

Efficient Use of Energy

Anthropology 137

November 6, 2008

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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?





The Guardian for America.

guardian.co.uk | **TheObserver**

Time runs out for islanders on global warming's front line

Rising sea levels threaten to flood many of the islands in the fertile Ganges delta, leading to an environmental disaster and a refugee crisis for India and Bangladesh

Dan McDougall in the Sundarbans
The Observer, Sunday March 30 2008

**To find this story, Google "Sundarbans Refugee
Camp"**

Two Energy Agencies in California

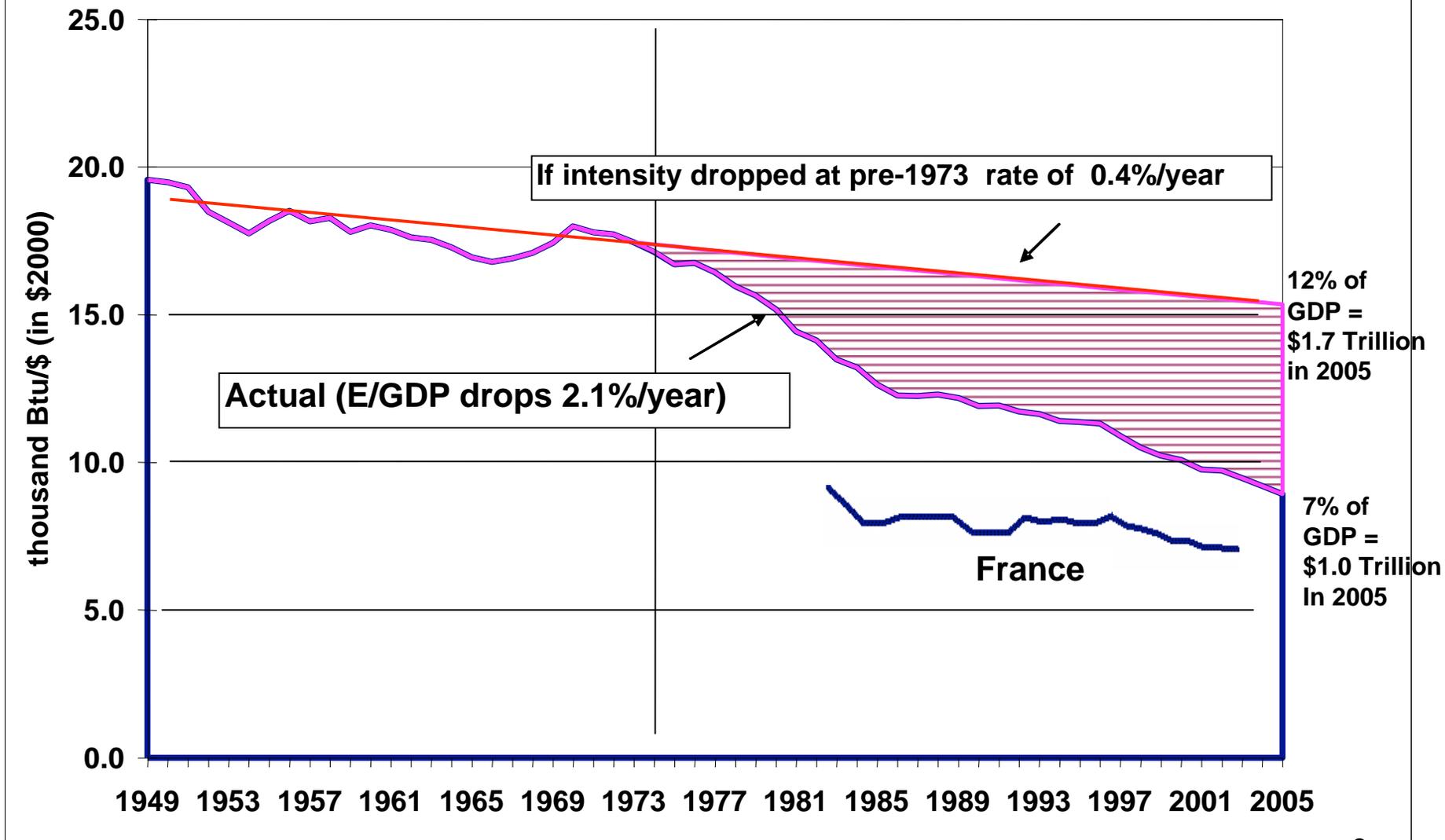
- The California Public Utilities Commission (CPUC) was formed in 1890 to regulate natural monopolies, like railroads, and later electric and gas utilities.
- The California Energy Commission (CEC) was formed in 1974 to regulate the environmental side of energy production and use.
- Now the two agencies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

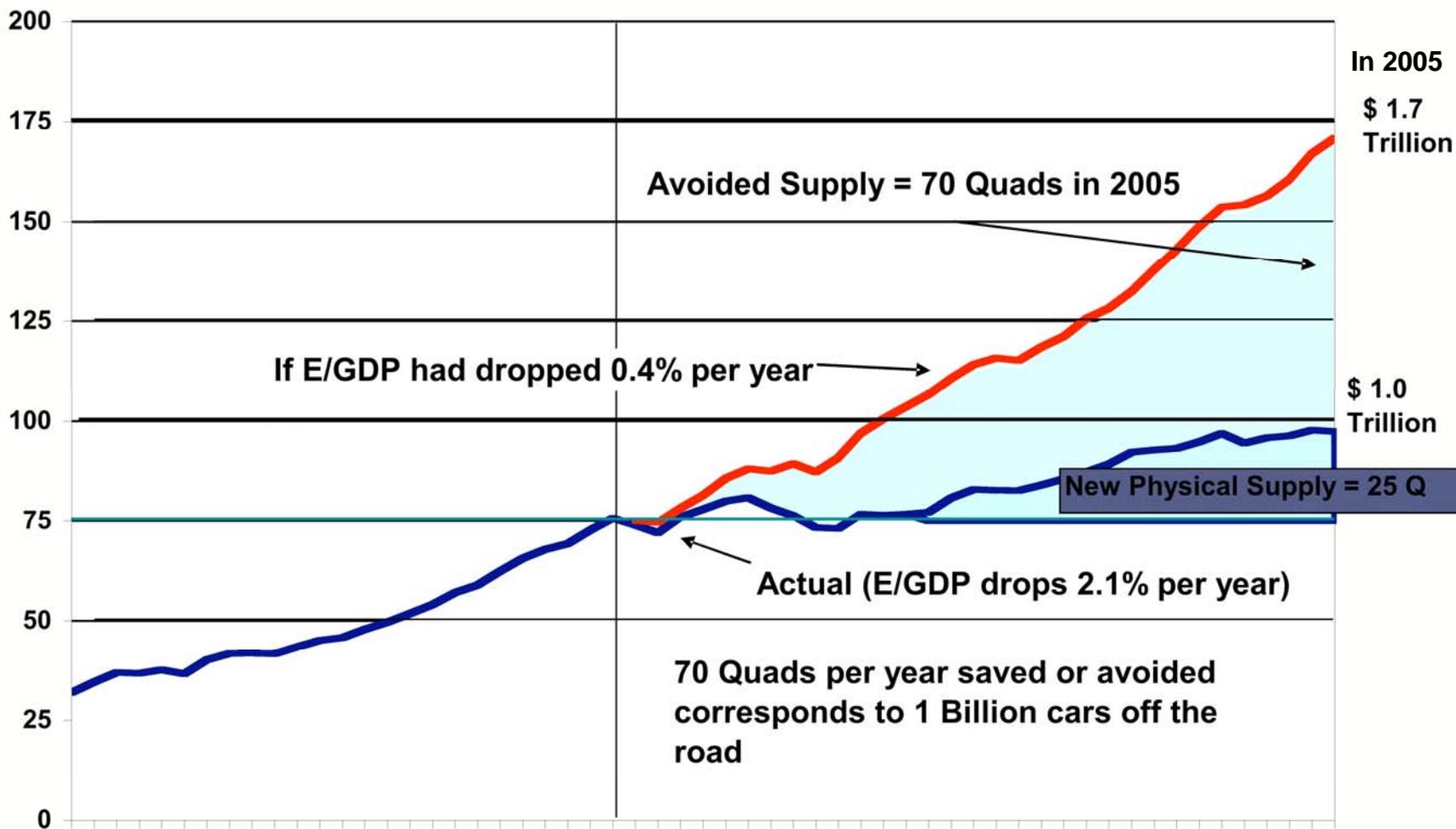
Both Regulation and R&D

- 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)



