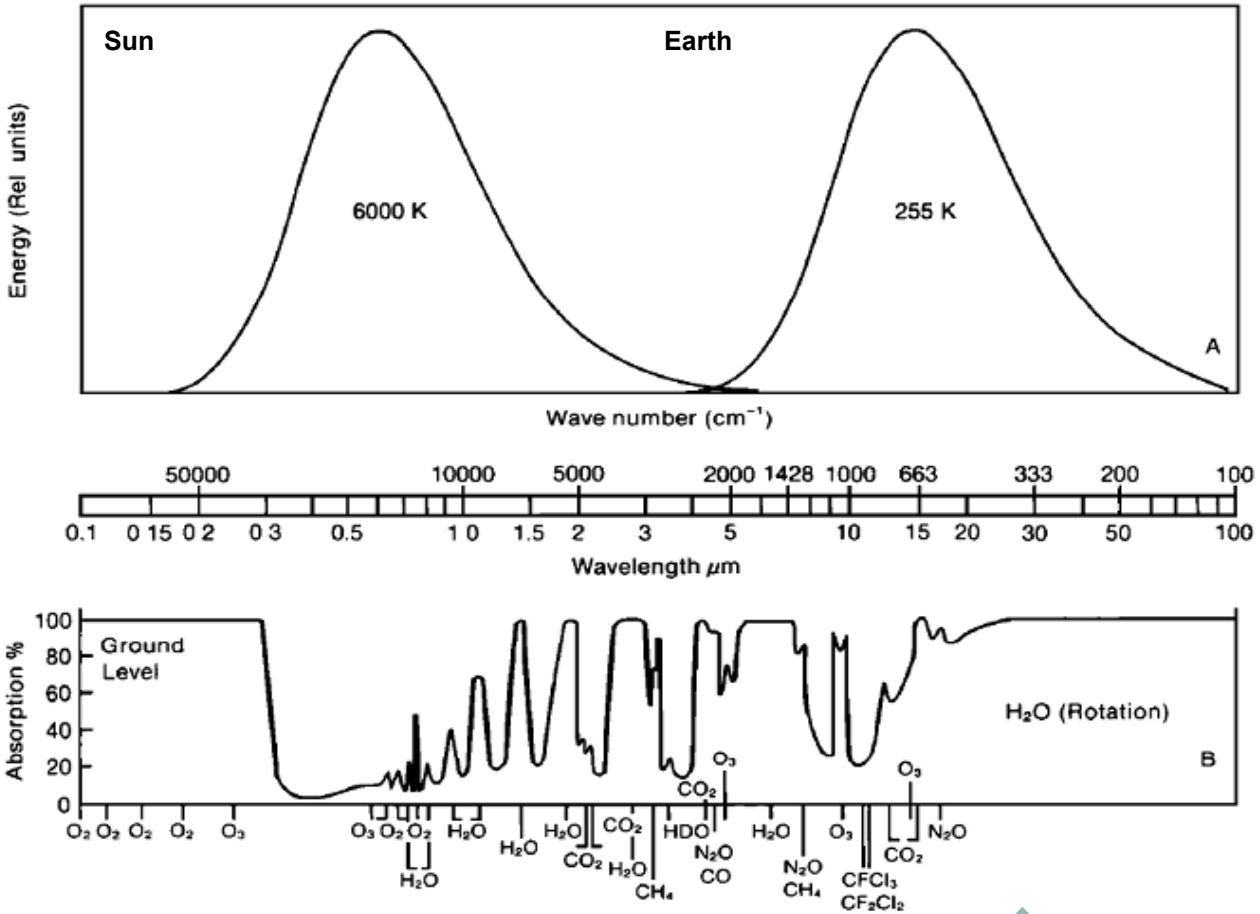

0.50
0.40
0.30
0.20
0.10
0.00
$/kWh eq saved
$/kWh eq of efficiency investment
$/kWh of PV
$/kWh eq including both efficiency and PV
Premier Gardens
Wheat Ridge
Armory Park del Sol
Smith Passivhaus
Hathaway House
Livermore
Lakeland


Annual kWh(eq) including heating load with natural gas converted at 10,000 Btu/kWh
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
-5,000
0
10,000
20,000
30,000
40,000
50,000
60,000
70,000
80,000
Incremental Cost of Efficiency Measures and PVs in $
Premier Gardens
Wheat Ridge
Armory Park del Sol
Smith Passivhaus
Lakeland
Indifference

