Efficient Use of Energy

Physics Colloquium at UC Davis

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http://www.energy.ca.gov/commissioners/rosenfeld.html
or just Google "Art Rosenfeld"

Some Background Reading

- For a Full (51 page) Biography of Dr. Rosenfeld, see his web site at:

http://www.energy.ca.gov/commissioners/rosenfeld_docs/index.html

- This Presentation Based on Work Published as:

"Opportunities in the Building Sector: Managing Climate Change," Rosenfeld, A. & McAuliffe, P., in *Physics of Sustainable Energy: Using Energy Efficiently and Producing it Renewably*, Edited by D. Hafemeister, et.al., American Institute of Physics Conference Proceedings, Vol. 1044, p. 3, 2008, College Park, MD

The symposium is available at http://rael.berkeley.edu/files/apsenergy/


Does Anyone See A Problem With This Picture?

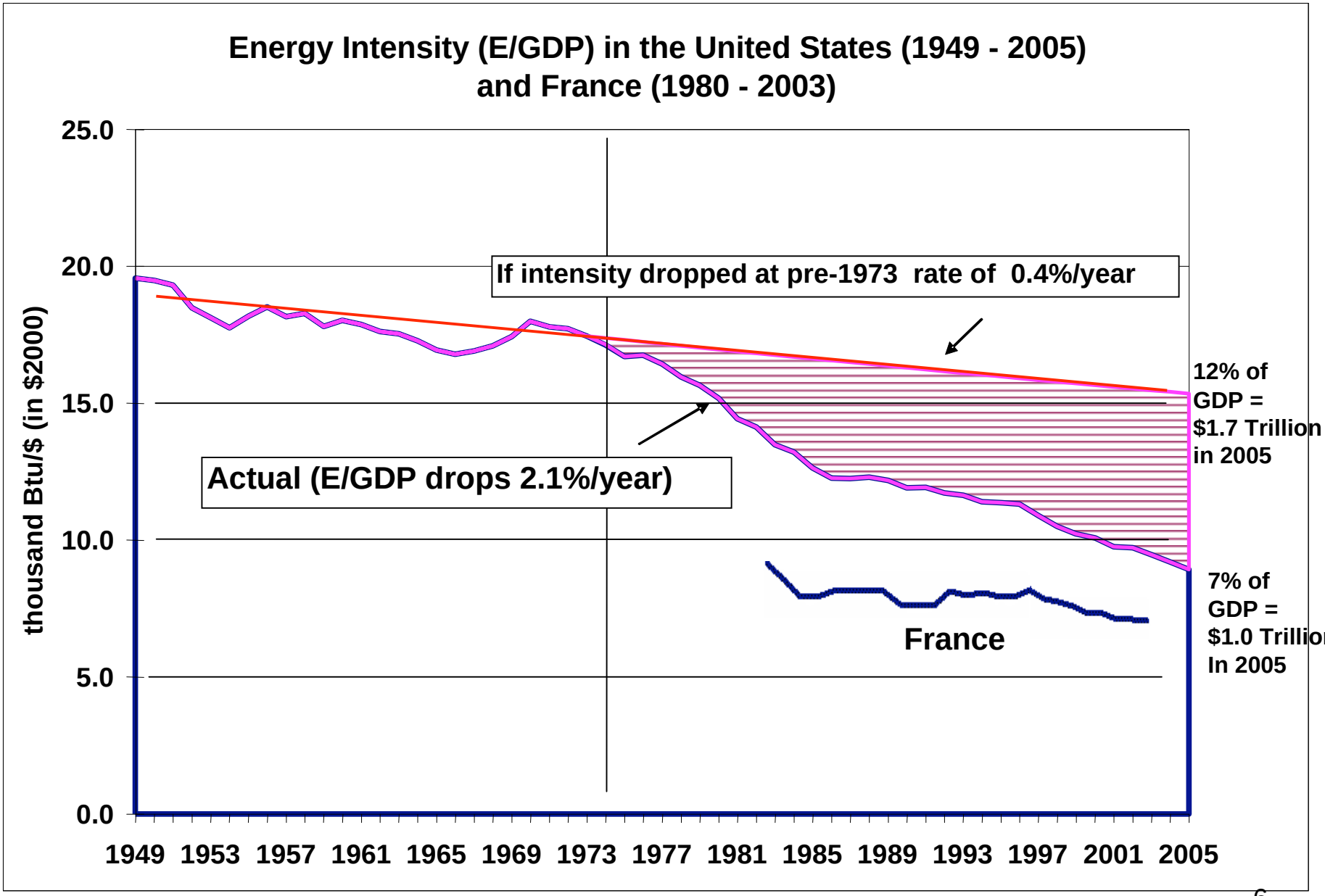
Two Energy Agencies in California

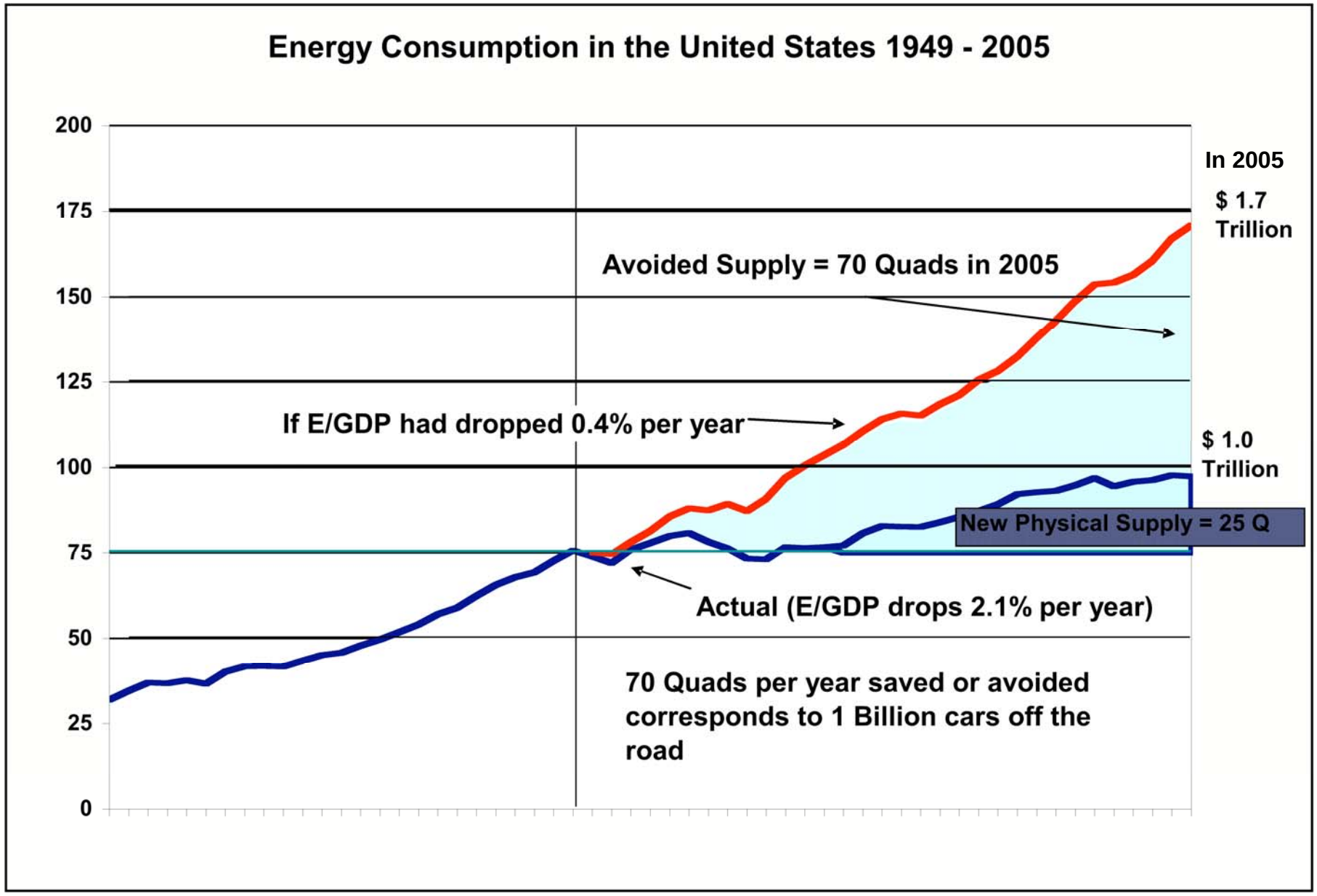
- The California Public Utilities Commission (CPUC) was formed in 1890 to regulate natural monopolies, like railroads, and later electric and gas utilities.
- The California Energy Commission (CEC) was formed in 1974 to regulate the environmental side of energy production and use.
- Now the two agencies 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.


Energy Intensity (E/GDP) in the United States (1949 - 2005)
and France (1980 - 2003)
thousand Btu/$ (in $2000)
25.0
20.0
15.0
10.0
5.0
0.0
1949
1953
1957
1961
1965
1969
1973
1977
1981
1985
1989
1993
1997
2001
2005
If intensity dropped at pre-1973 rate of 0.4%/year
Actual (E/GDP drops 2.1%/year)
France
12% of GDP = $1.7 Trillion in 2005
7% of GDP = $1.0 Trillion In 2005


Energy Consumption in the United States 1949 - 2005
200
175
150
125
100
75
50
25
0
In 2005
$ 1.7 Trillion
Avoided Supply = 70 Quads in 2005
If E/GDP had dropped 0.4% per year
$ 1.0 Trillion
New Physical Supply = 25 Q
Actual (E/GDP drops 2.1% per year)
70 Quads per year saved or avoided corresponds to 1 Billion cars off the road

How Much of The Savings Come from Efficiency

- Some examples of estimated savings in 2006 based on 1974 efficiencies minus 2006 efficiencies

	Billion $
Space Heating	**40**
Air Conditioning	**30**
Refrigerators	**15**
Fluorescent Tube Lamps	**5**
Compact Floursecent Lamps	**5**
Total	**95**

- Beginning in 2007 in California, reduction of “vampire” or stand-by losses
  - This will save $10 Billion when finally implemented, nation-wide
- Out of a total **$700 Billion**, a crude summary is that 1/3 is structural, 1/3 is from transportation, and 1/3 from buildings and industry.