Energy Consumption in the United States 1949 - 2005



How Much of The Savings Come from Efficiency

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

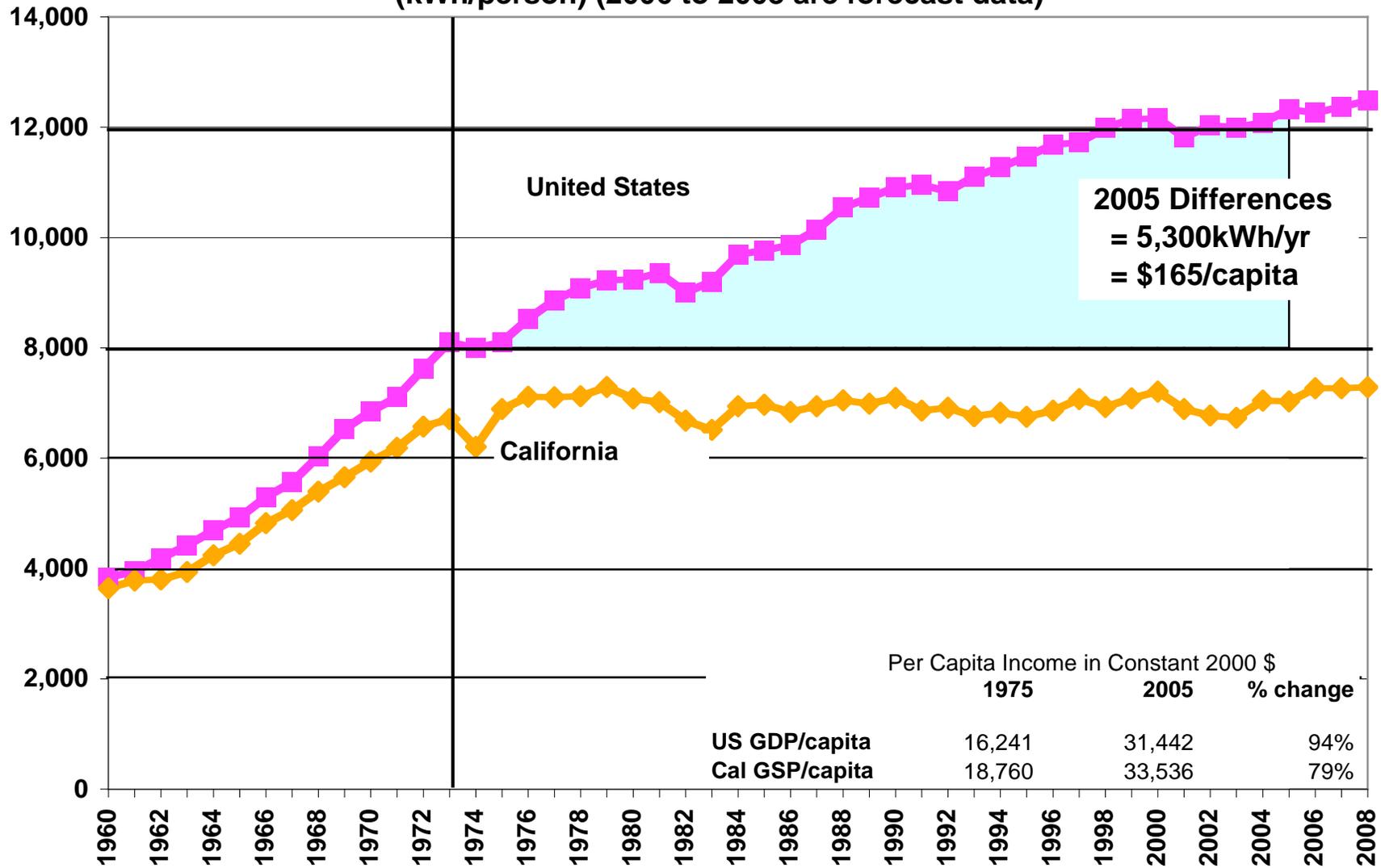
	Billion \$
Space Heating	40
Air Conditioning	30
Refrigerators	15
Fluorescent Tube Lamps	5
Compact Fluorescent Lamps	5
Total	95

- Beginning in 2007 in California, reduction of “vampire” or stand-by losses
 - This will save \$10 Billion when finally implemented, nationwide
- 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.