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

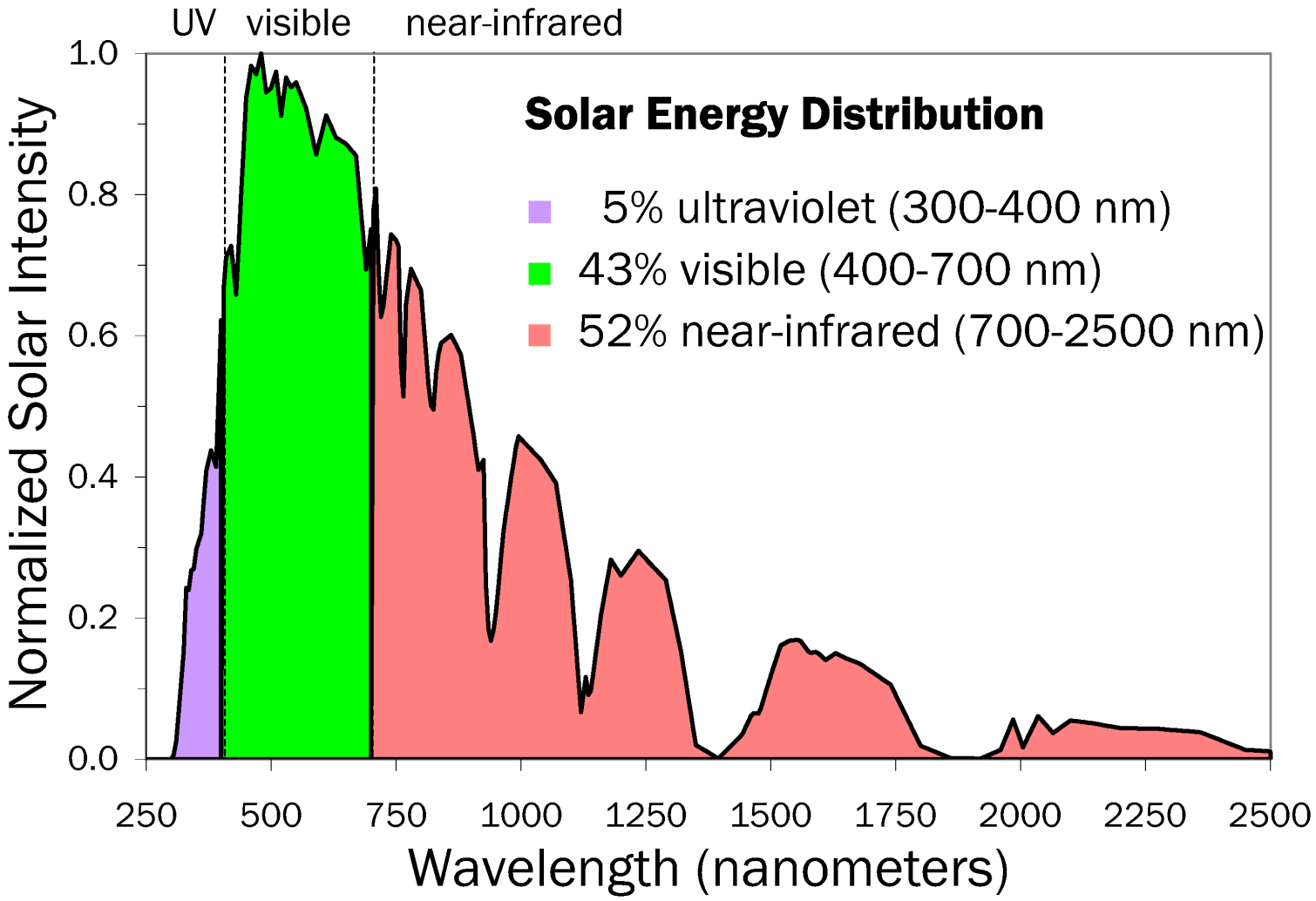

Andrew Isaacs cooling the world with his shiny new white roof in Marin County.

Atmospheric greenhouse effect (i/ii)