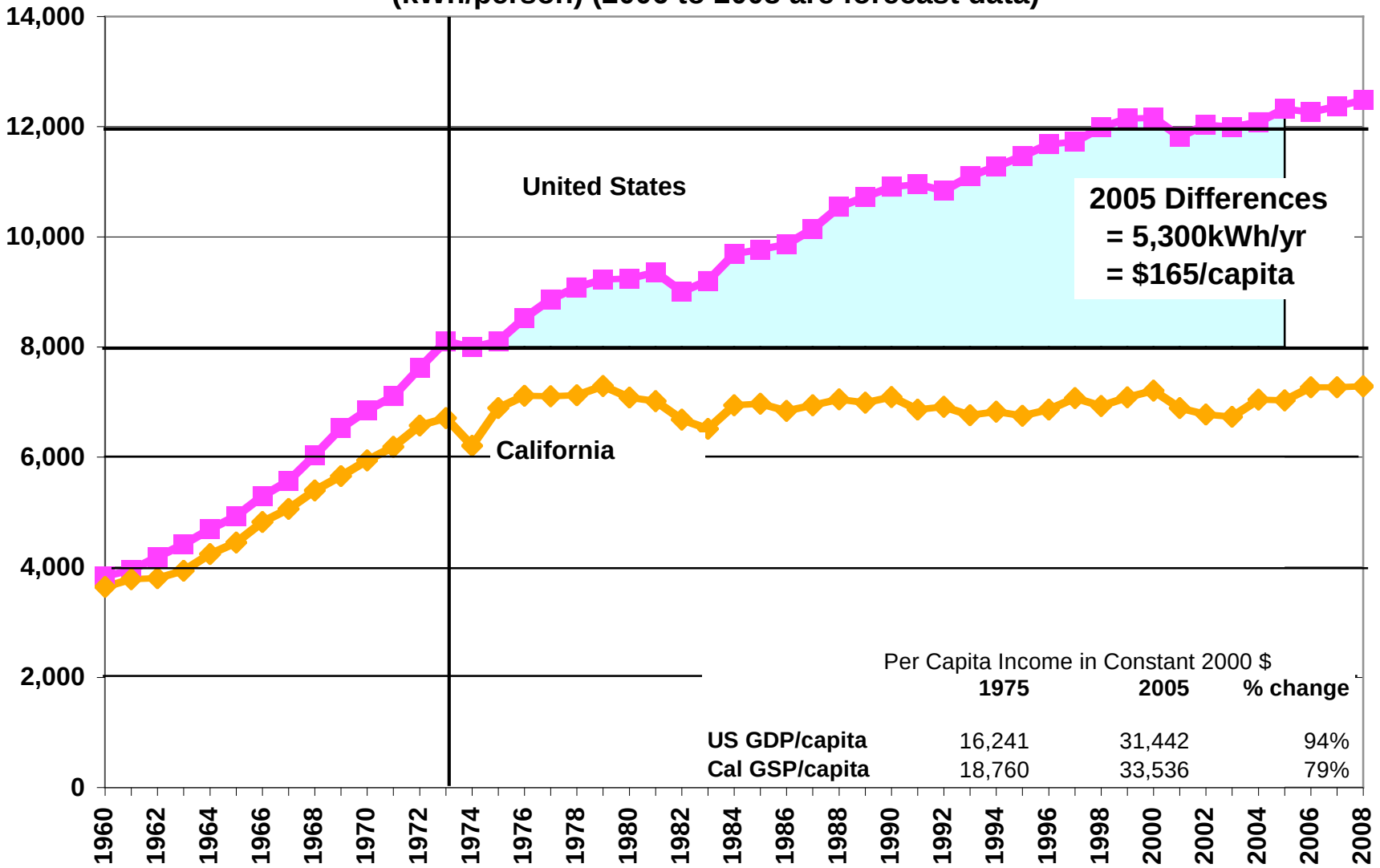
California's Energy Action Plan

- 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.

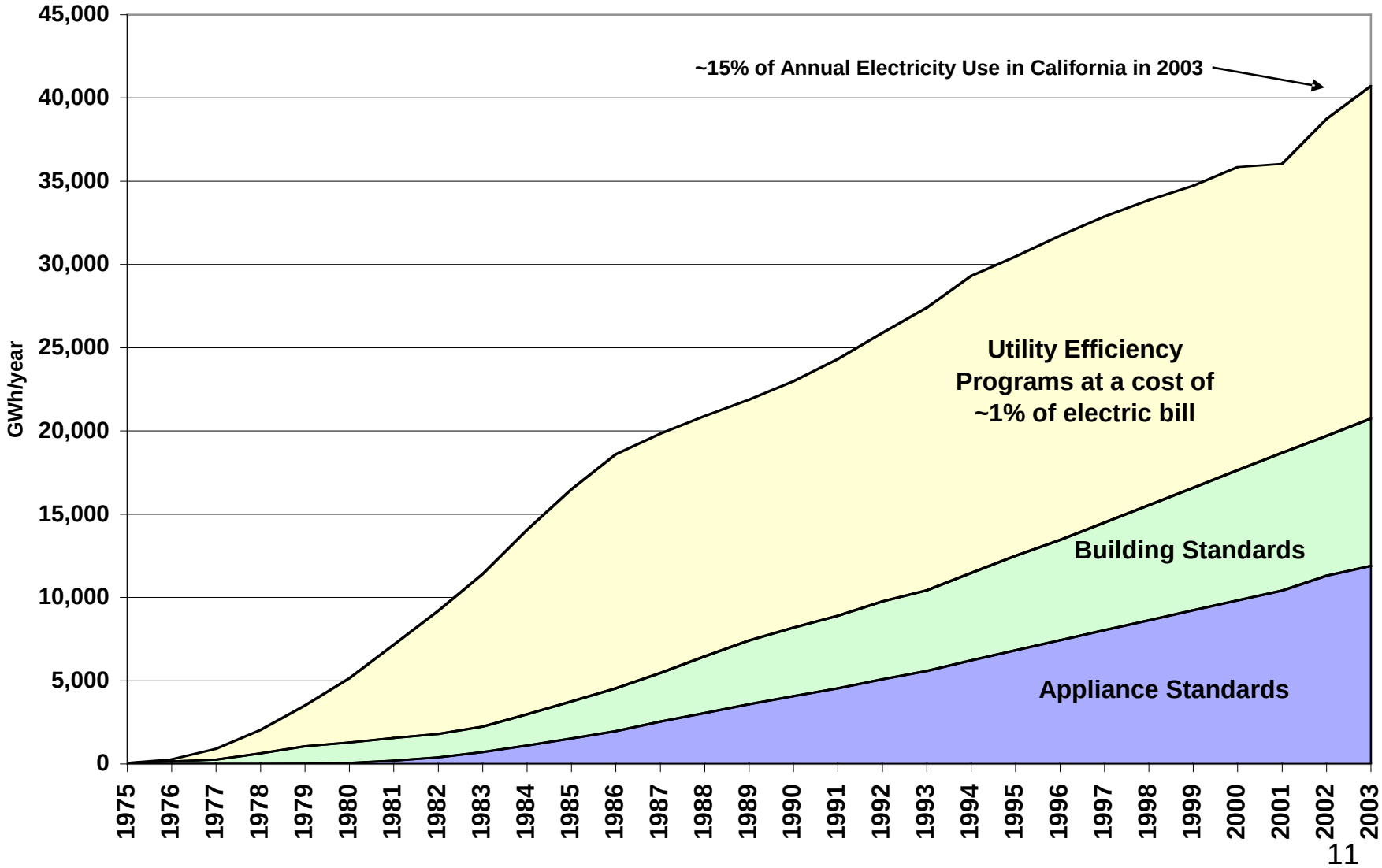
- 1. Energy efficiency and Demand Response
- 2. Renewable Generation,
- 3. Increased development of affordable & reliable conventional generation
- 4. Transmission expansion to support all of California's energy goals.

- The Energy Action Plan has been updated since 2003 and provides overall policy direction to the various state agencies involved with the energy sectors

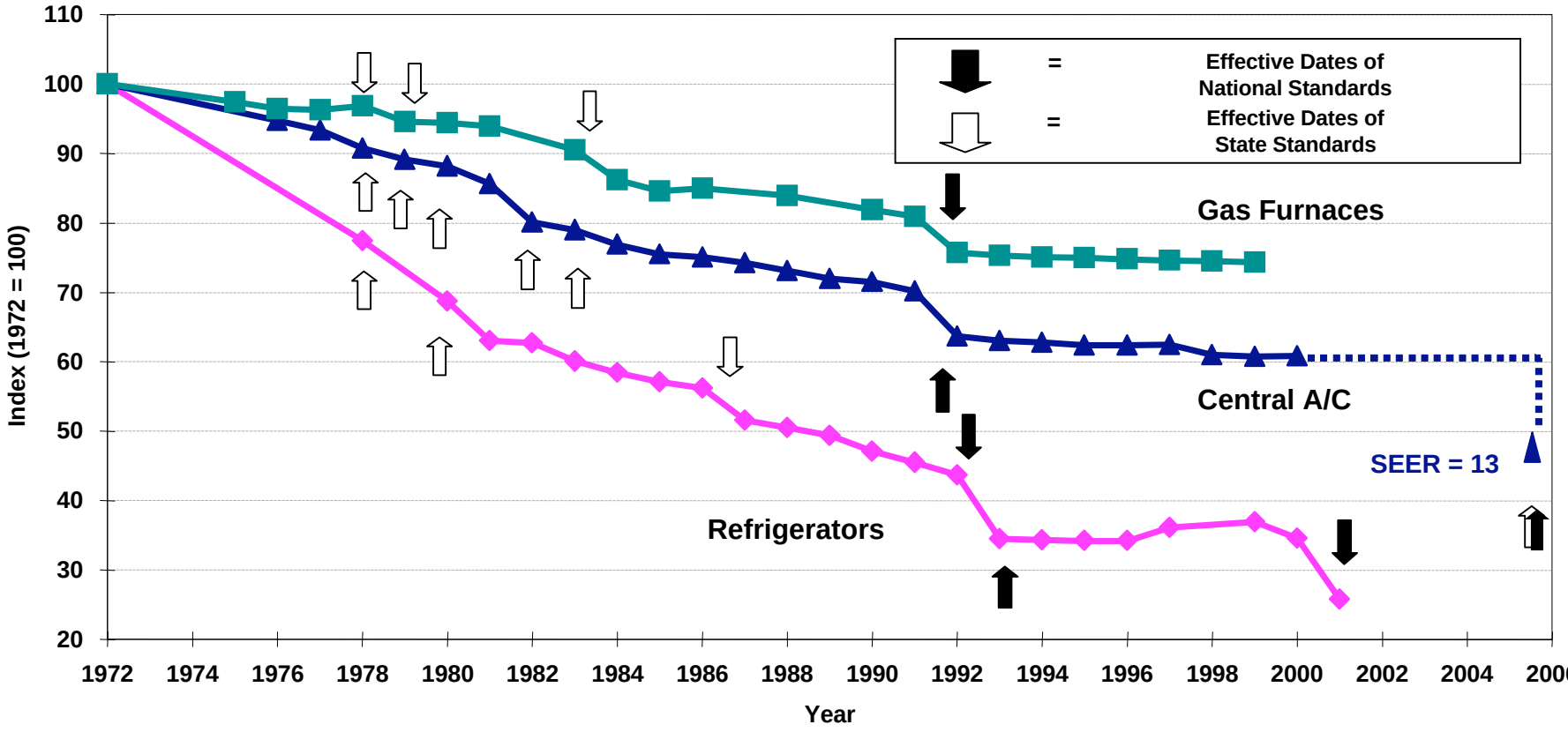
Per Capita Electricity Sales (not including self-generation) (kWh/person) (2006 to 2008 are forecast data)