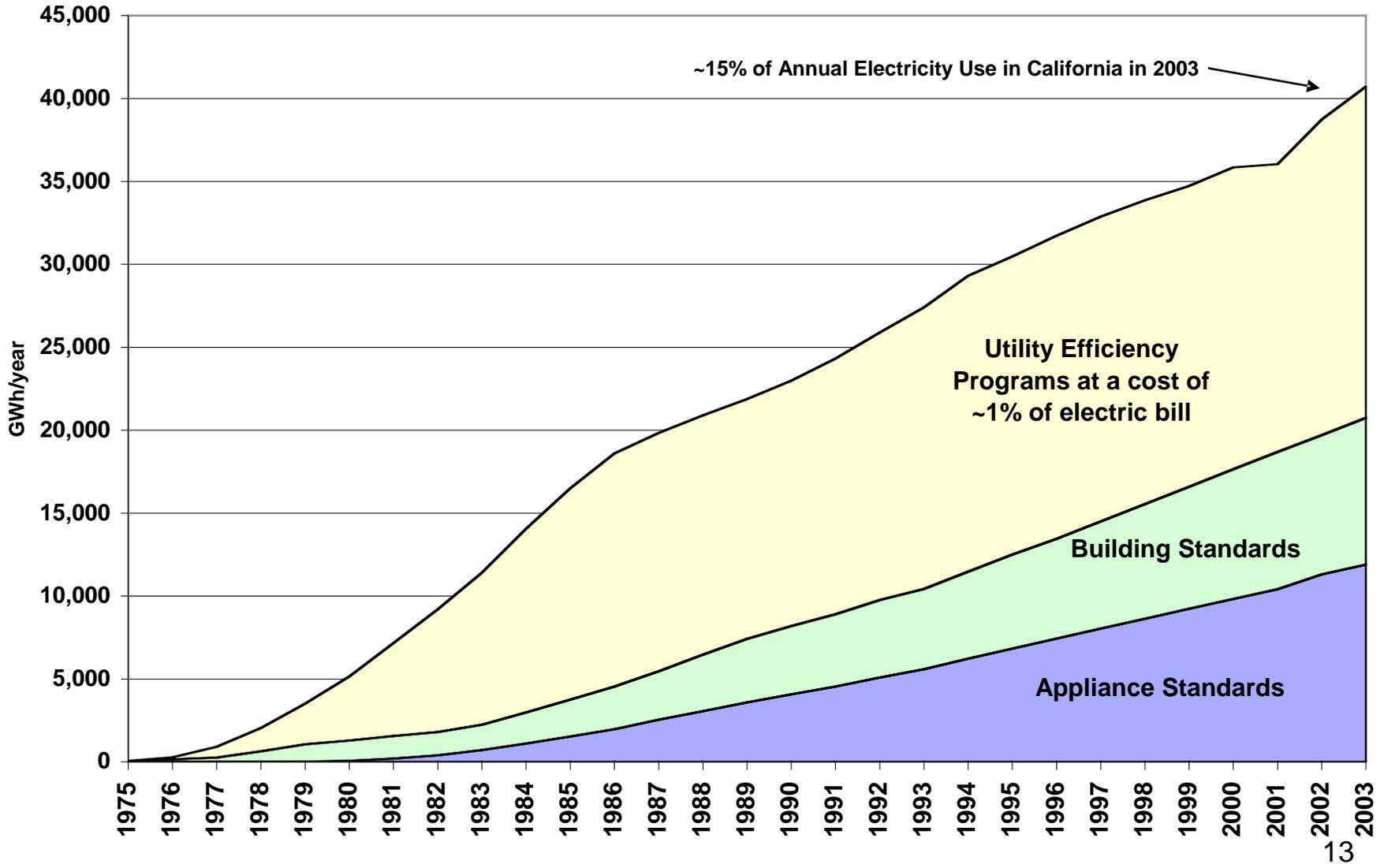
California's Energy Action Plan

- 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

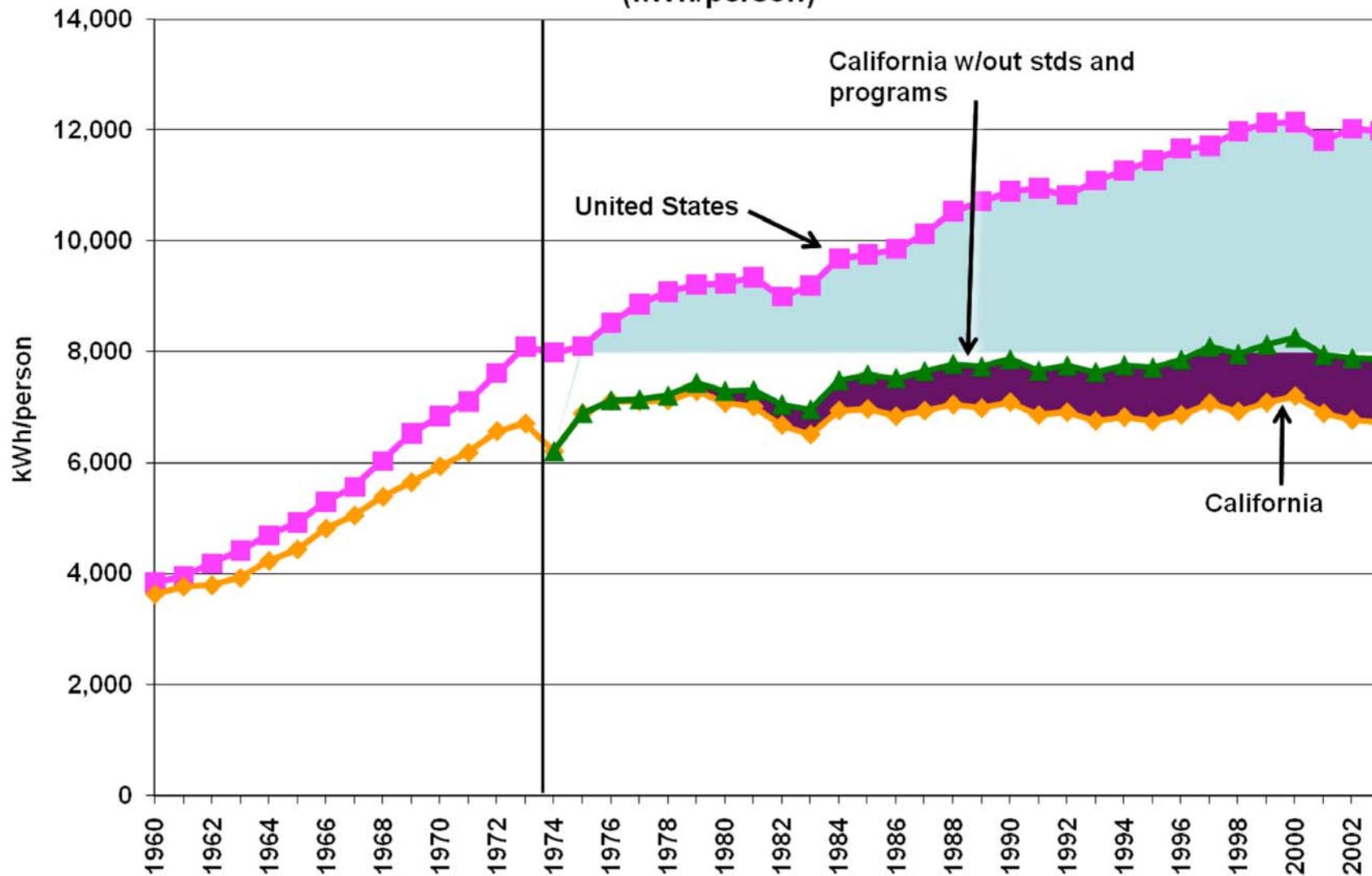
**Per Capita Electricity Sales (not including self-generation)
(kWh/person) (2006 to 2008 are forecast data)**



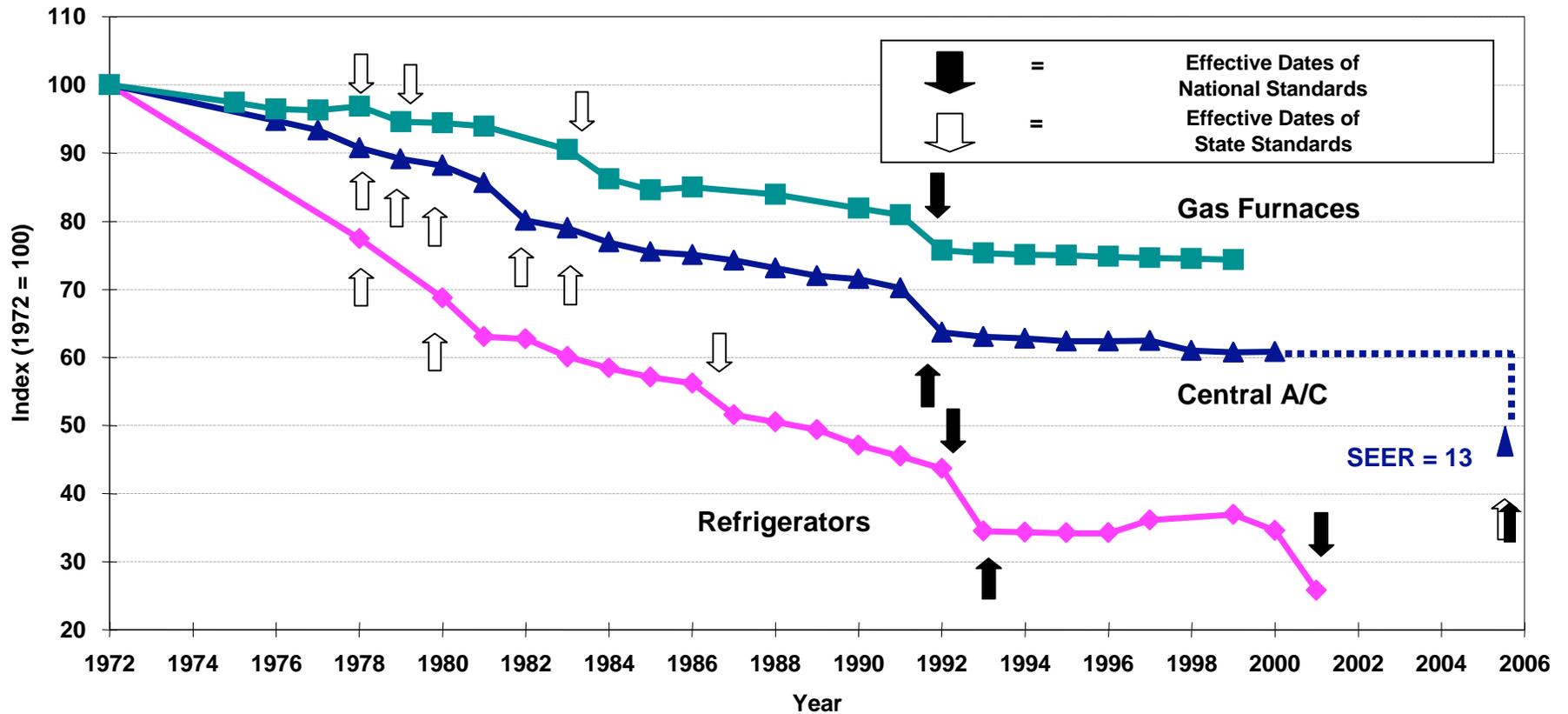
Annual Energy Savings from Efficiency Programs and Standards



Per Capita Electricity Sales (not including self-generation)
(kWh/person)