Absorption by the atmosphere

Cool Colors Reflect Invisible Near-Infrared Sunlight

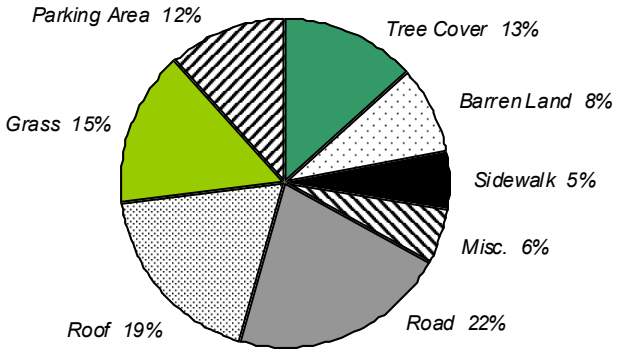


Bird's eye view of urban land use

~ 1 km^2

The surface of Sacramento, CA is about

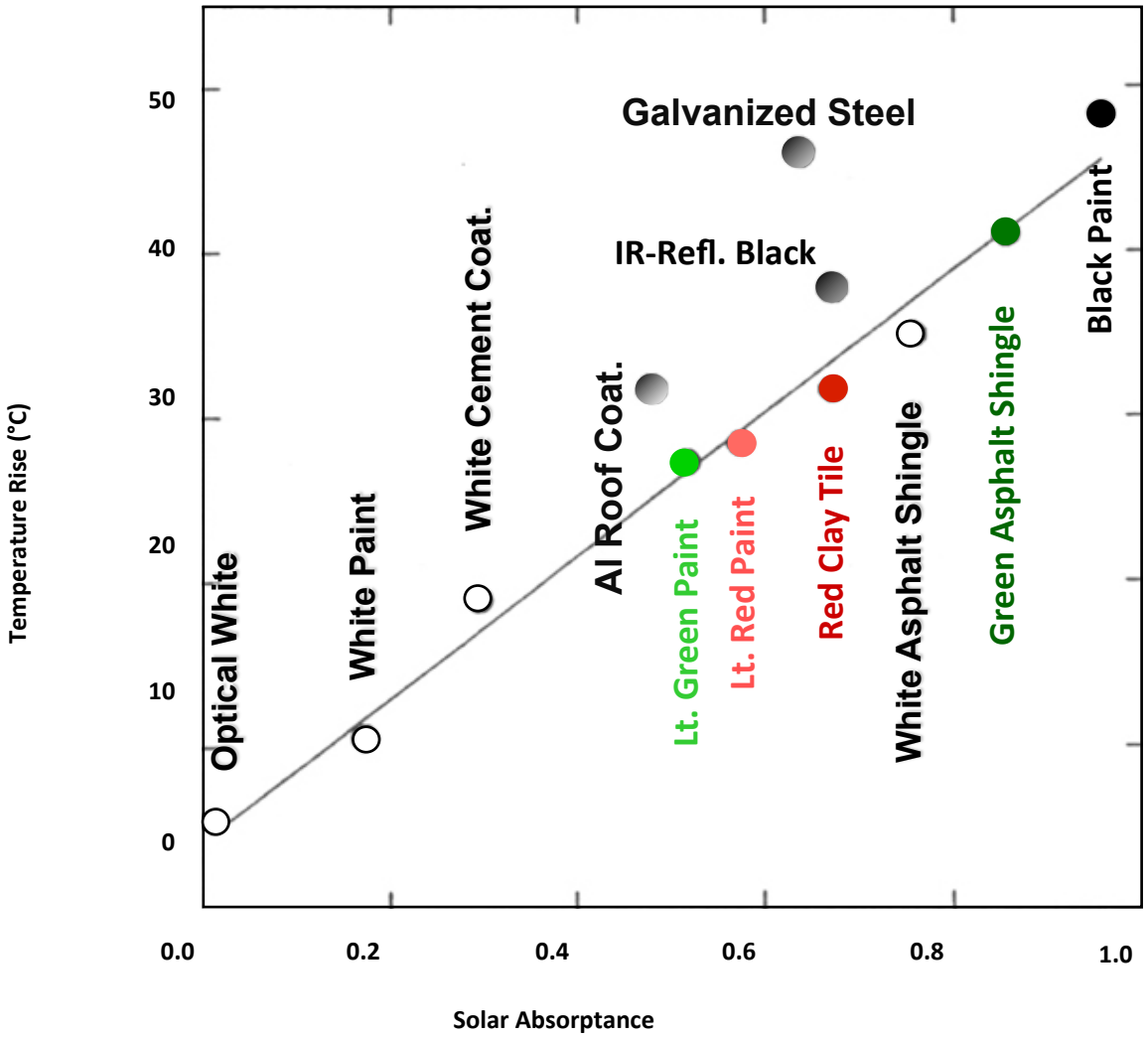
- **20% roofs**
- **30% vegetation**
- **40% pavement**



Area by Land-Cover Category Above the Canopy

37

Reflective roofs stay cooler in the sun



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White roofs, cool-colored roofs save money

OLD

flat, white

pitched, white

NEW

pitched, cool & colored

Advanced white roof coatings, membranes

Both roofs exposed for 9 years in Florida

Kynar® based coated metal roof with 0.80 Total Solar Reflectance

Elastomeric Acrylic over PVC with 0.55 Total Solar Reflectance

White metal roof stays clean, saving 70% more energy than soiled white coating.

- **White roof coatings, membranes soil rapidly, lose solar reflectance (SR)**
  - initial SR ≈ 0.80
  - aged SR ≈ 0.55
- **How to keep white roofs clean and reflective?**
  - reduce leaching of plasticizers
  - decrease surface roughness & stickiness
  - photocatalytic self-cleaning
  - photoinduced hydrophilicity