Annual Energy Savings from Efficiency Programs and Standards

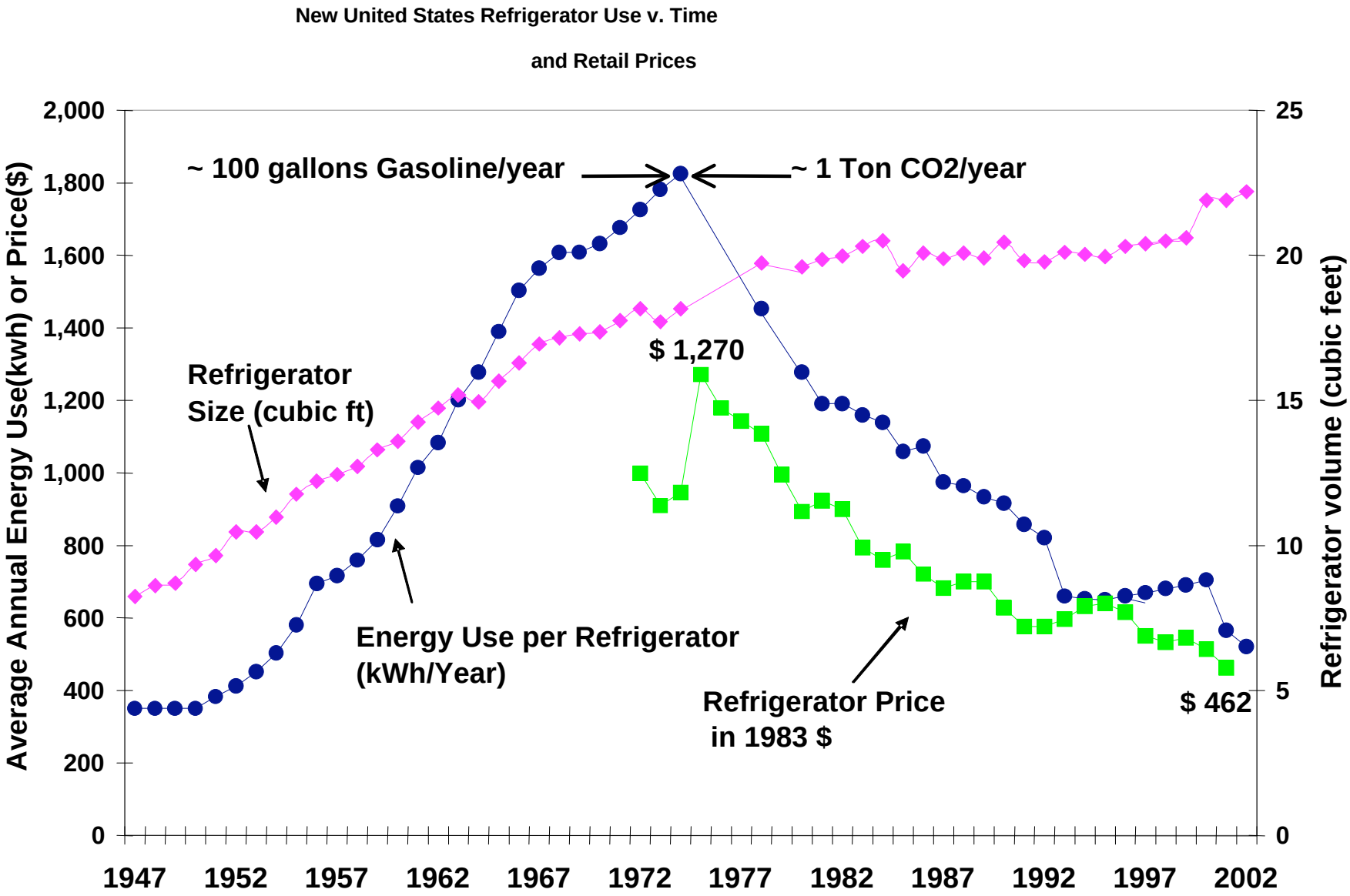


Impact of Standards on Efficiency of 3 Appliances



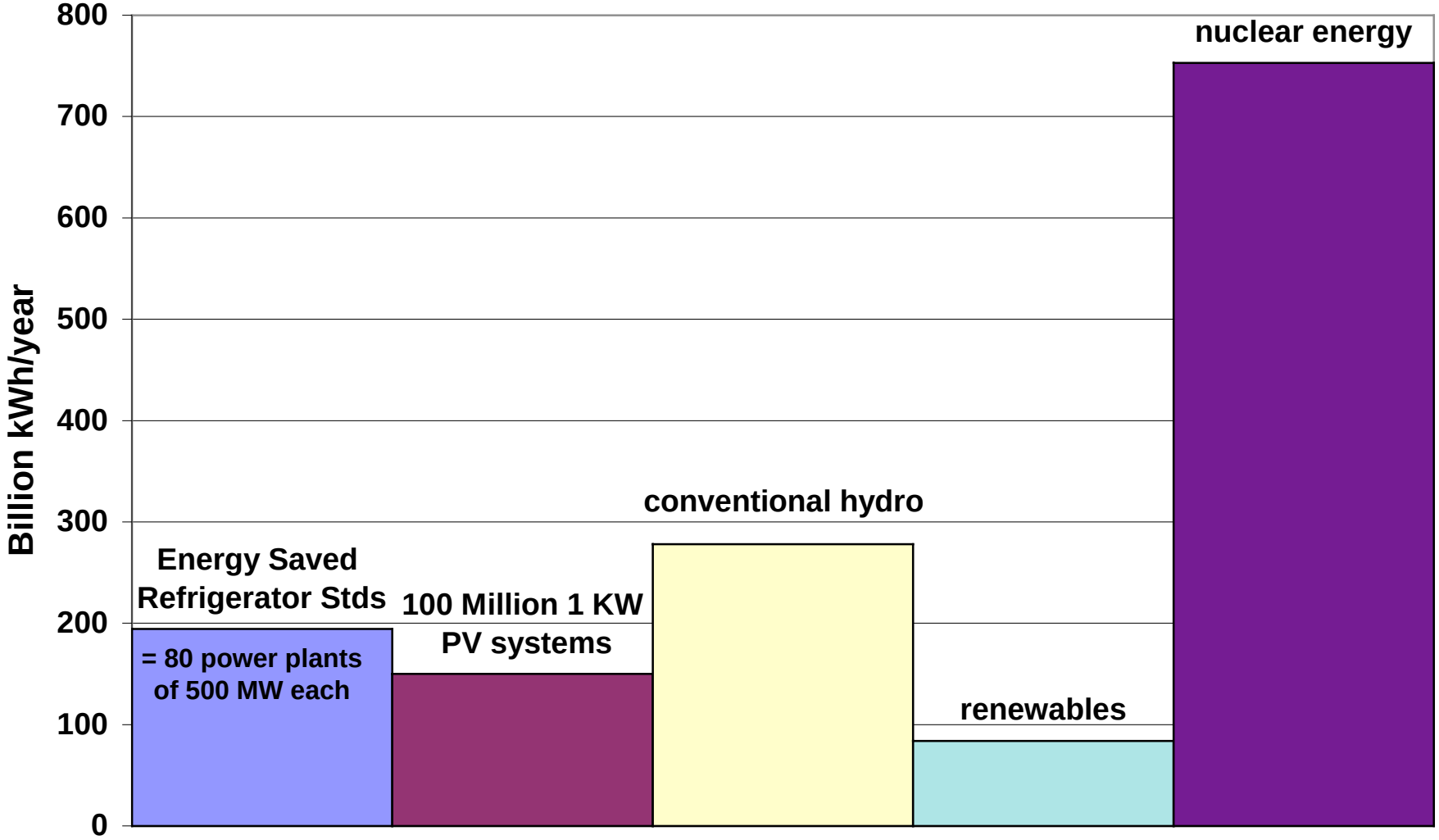
Source: S. Nadel, ACEEE,

in ECEEE 2003 Summer Study, www.eceee.org



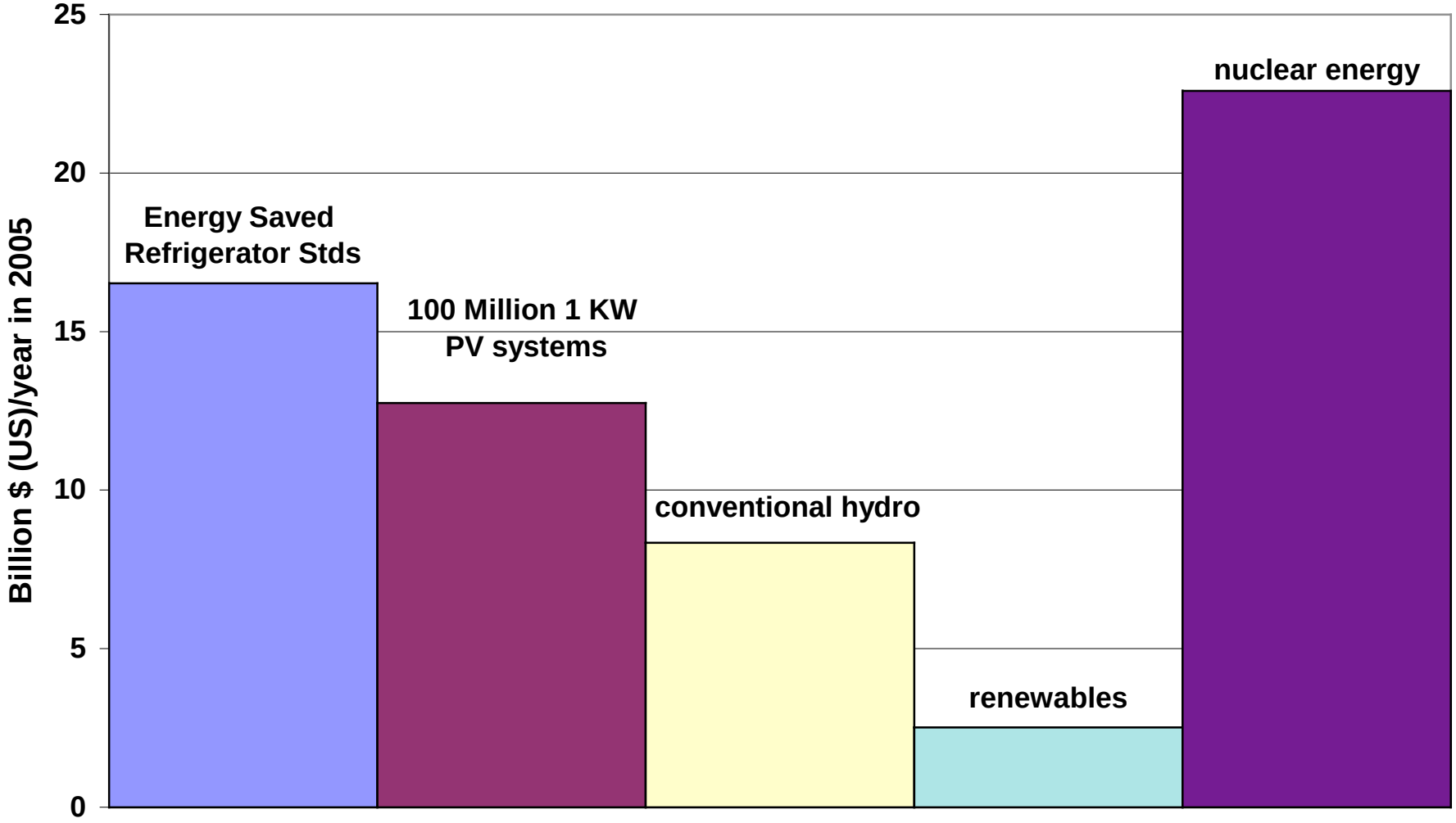
Source: David Goldstein