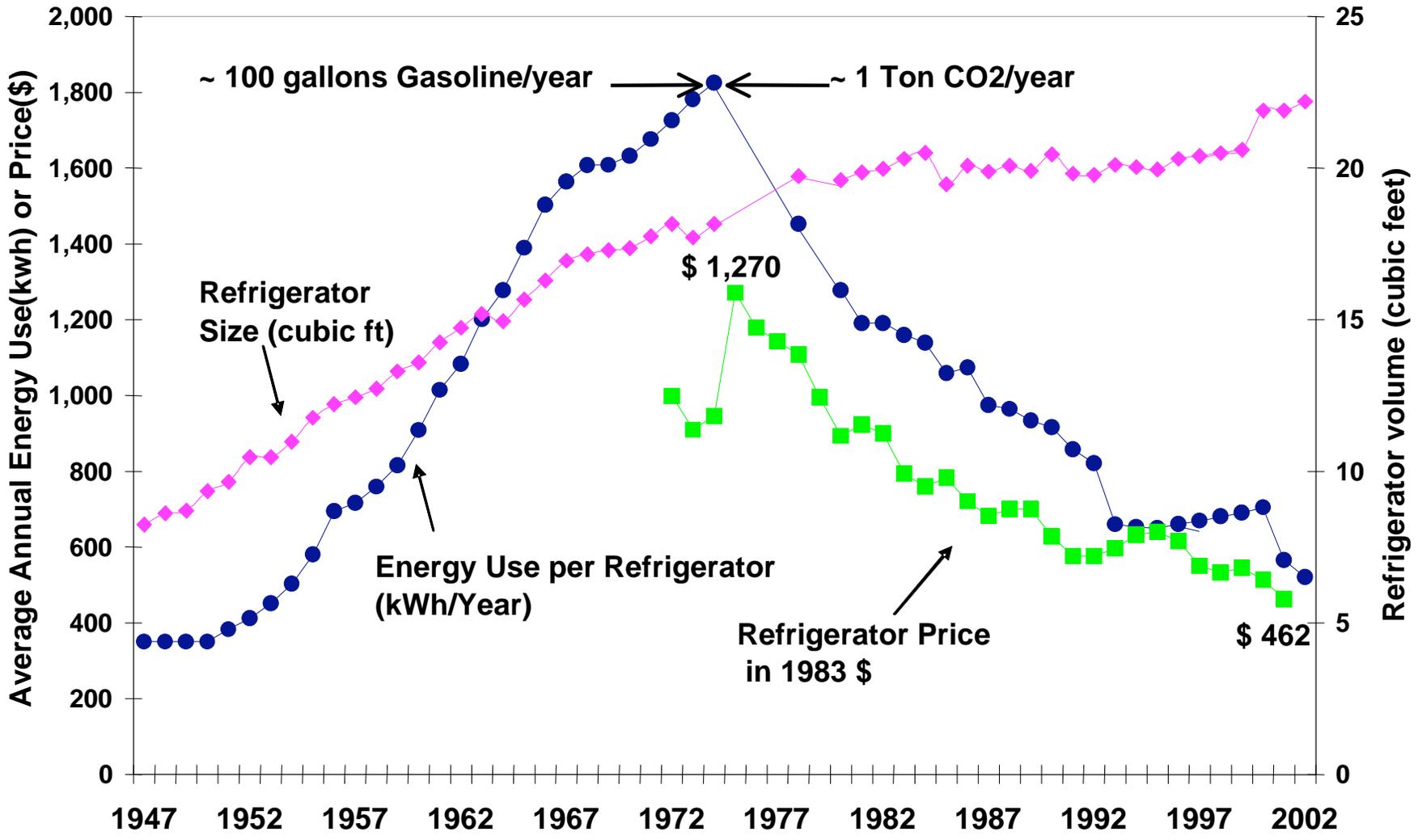


Impact of Standards on Efficiency of 3 Appliances



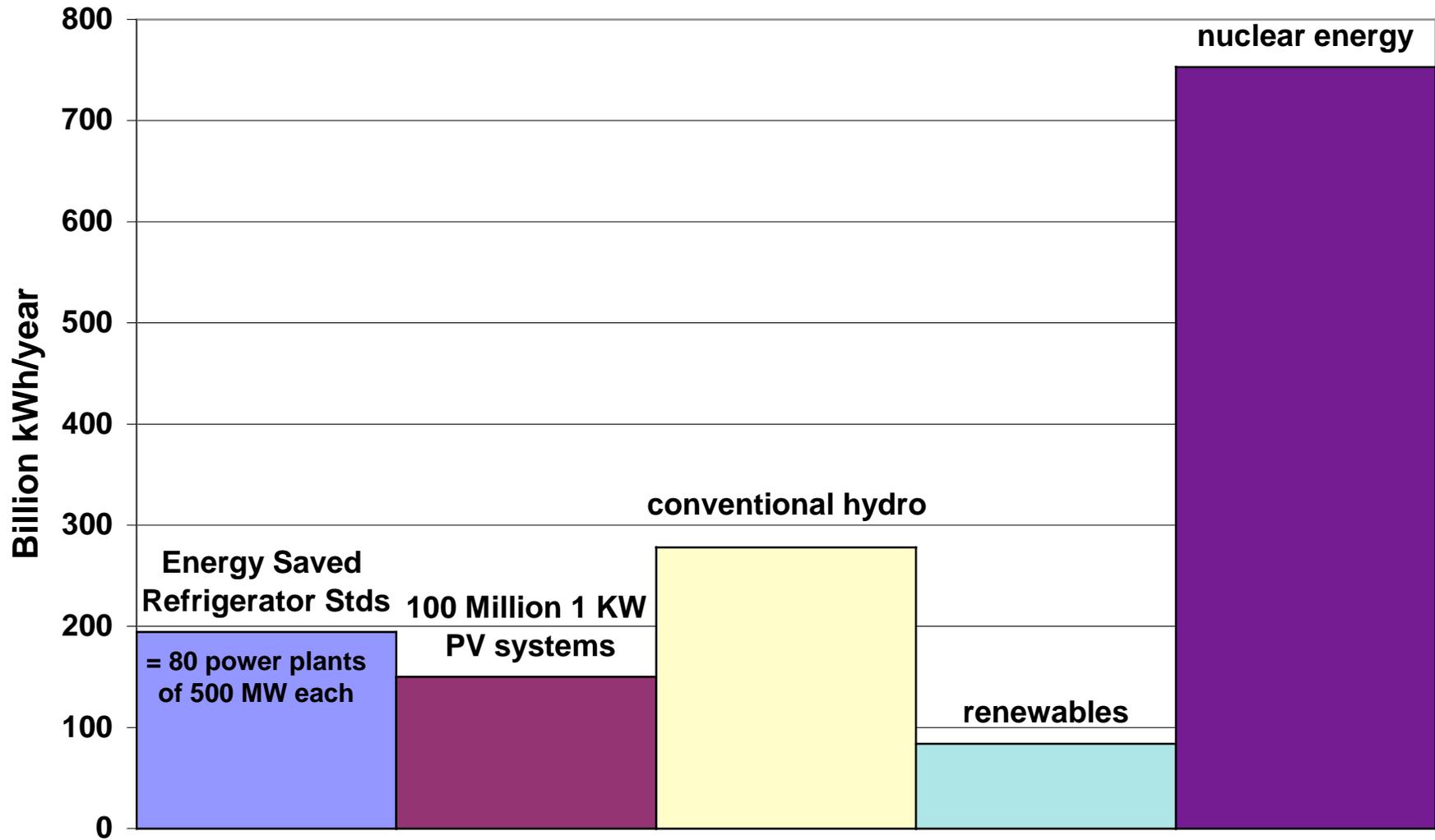
Source: S. Nadel, ACEEE,
in ECEEE 2003 Summer Study, www.eceee.org