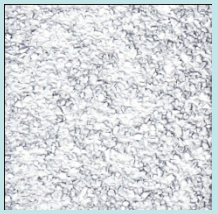
Advanced cool-colored asphalt shingles

today's cool asphalt shingles reflect ≈ 25% of sunlight

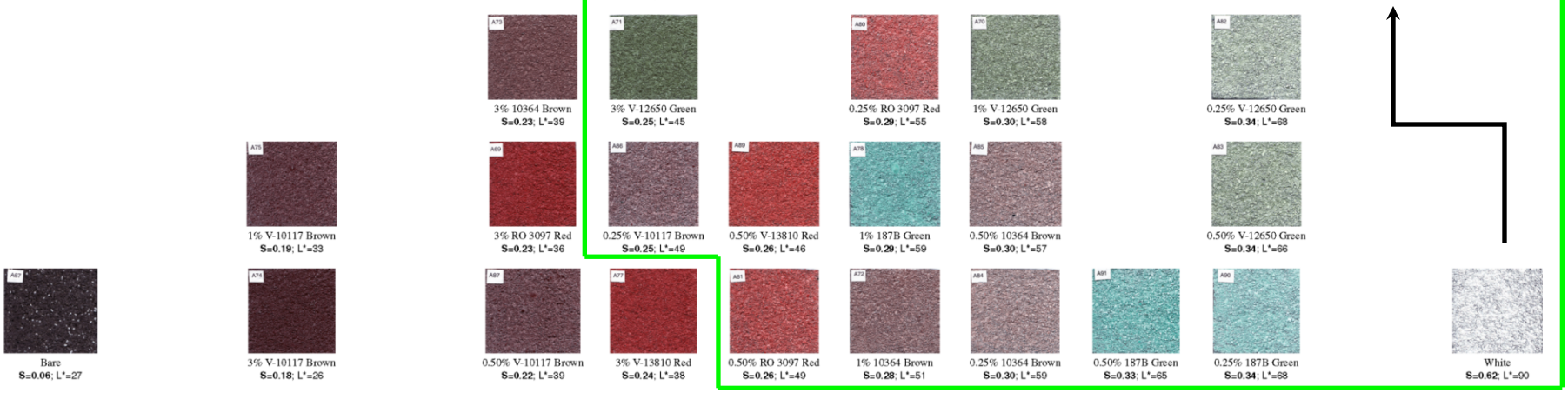
Courtesy
Elk Corporation

Solar reflectance ≥ 25%

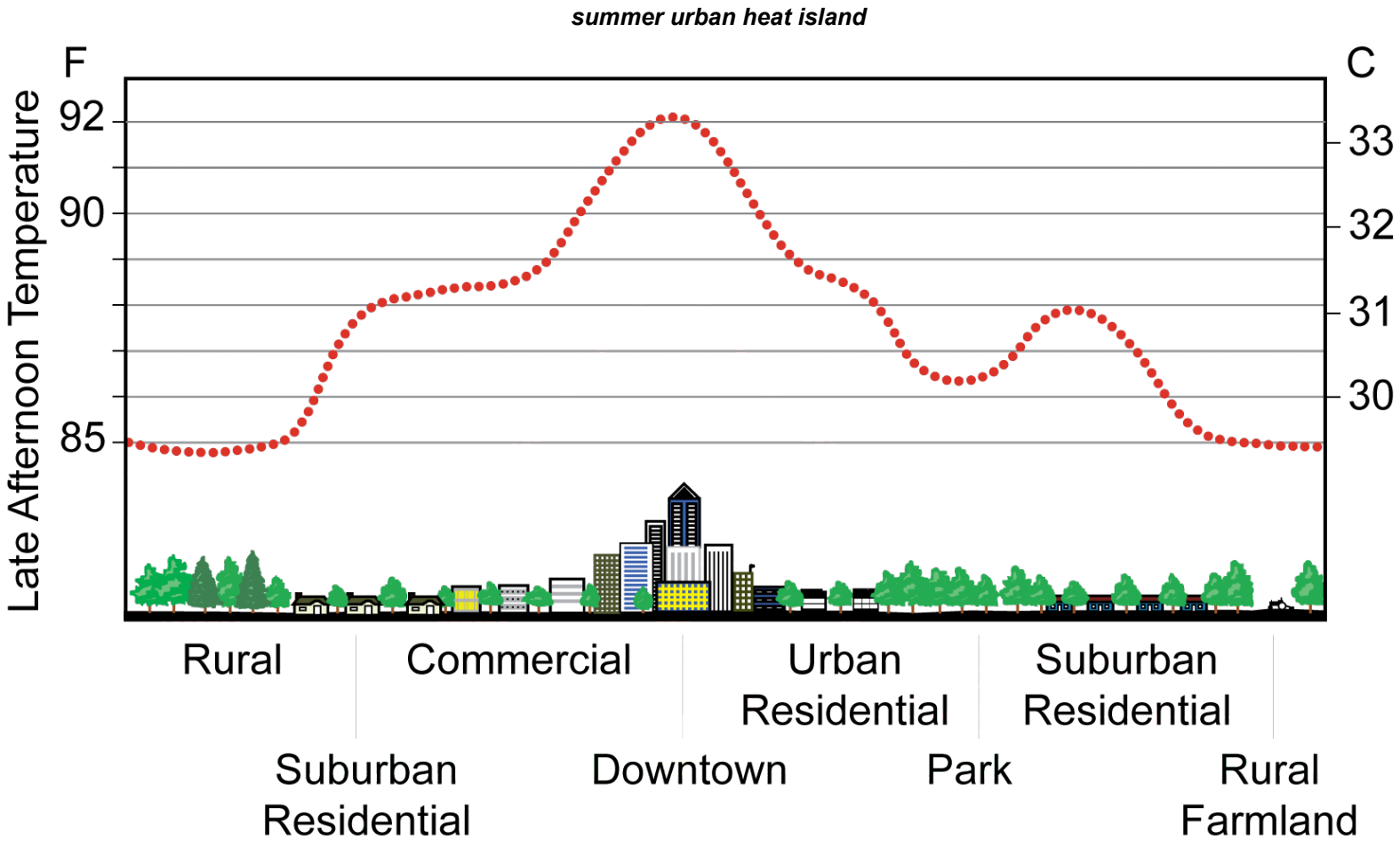
Prototype cool-colored asphalt shingles
- **reflect up to 35% of sunlight**
- **can save up to 60% more energy**