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

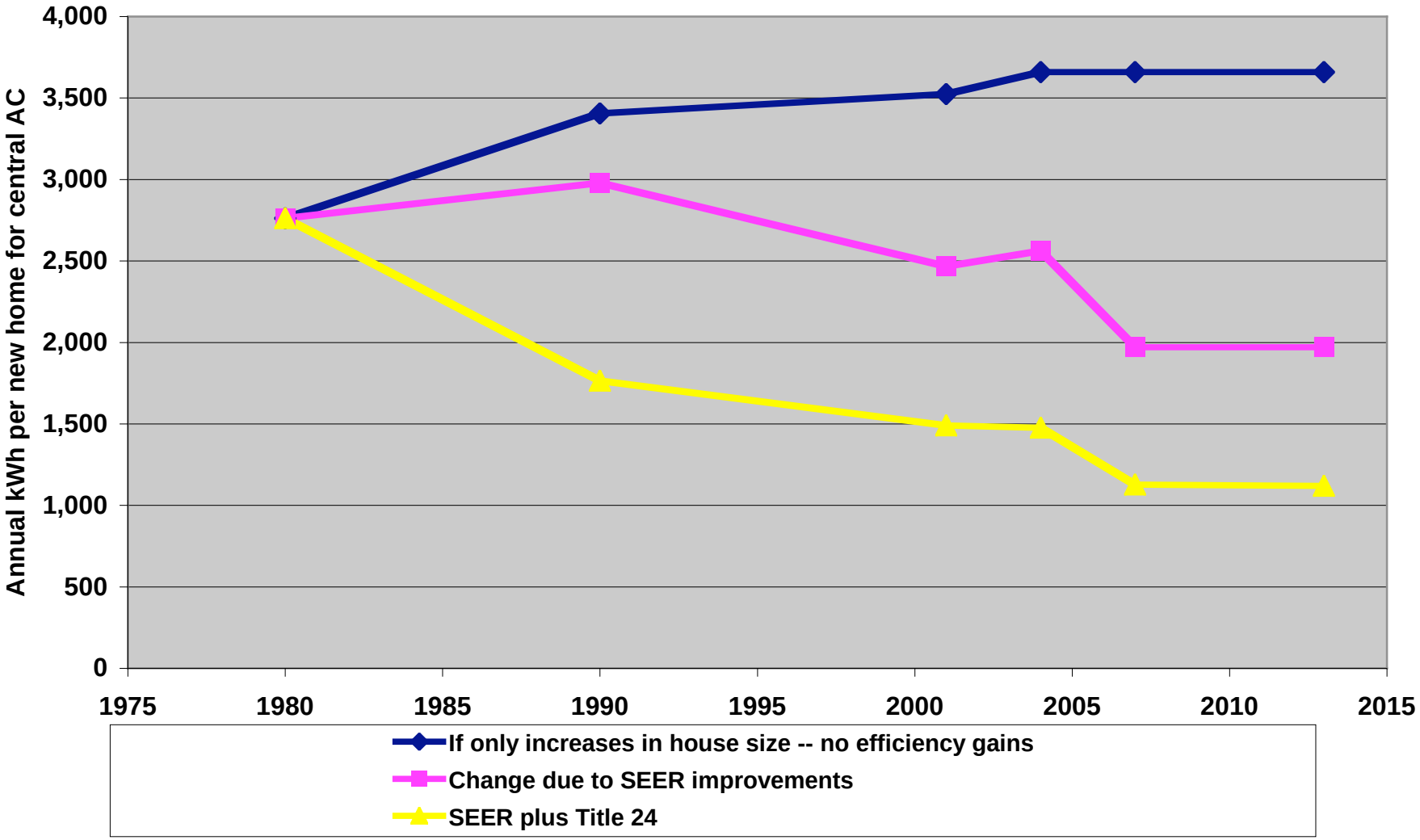


In the United States

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)

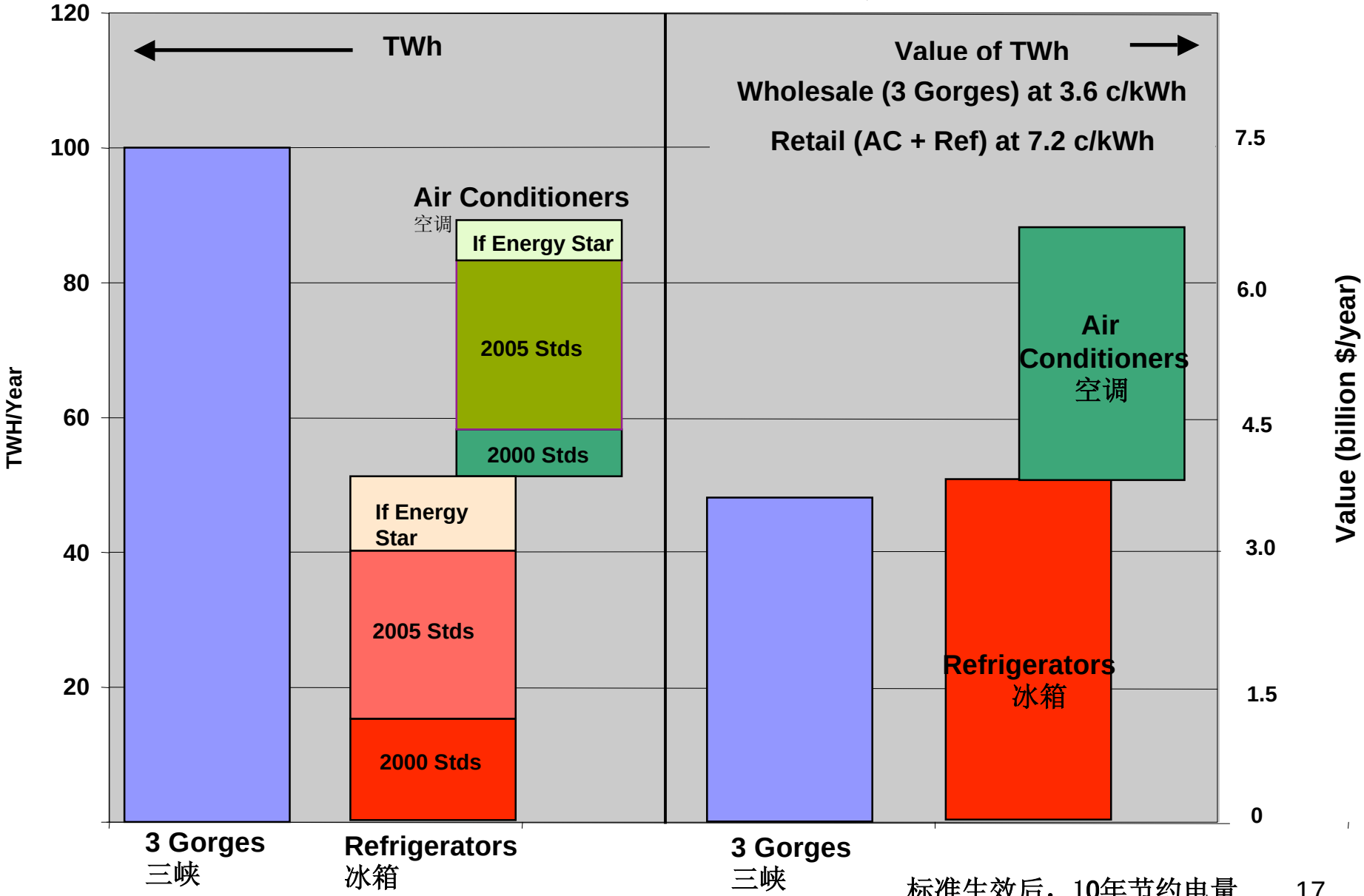


Air Conditioning Energy Use in Single Family Homes in PG&E
The effect of AC Standards (SEER) and Title 24 standards