New United States Refrigerator Use v. Time
and Retail Prices

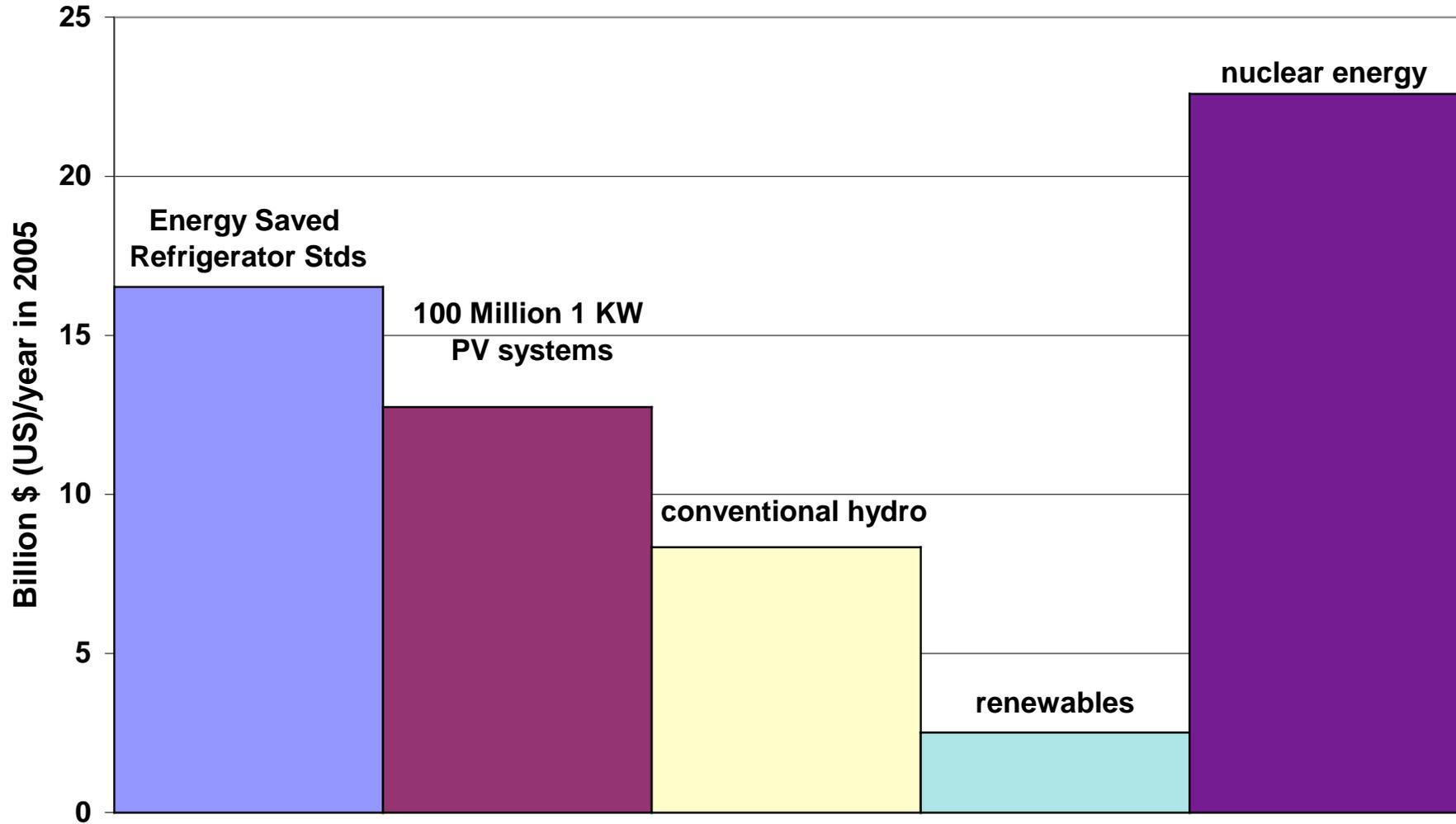


Source: David Goldstein

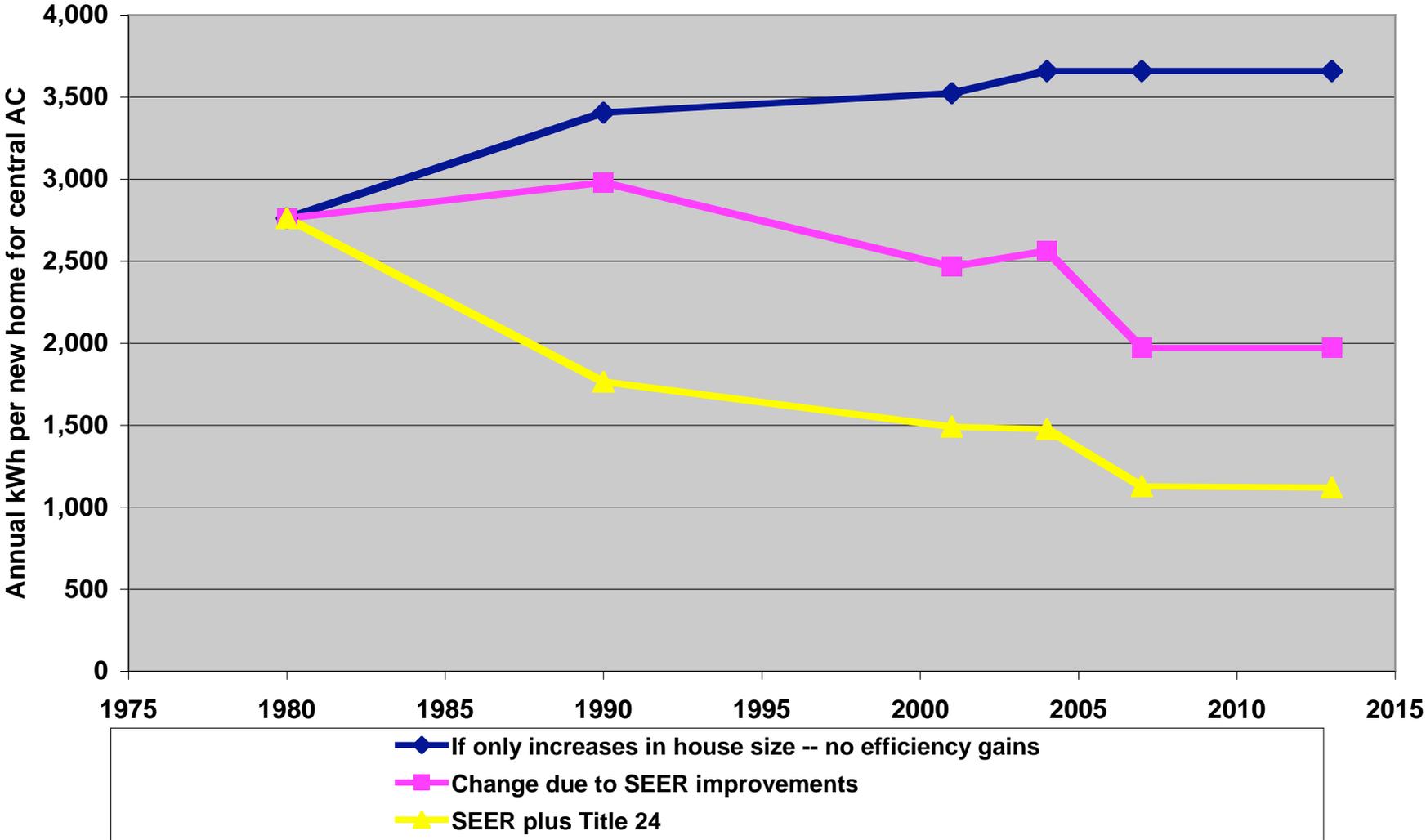
Annual Energy Saved vs. Several Sources of Supply In the United States



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)

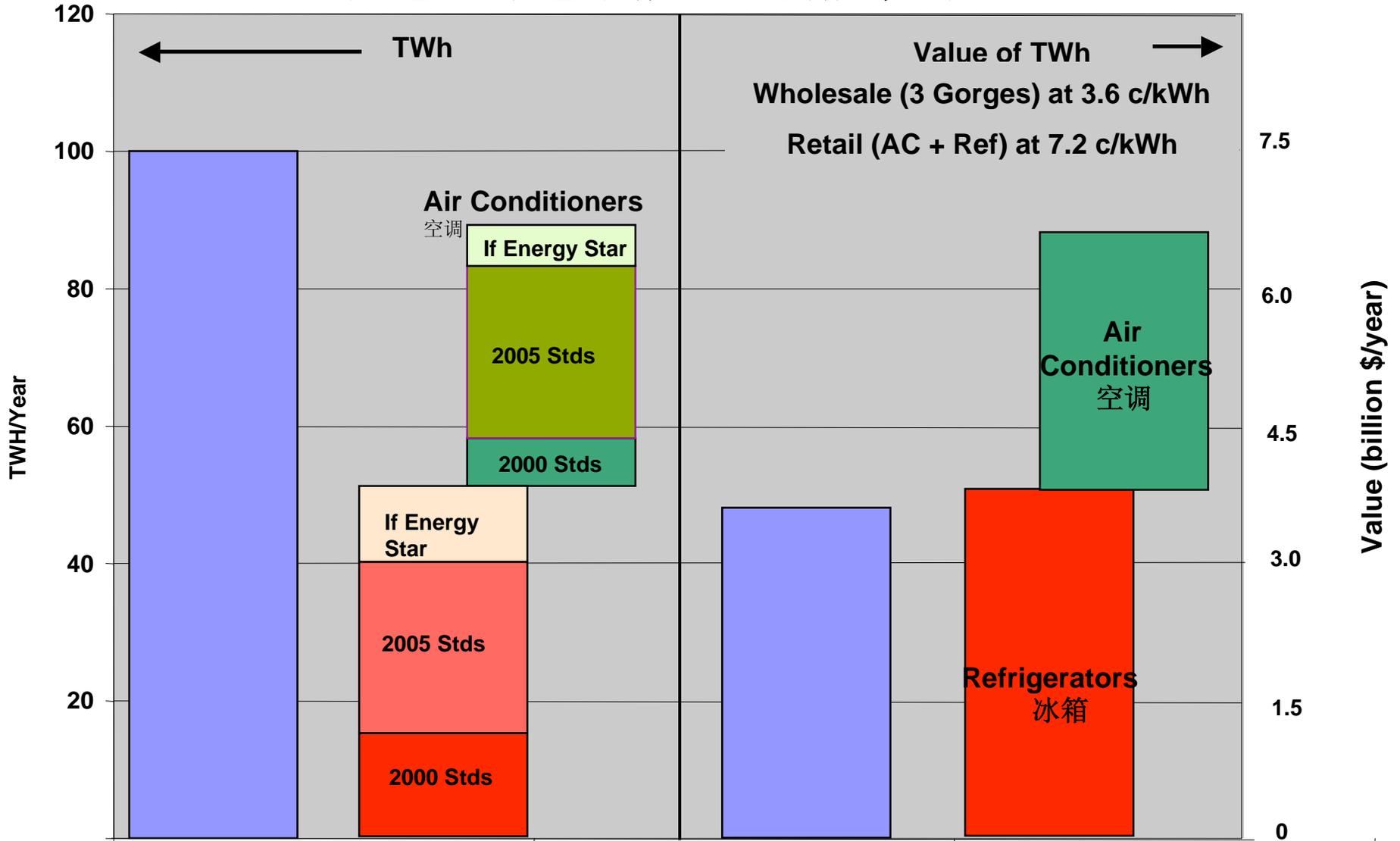


Air Conditioning Energy Use in Single Family Homes in PG&E The effect of AC Standards (SEER) and Title 24 standards