Bright-white shingle
SR > 60%



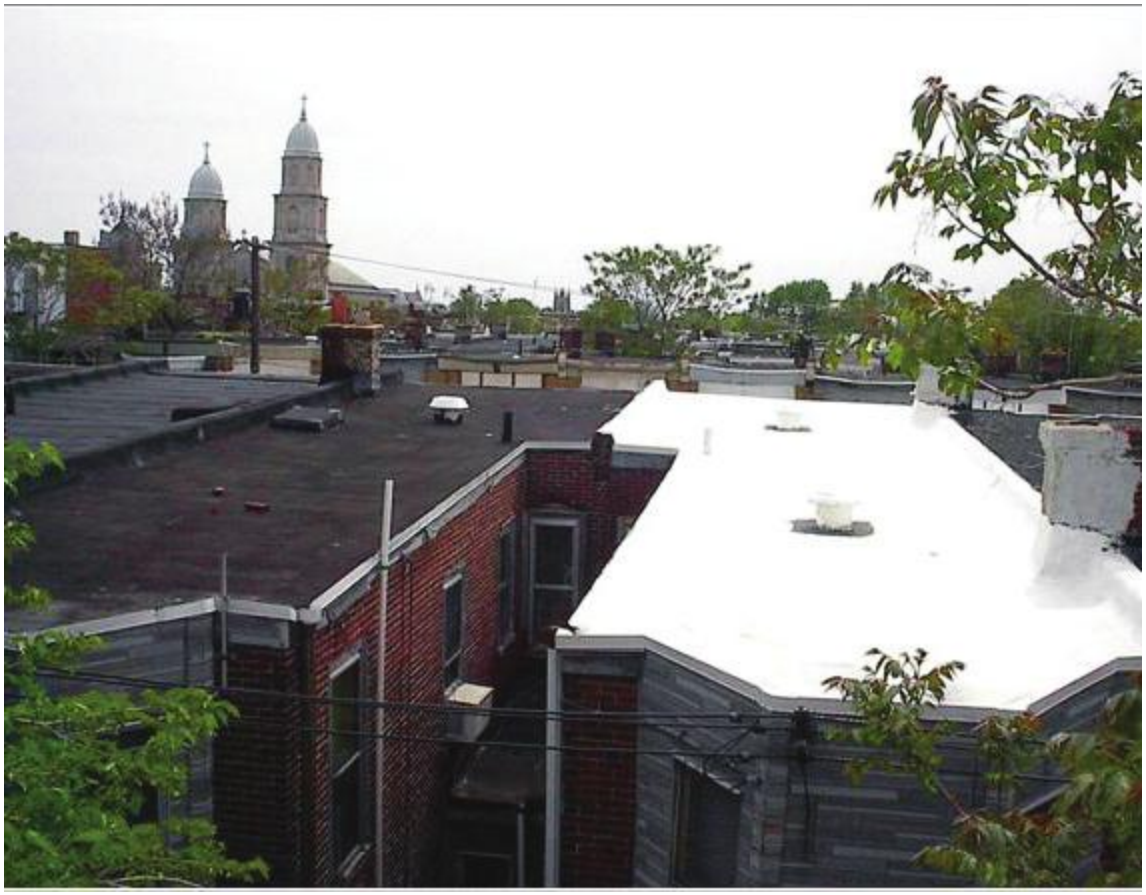
Summer in the city



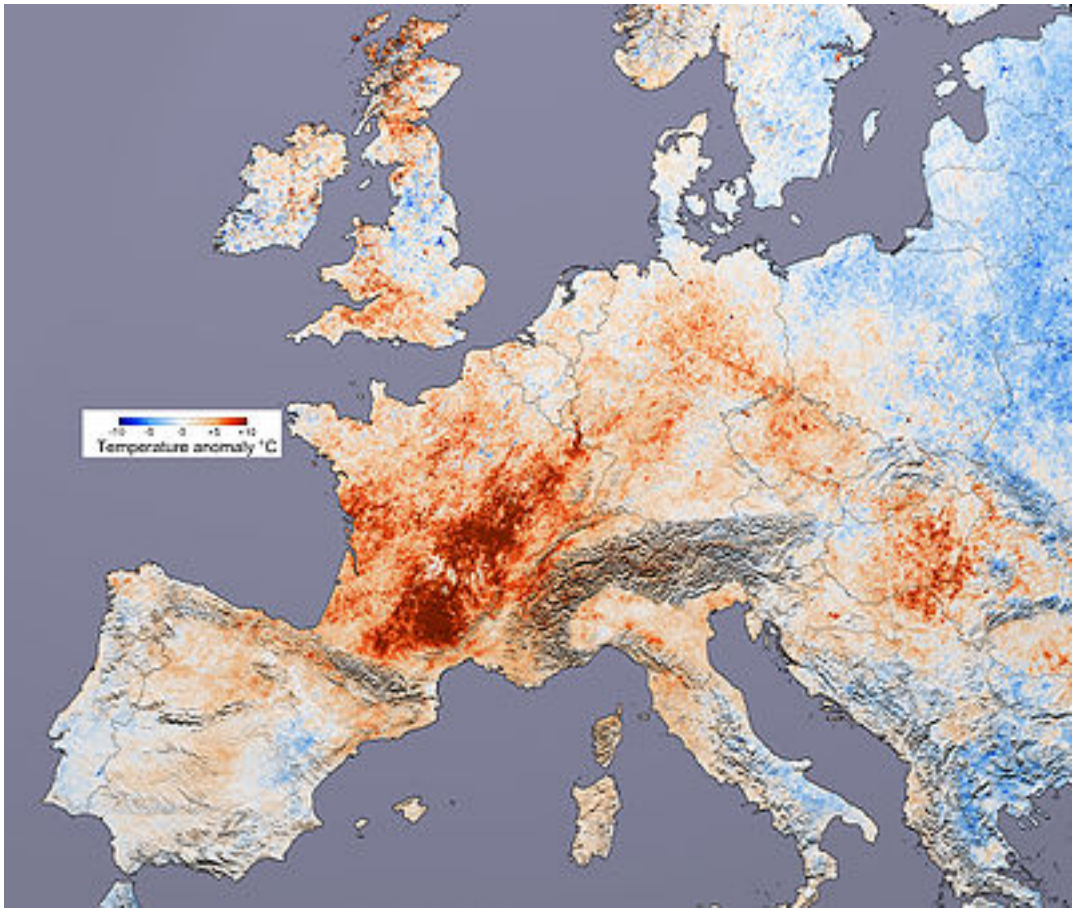
42

Chicago Heat Wave 1995, 739 Deaths

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



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



White roofs around the world

…in Santorini, Greece

46

…in Hyderabad, India

…and widely in the state of Gujarat, India.