Comparison of 3 Gorges to Refrigerator and AC Efficiency Improvements

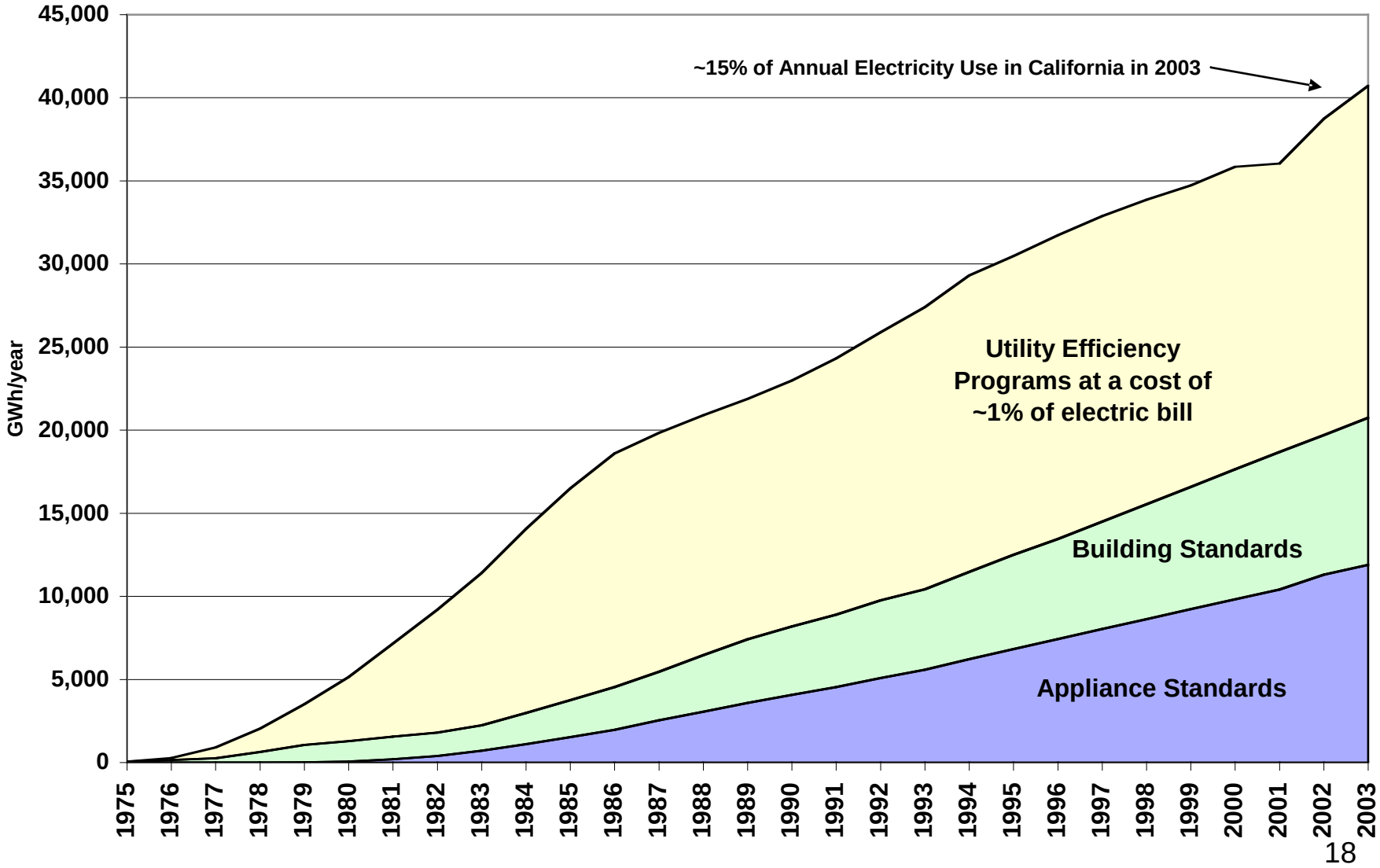
三峡电量与电冰箱、空调能效对比



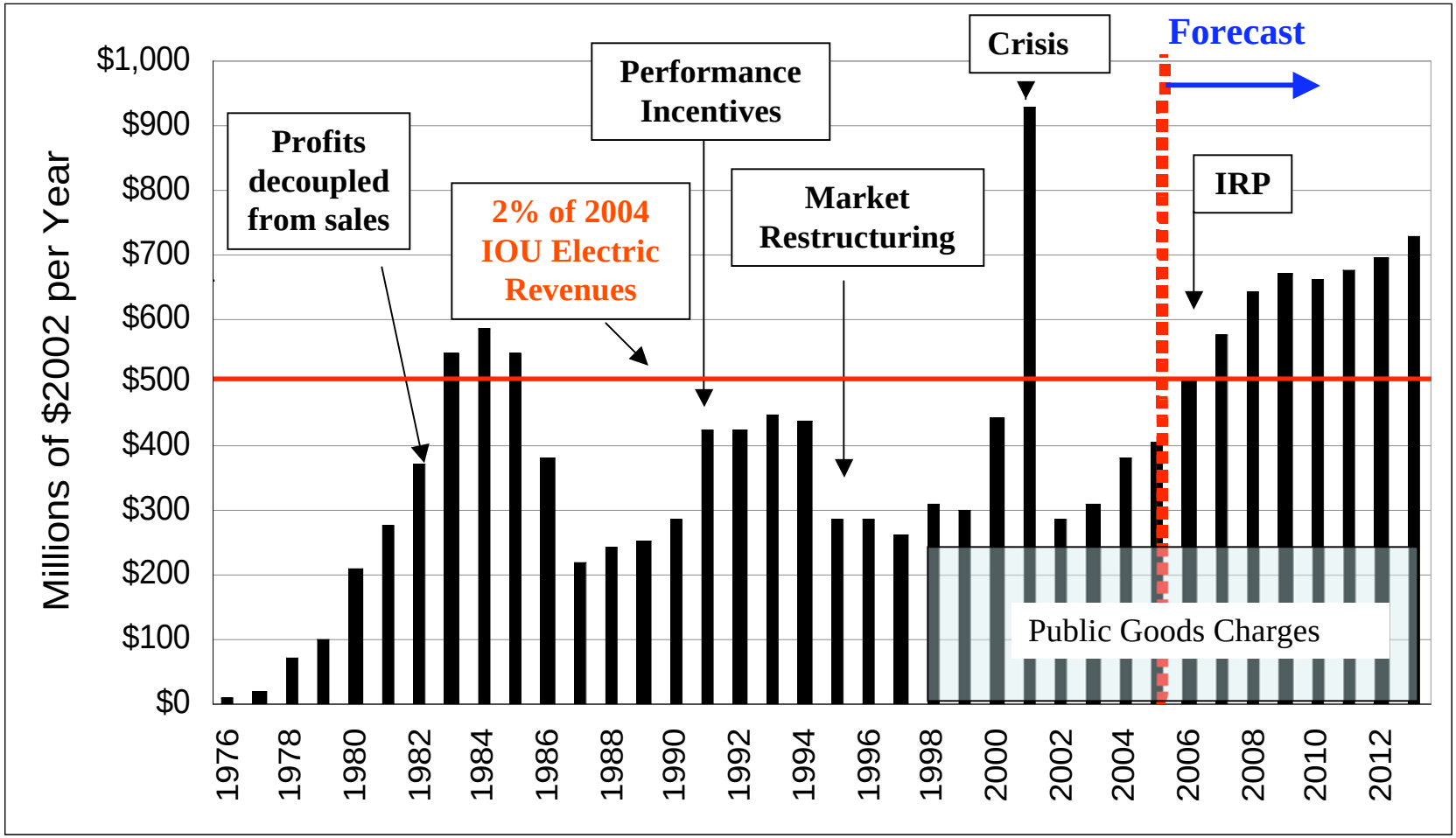
Savings calculated 10 years after standard takes effect. Calculations provided by David Fridley, LBNL