Comparison of 3 Gorges to Refrigerator and AC Efficiency Improvements

三峡电量与电冰箱、空调能效对比



3 Gorges
三峡

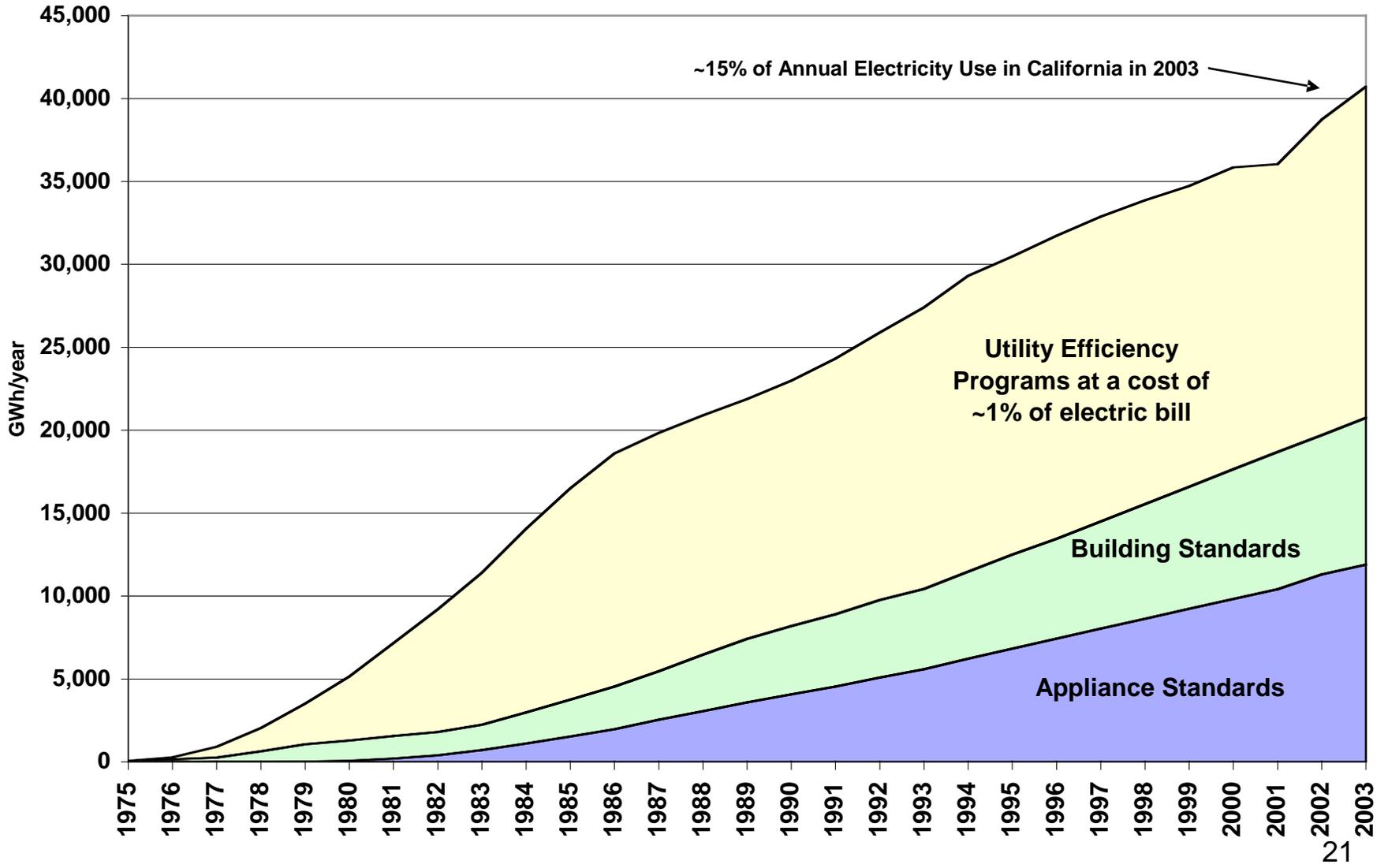
Refrigerators
冰箱

3 Gorges
三峡

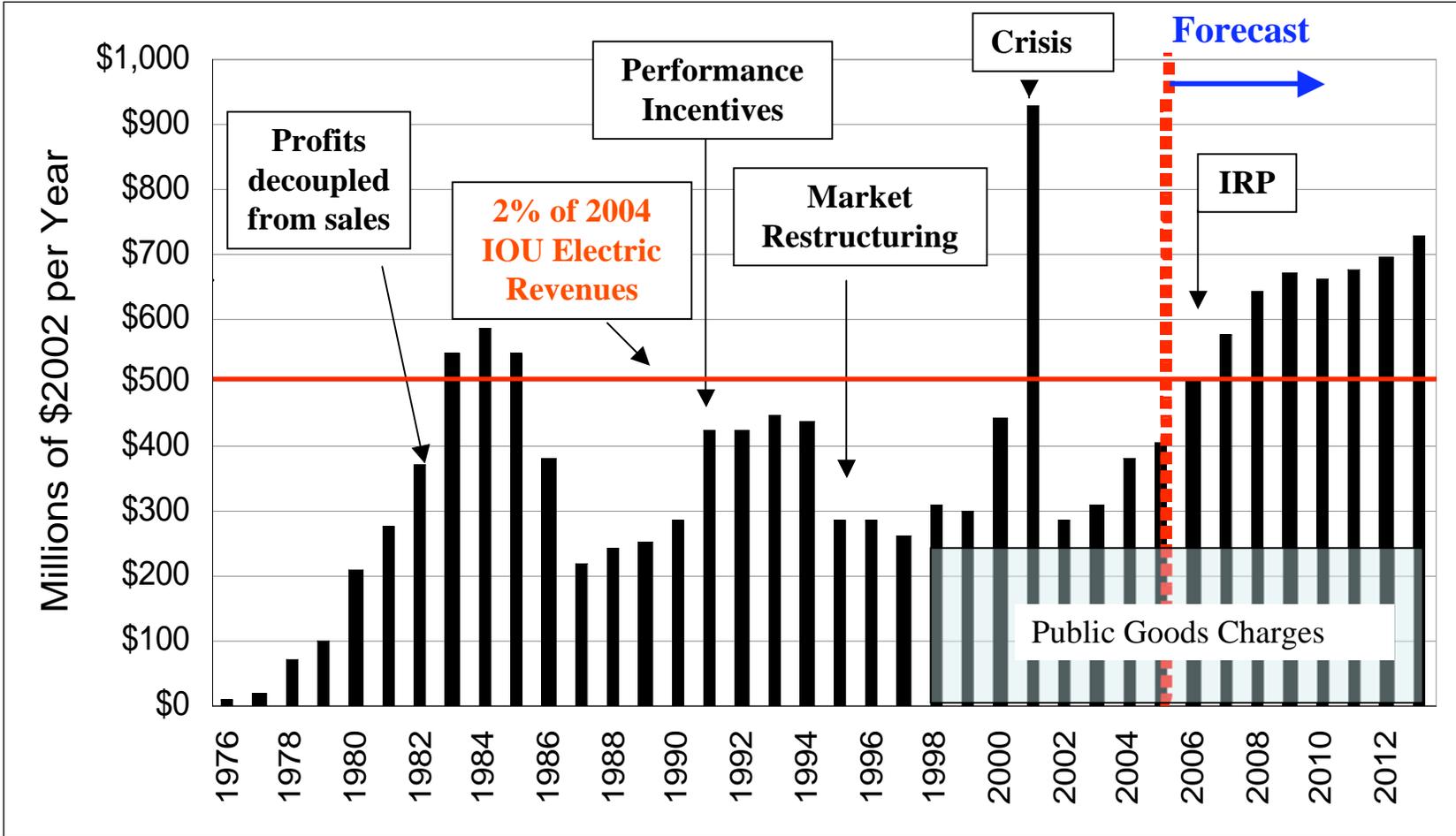
Savings calculated 10 years after standard takes effect. Calculations provided by David Fridley, LBNL

标准生效后，10年节约电量 20

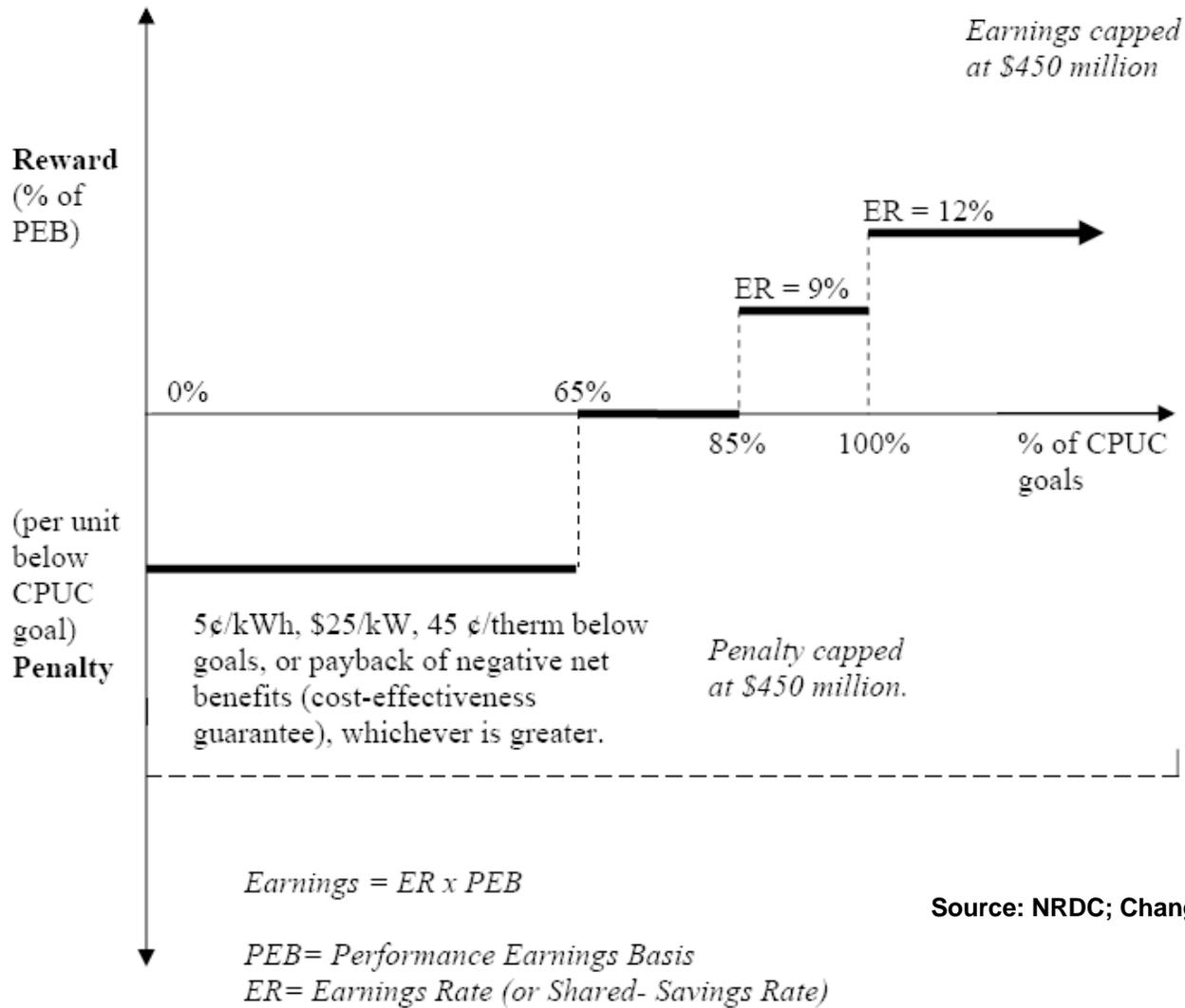
Annual Energy Savings from Efficiency Programs and Standards