Walmart store in northern California

48

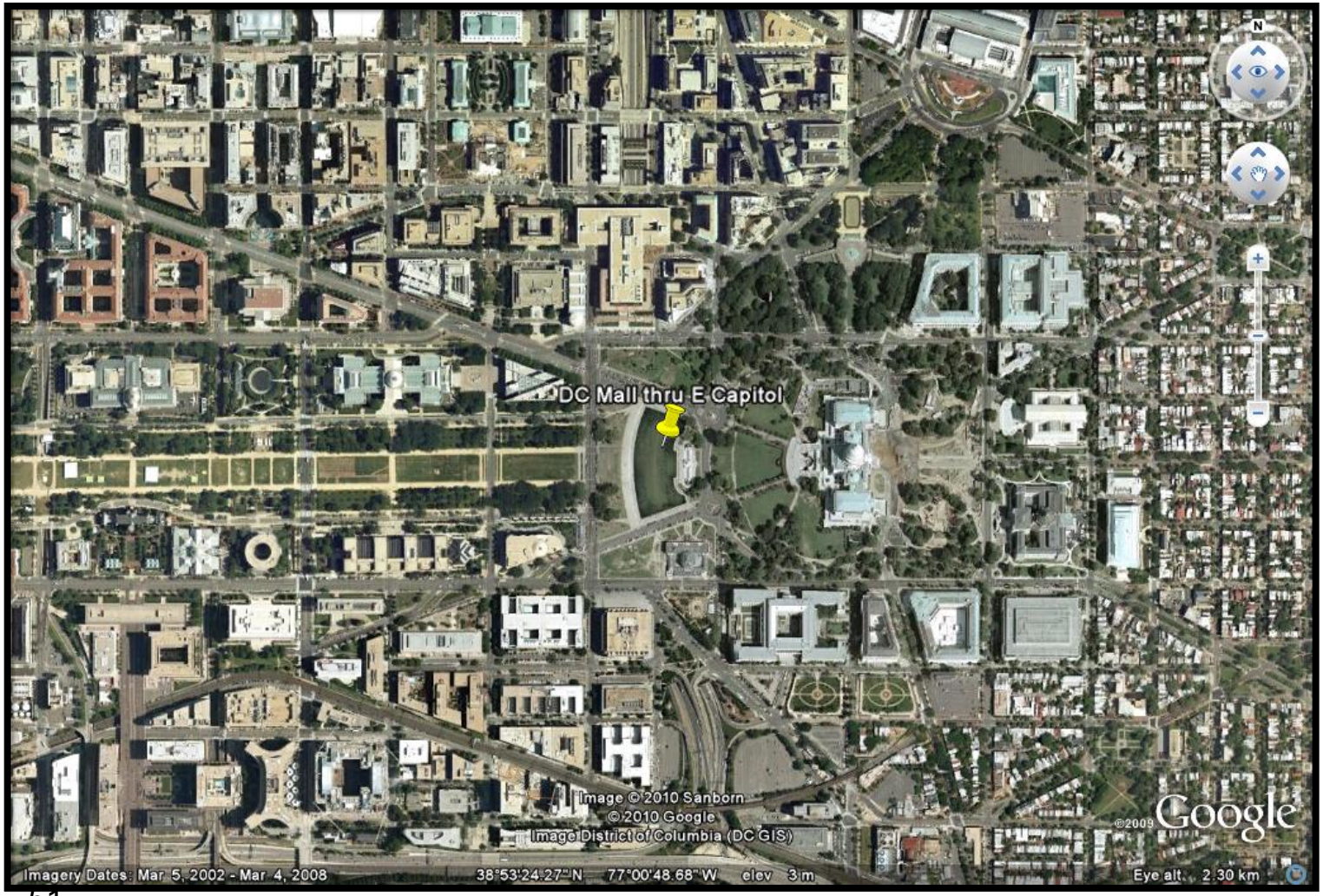
Congratulations to UC Davis

49

White roofs are popular in Tucson, AZ

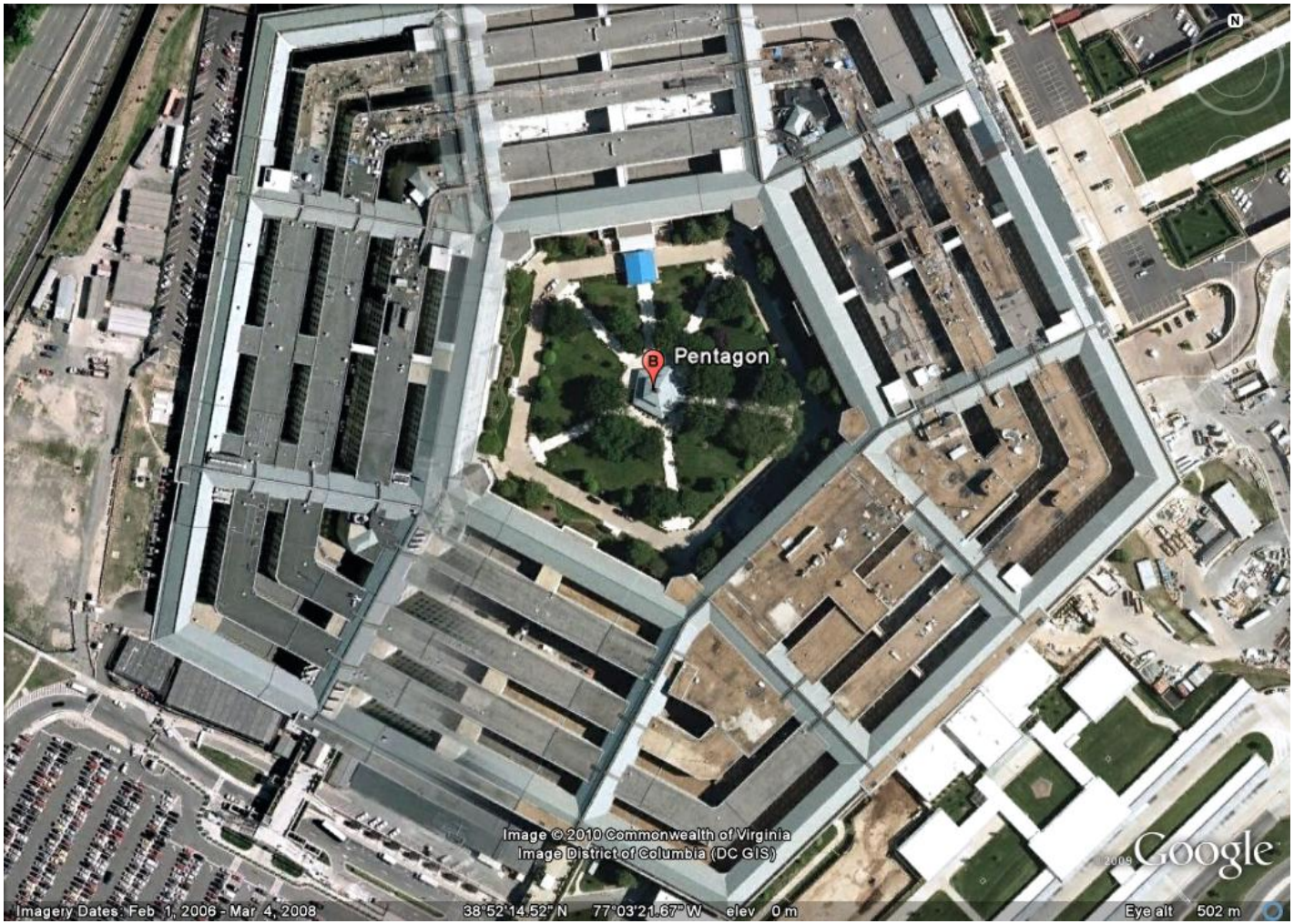
50

Washington, DC (Federal) has problems