标准生效后，10年节约电量

Annual Energy Savings from Efficiency Programs and Standards

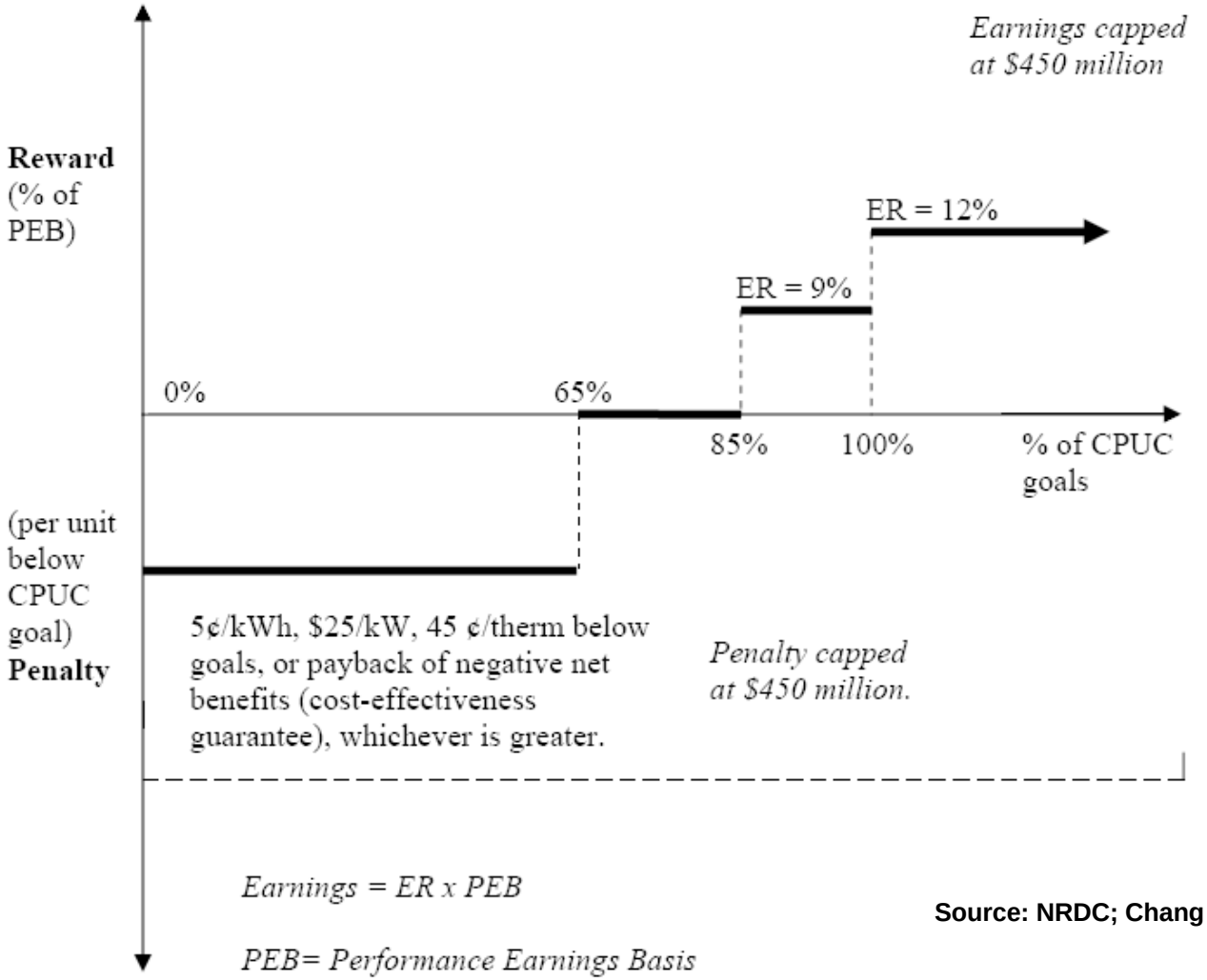


California IOU's Investment in Energy Efficiency



Energy Efficiency Incentive Mechanism Earnings/Penalty Curve

(D.07-09-043, p. 8)



Source: NRDC; Chang and Wang, 9/26/2007

- *To be published in Climatic Change 2008.*

• Global Cooling: Increasing World-wide Urban Albedos to Offset CO2

July 28, 2008

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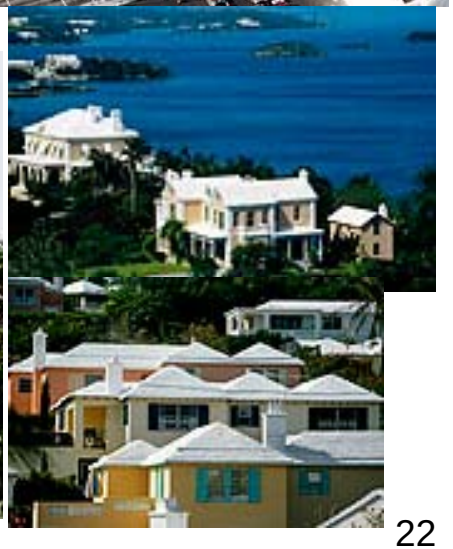
• A First Step In Geo-Engineering Which Saves Money and Has Known Positive Environmental Impacts

1000 ft^2 of a white roof, replacing a dark roof, offset the emission of 10 tonnes of CO_2



CO_2 Equivalency of Cool Roofs World-wide (Tropics+Temperate)

- Cool Roofs alone offset 24 Gt CO2
- Worth > €600 Billion
- To Convert 24 Gt CO2 one time into a rate
- Assume 20 Year Program, thus

1.2 Gt CO2/year

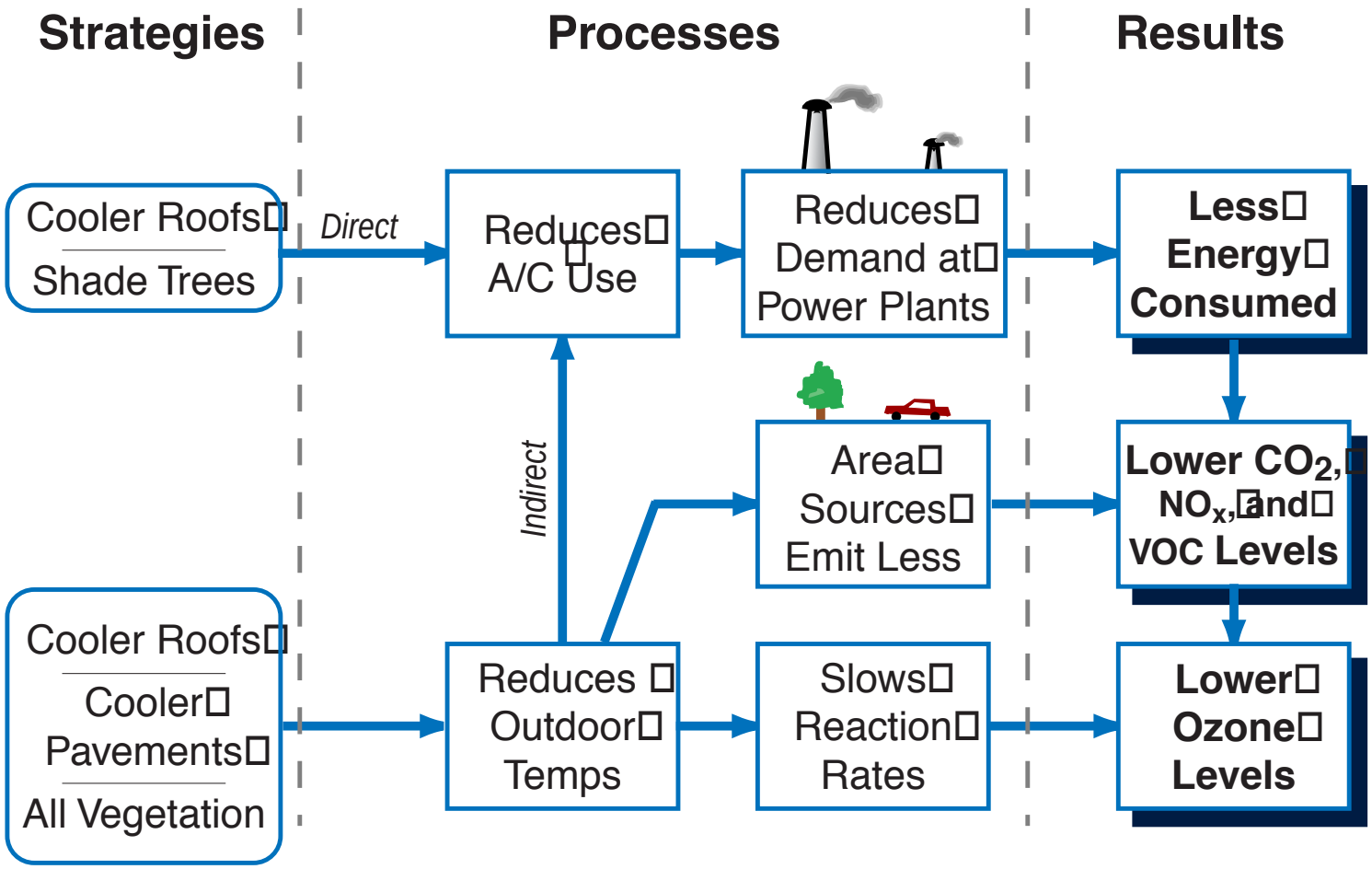
- Average World Car Emits 4 tCO2/year,

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

ENERGY EFFICIENCY CENTER

- **AT UC DAVIS:**
- **Daniel Sperling: Acting Director**
- **Alan Meier: Associate Director and Faculty Researcher**
- **Mark Modera: Director of the Western Cooling Efficiency Center**
- **Michael Siminovitch: Director of the California Lighting Technology Center (CLTC)**