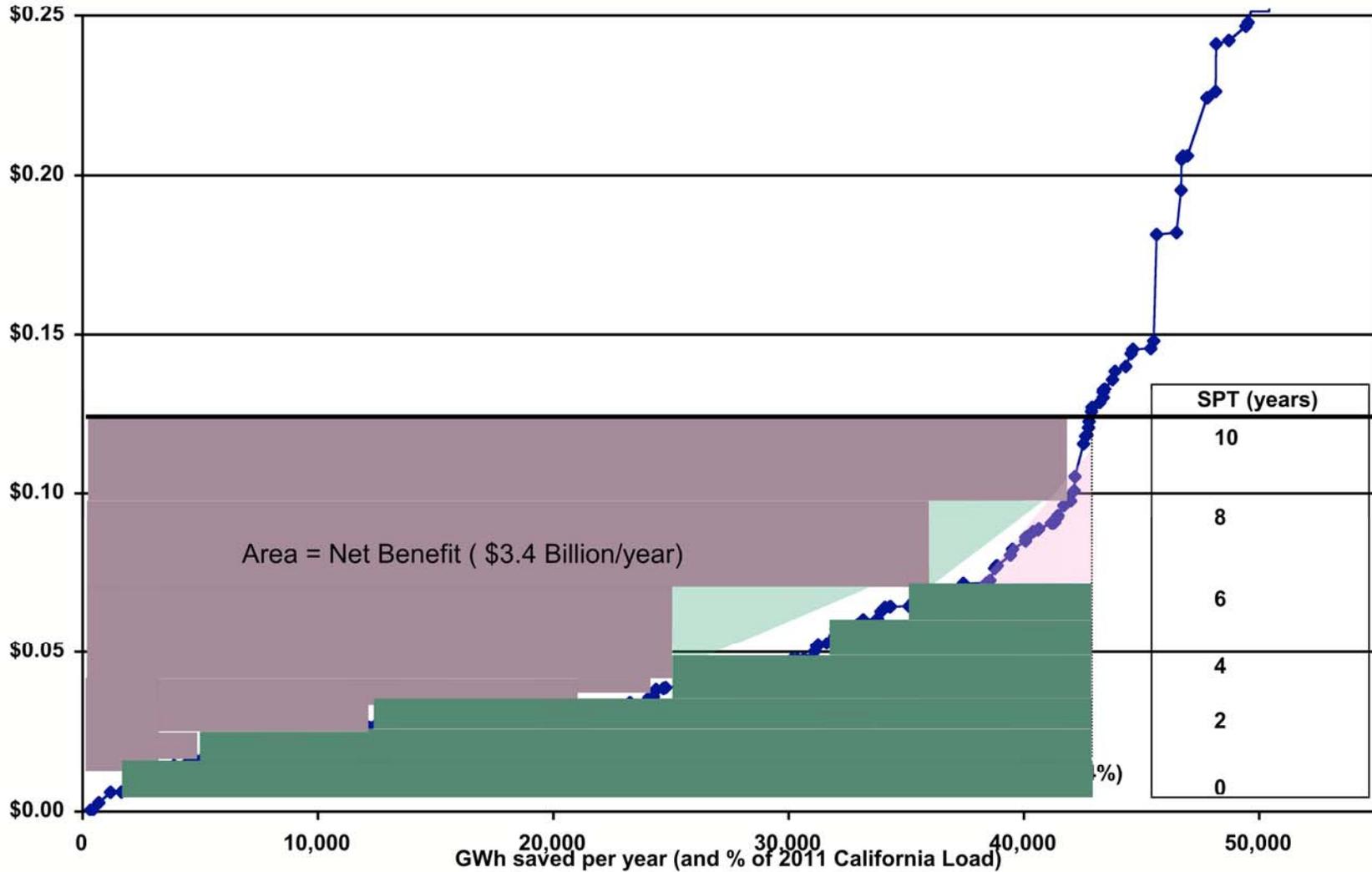
California IOU's Investment in Energy Efficiency



Energy Efficiency Incentive Mechanism Earnings/Penalty Curve
 (D.07-09-043, p. 8)

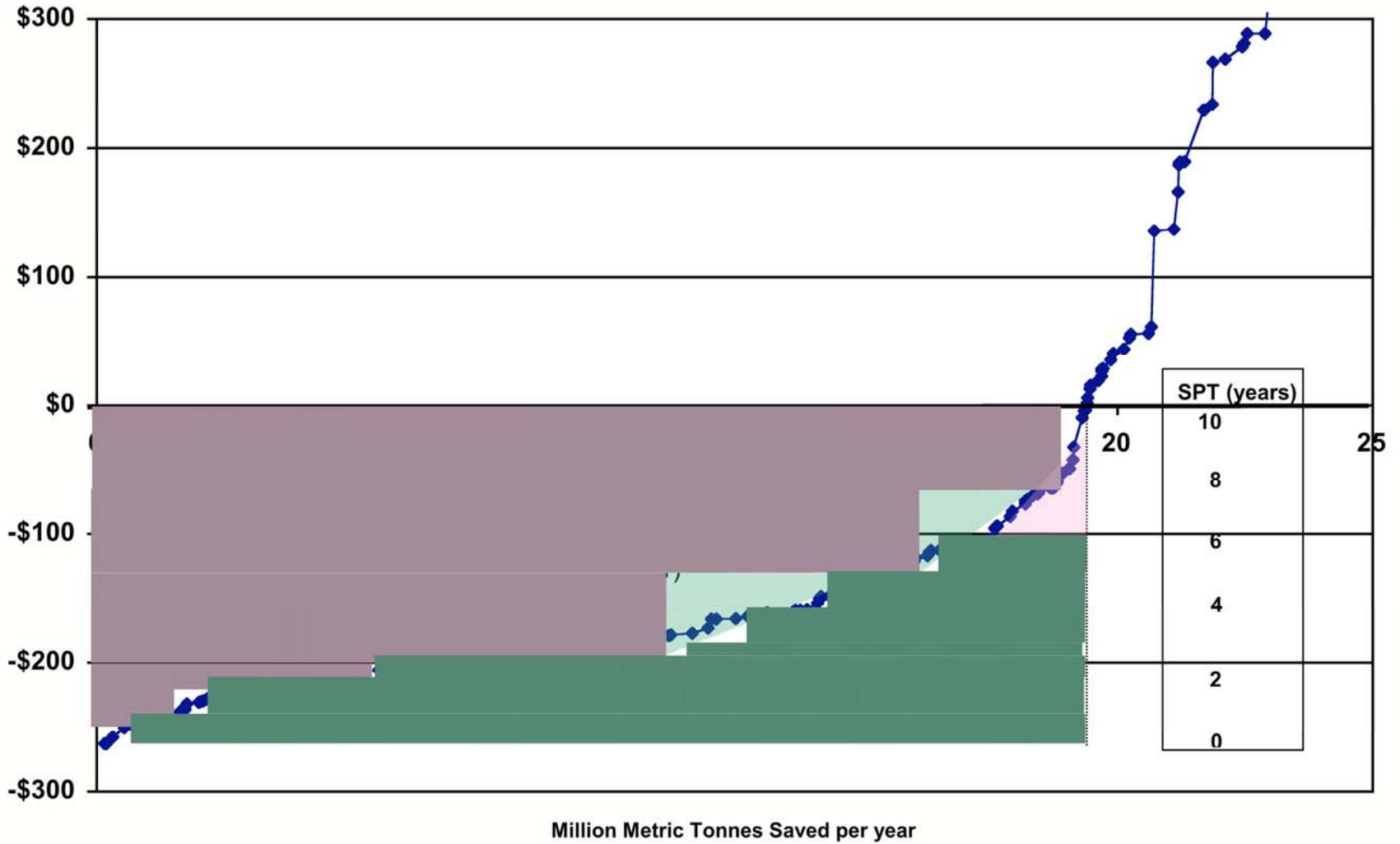


Electricity Conservation Supply Curve 220 Measures California in 2011 -- Levelized Cost and kWh saved