51

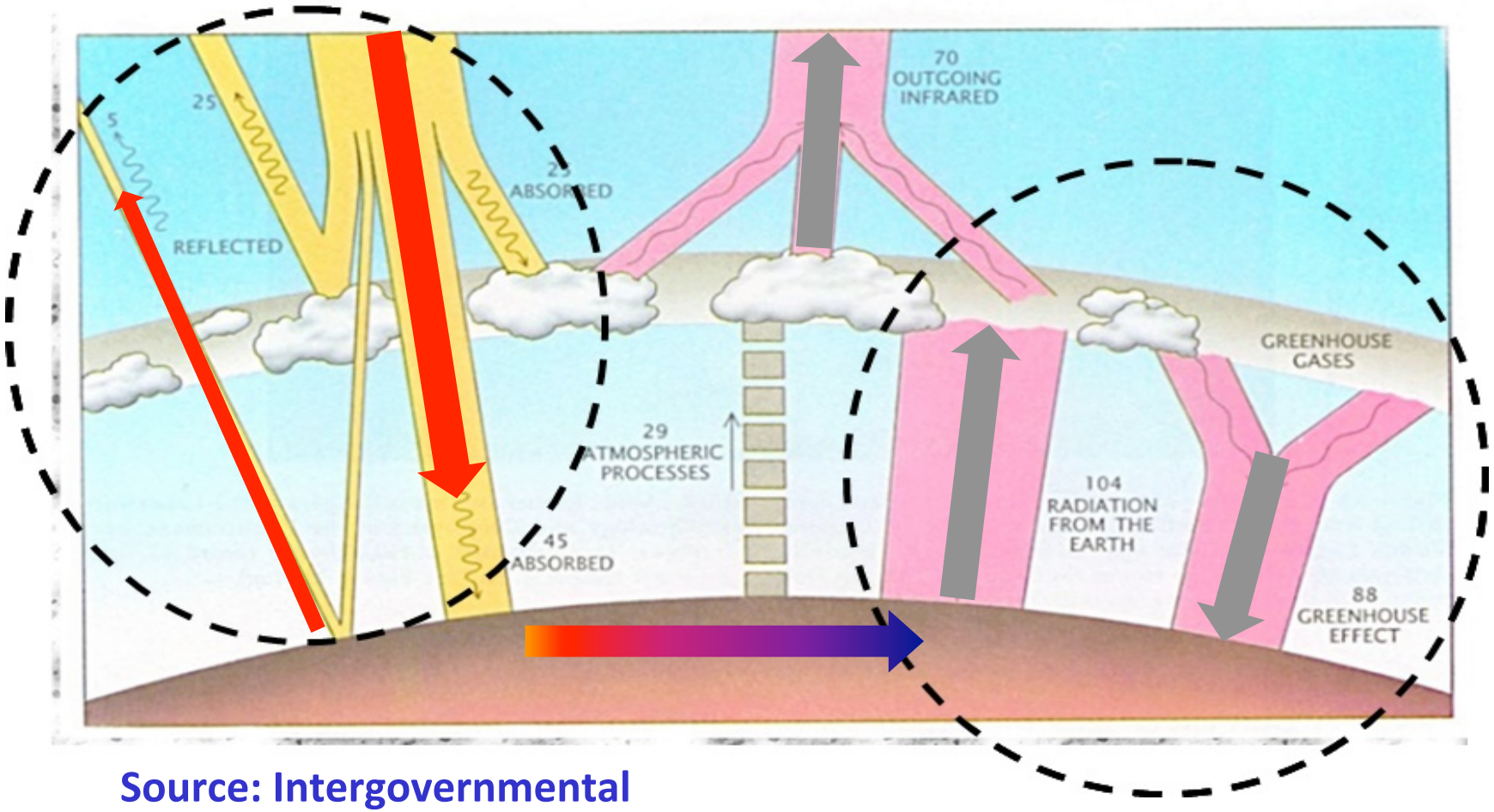
Pentagon


Pentagon
Image © 2010 Commonwealth of Virginia
Image District of Columbia (DC GIS)
Google
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