Methodology: Energy and Air-Quality Analysis



White is ‘cool’ in Bermuda

and in Santorini, Greece

Cool Roof Technologies

Old

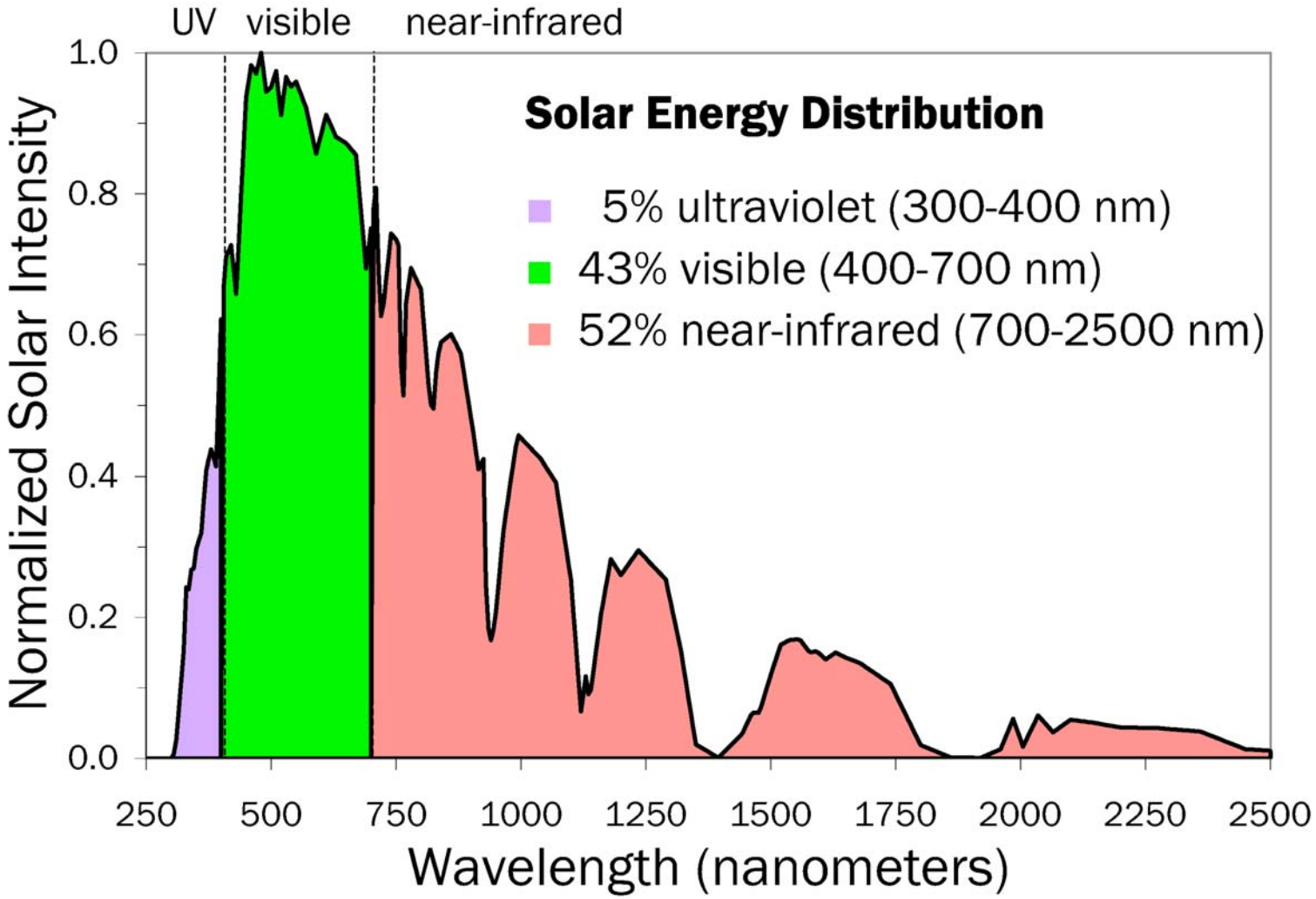
flat, white

pitched, white

New

pitched, cool & colored

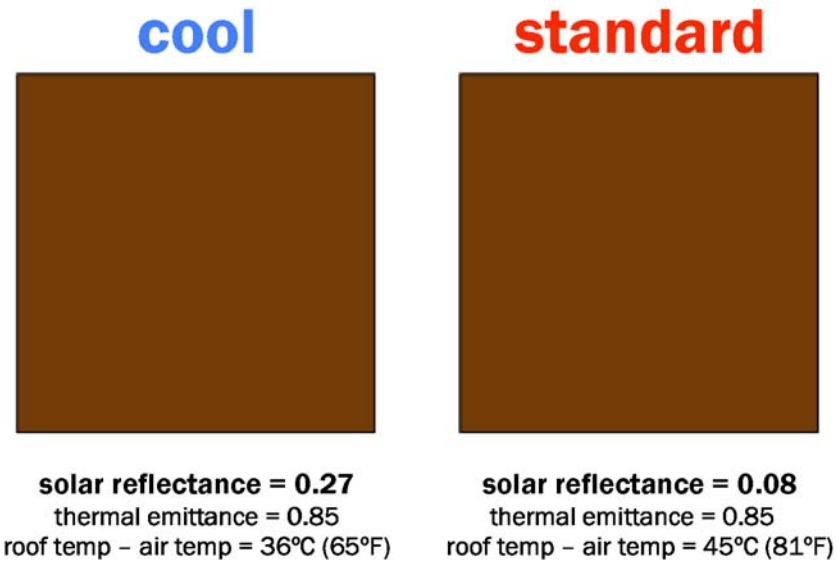
Cool Colors Reflect Invisible Near-Infrared Sunlight

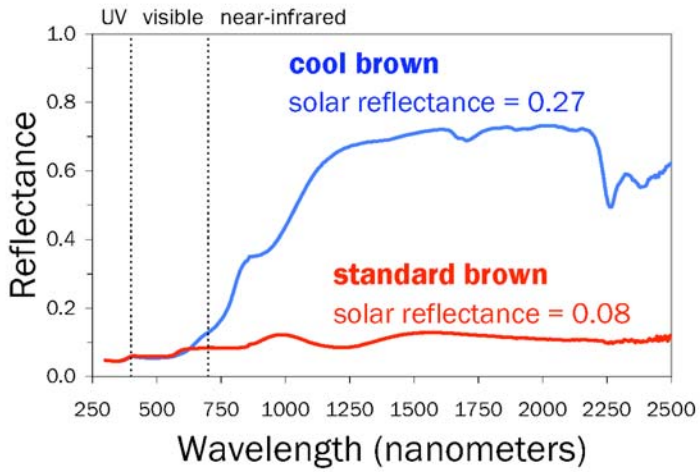


Cool and Standard Brown Metal Roofing Panels

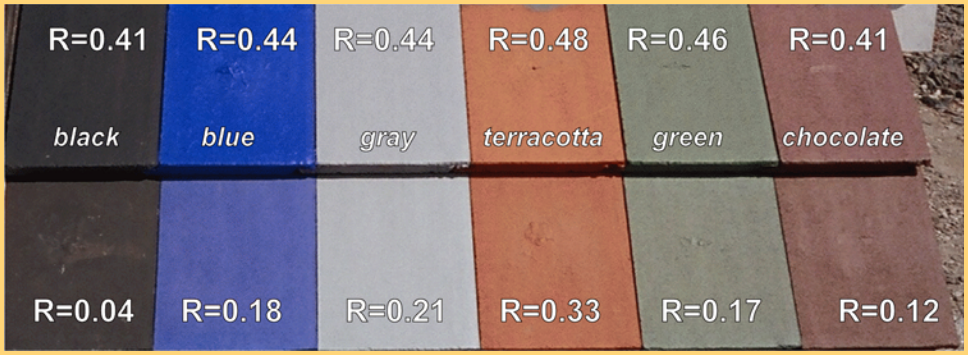
- Solar reflectance ~ 0.2 higher
- Afternoon surface temperature ~ 10ºC lower

Courtesy BASF Coatings





Designing Cool Colored Roofing



cool concrete tile
R ≥0.40

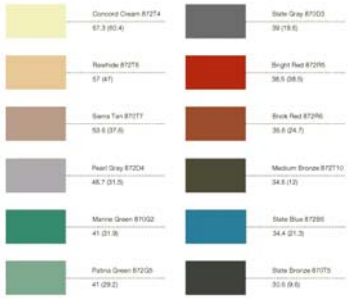
standard concrete tile
(same color)

solar reflectance gain = **+0.37** **+0.26** **+0.23** **+0.15** **+0.29** **+0.29**

Courtesy American Rooftile Coatings

cool clay tile
R ≥0.40

Courtesy MCA Clay Tile



cool metal
R ≥0.30

Courtesy BASF Industrial Coatings

cool fiberglass asphalt shingle
R ≥0.25
Courtesy Elk Corporation

Cool is Cool: From Cool Color Roofs to Cool Color Cars and Cool Jackets

- Toyota experiment (surface temperature 10K cooler)
- Ford is also working on the technology

Courtesy: BMW (http://www.ips-innovations.com/solar_reflective_clothing.htm)

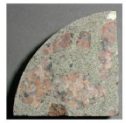
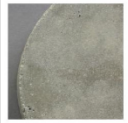
The End

For More Information:

http://www.energy.ca.gov/commissioners/rosenfeld_docs/index.html

or just Google “Art Rosenfeld”

Cool Paving Materials:

Concrete	**(a)** Unexposed	**(b)** Weathered	**(c)** Weathered, wetted	**(d)** Soiled	**(e)** Abraded	**(f)** Formed
C1:S1:R2 gray cement/ riverbed sand/ granite rock	 ρ=0.44	 ρ=0.34	 ρ=0.14	 ρ=0.43	 ρ=0.24	 ρ=0.25