52

Cooling our planet

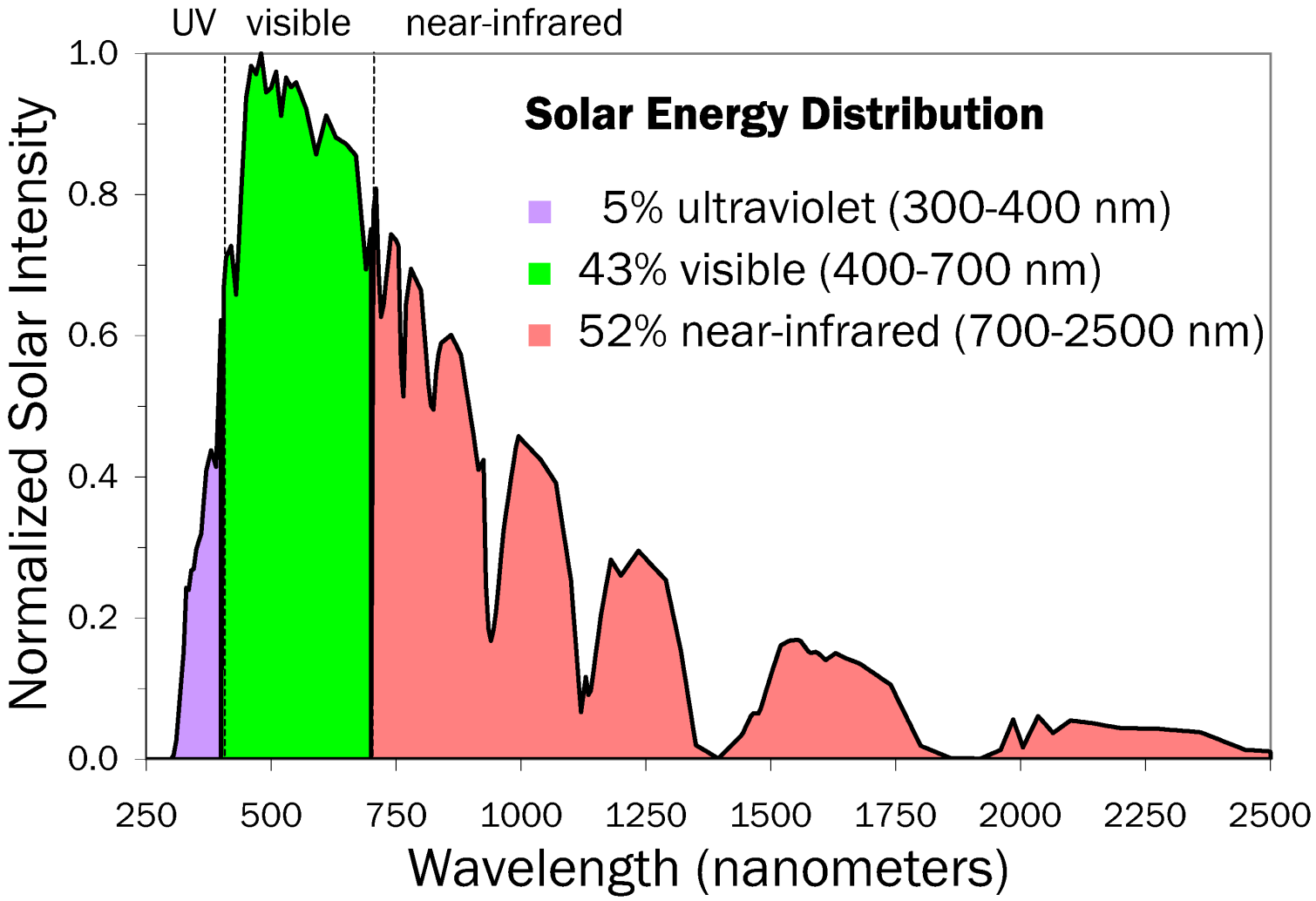
Solar-reflective surfaces cool the globe via “negative radiative forcing”



Source: Intergovernmental Panel on Climate Change (IPCC)

54

Cool Colors Reflect Invisible Near-Infrared Sunlight



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

56

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.

For White Roofs, 24 Gt could be 74Gt.

We assumed:

- Urban area is only 1% of global land area, BUT it could be 2%, and growing fast.
- We assumed, as in California, half of roofs are sloped and that architectural concerns would not permit white. And cool colored roofs are more expensive and less reflective. BUT in warm climates with no snow load, flat roofs should be in the majority.

Conclusion: The LBNL papers can probably be scaled up to 50 GtCO2.

50 Gt/20 years = 2.5 Gt/year, which offsets the emissions of >800 medium sized coal plants.

(I assume each plant is a "Rosenfeld," as defined by Koomey et al, Namely 500 MW, operating 6000 hr/year, generating 3 Mt CO2/year.

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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.**

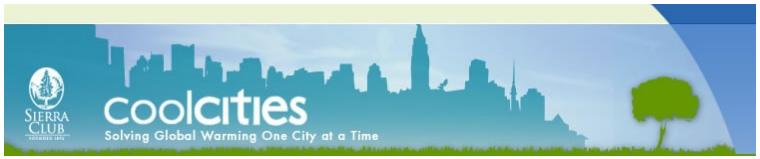
Recent cool roof progress (2005 – 2011)

- 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