Reflective Pavements are Cooler

- **Fresh asphalt**

Albedo: 0.05
Temperature: 123°F

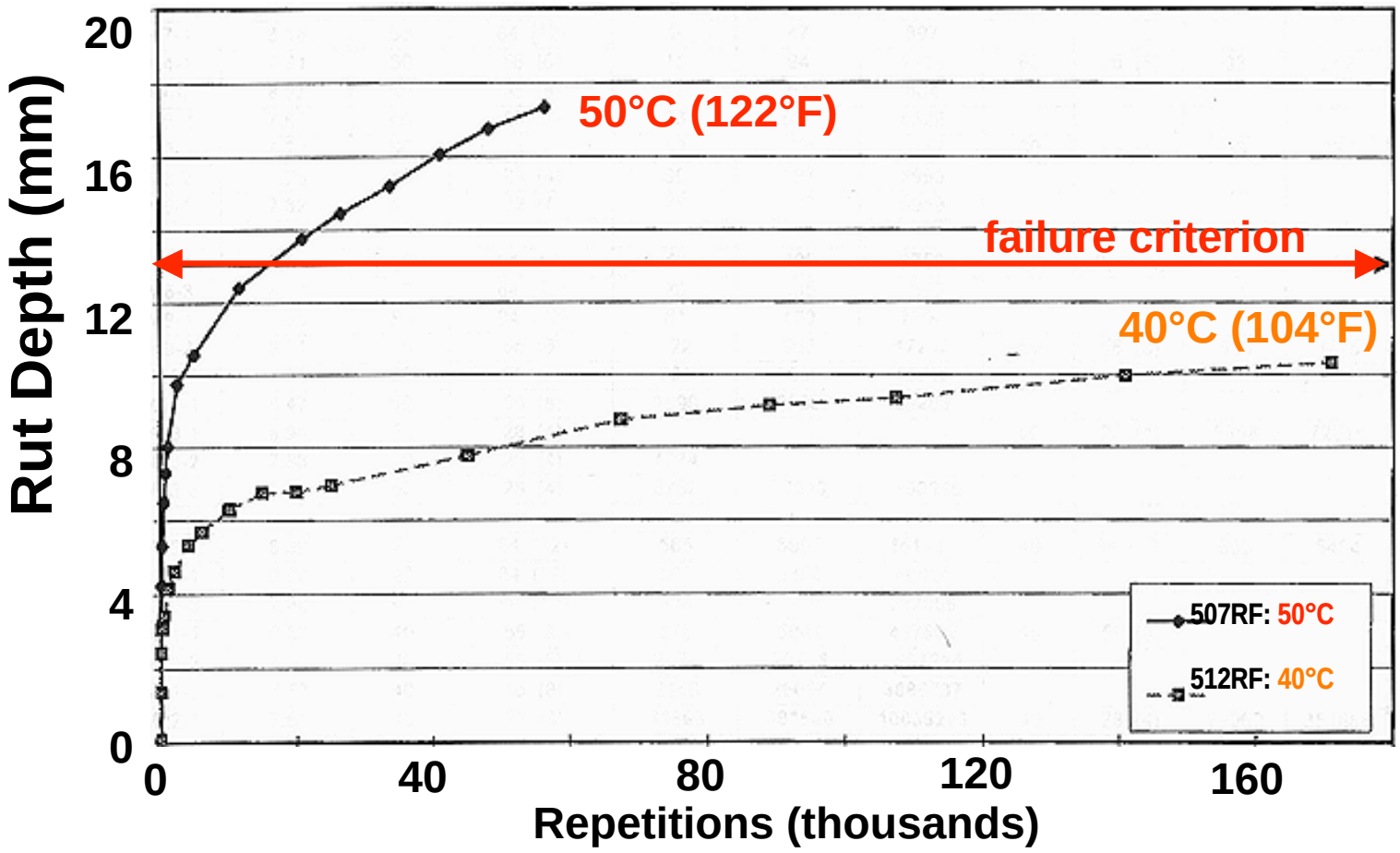
- **Aged asphalt**

Albedo: 0.15
Temperature: 115°F

- **Prototype asphalt coating**

Albedo: 0.51
Temperature: 88°F

Temperature Effect on Rutting

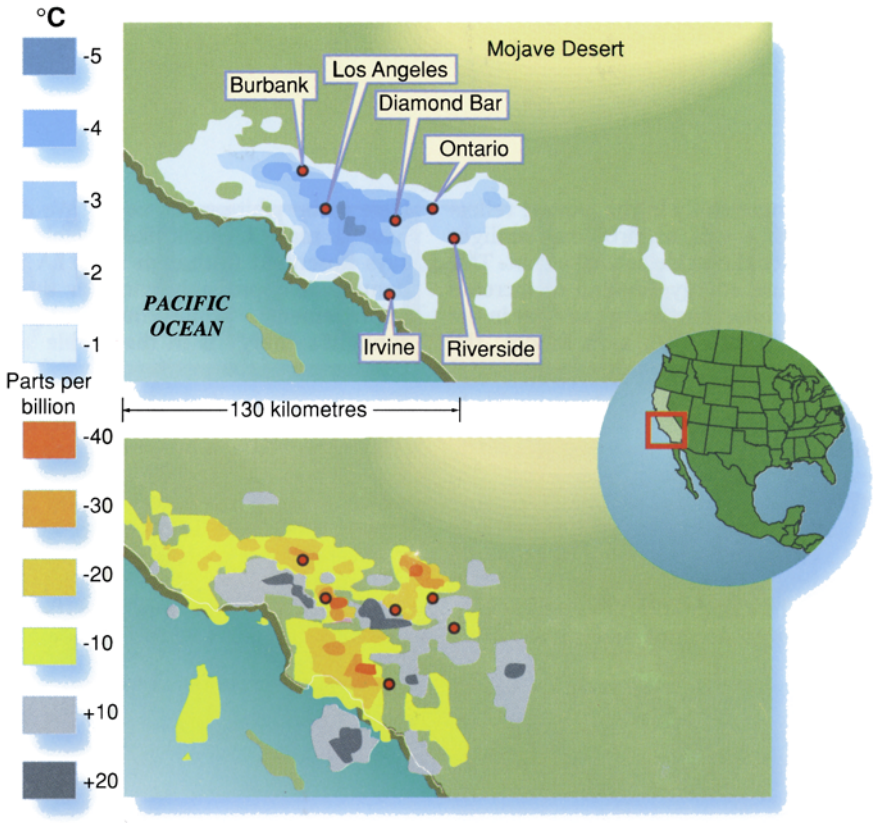


Source: Dr. John Harvey, UC B Civil Engineering, Inst. Transpo. Studies

Simulated Meteorology and Air-quality Impacts in LA

Temperature Change

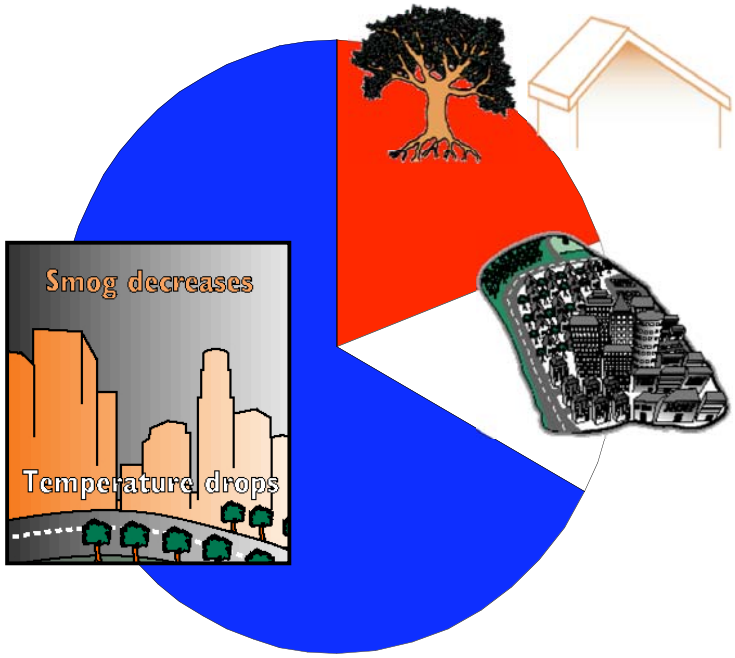
Ozone Concentration Change



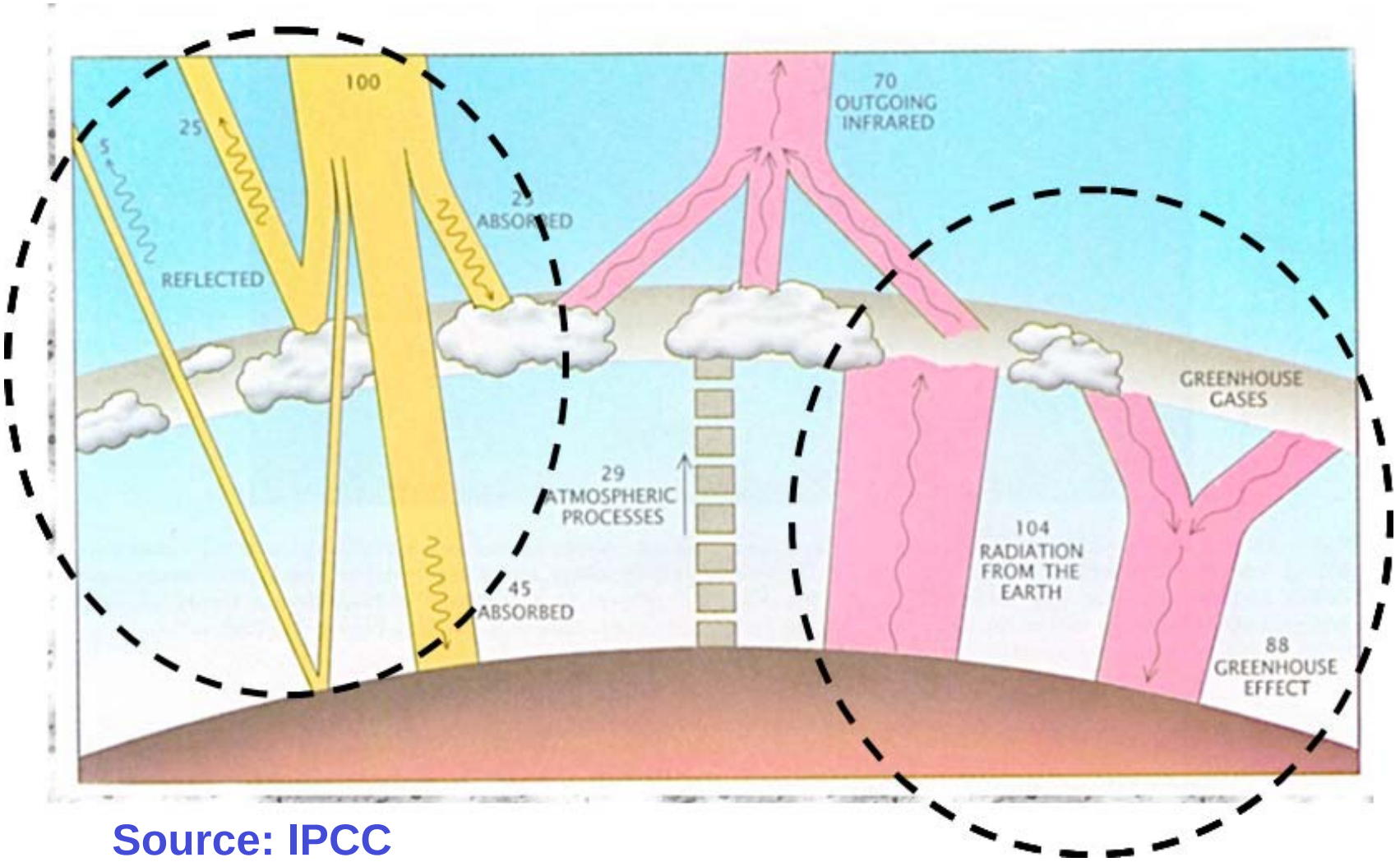
Potential Savings in LA

- **Savings for Los Angeles**
  - Direct, $100M/year
  - Indirect, $70M/year
  - Smog, $360M/year

- **Estimate of national savings: $5B/year**



Solar Reflective Surfaces Also Cool the Globe



Source: IPCC

Effect of Solar Reflective Roofs and Pavements in Cooling the Globe

(Source: Akbari et al. 2008, in press Climatic Change)

- Increasing the solar reflectance of a m^2 of roofs by 0.40 (white roof) is equivalent to offsetting 63 kg CO_2 emissions
  ($10\ m^2$ of white roof = 1 T CO_2 emission offset)
- Increasing the solar reflectance of a m^2 of roofs by 0.25 (cool roof) is equivalent to offsetting 63 kg CO_2 emissions
  ($16\ m^2$ of cool roof = 1 T CO_2 emission offset)
- Increasing the solar reflectance of a m^2 of paved surfaces by 0.15 is equivalent to offsetting 38 kg CO_2 emissions
- Total world-wide emission offset from cool roofs and cool pavements is 44 GT CO_2
- 44 GT CO_2 is over one year of the world 2025 emission of 37 GT CO_2
- CO_2 emissions currently trade at ~$25/T; 44 GT CO_2 worth $1100 billion

A Global Action Plan: The Big Picture

- Develop an international to install cool roof/pavement in world's100 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