Source: California's Secret Energy Surplus: The Potential For Energy Efficiency, Rufo and Coito, 9/2002

**Electricity Conservation Supply Curve 220 Measures
translated to Carbon Dioxide Reduction curve
California in 2011 -- (1 kwh reduction saves 1 pound of CO2)**



Reducing U.S. Greenhouse Gas Emissions: *How Much at What Cost?*

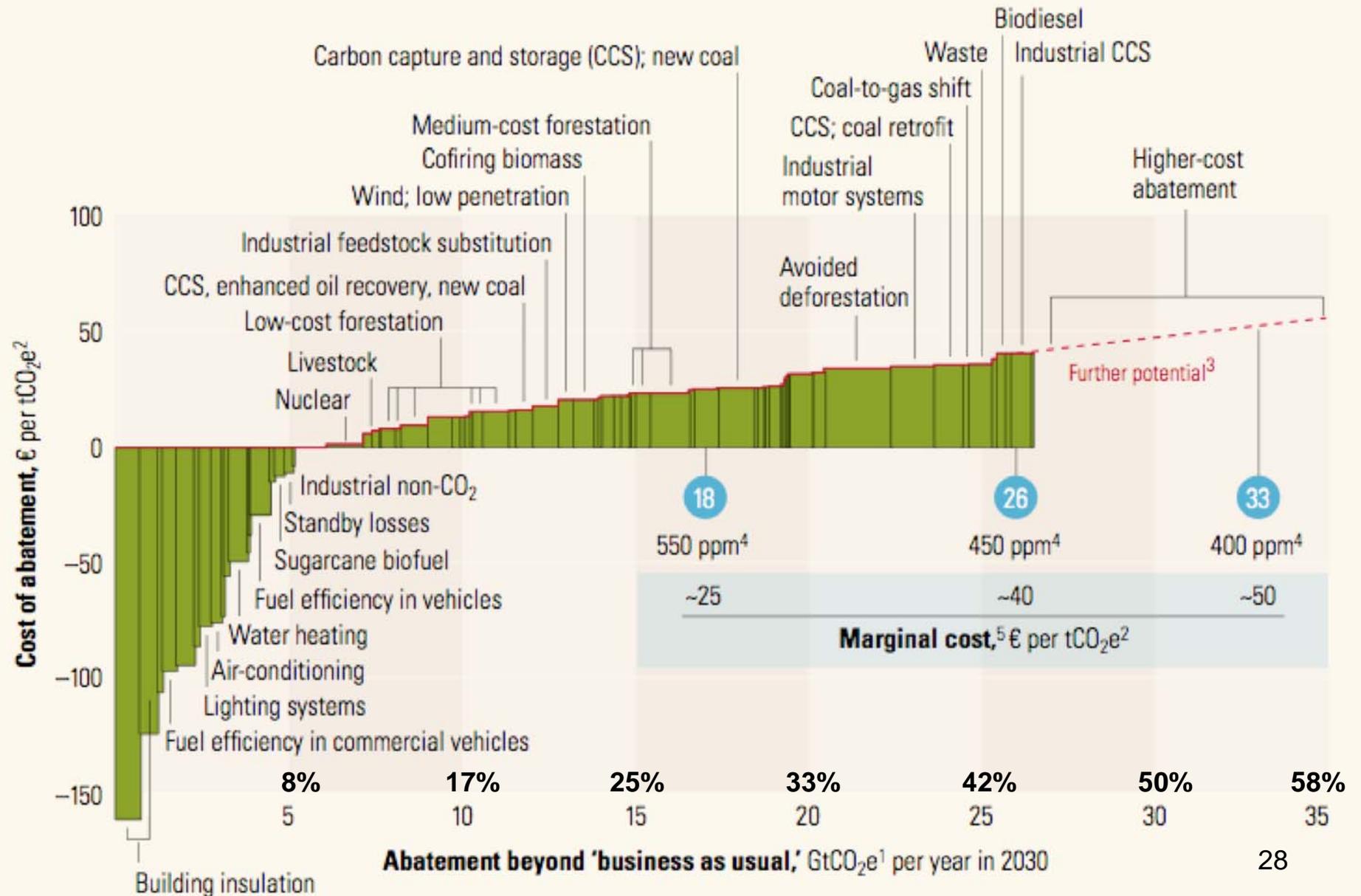
US Greenhouse Gas Abatement Mapping Initiative

December 12, 2007

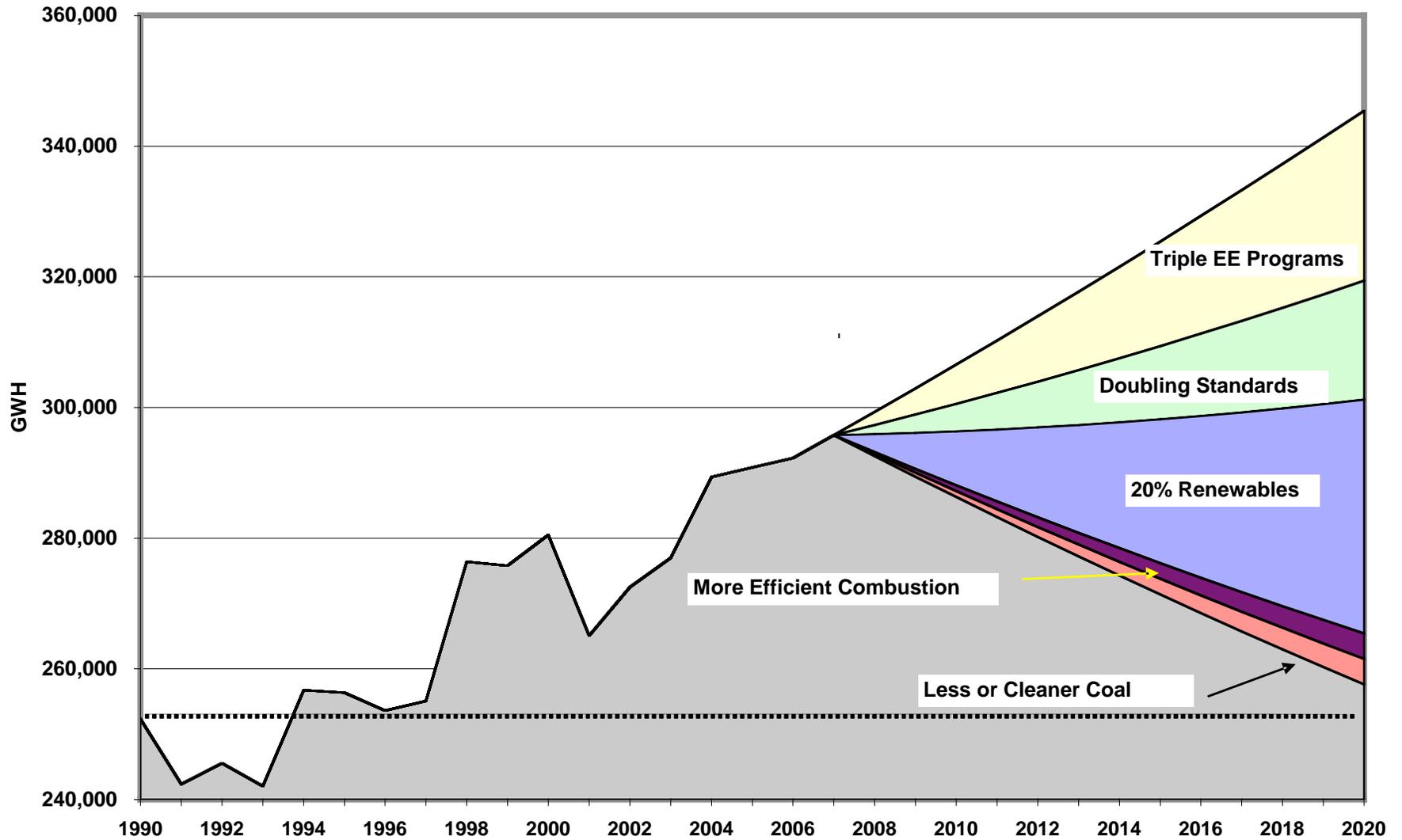
McKinsey&Company

Global cost curve for greenhouse gas abatement measures beyond 'business as usual'; greenhouse gases measured in GtCO₂e¹

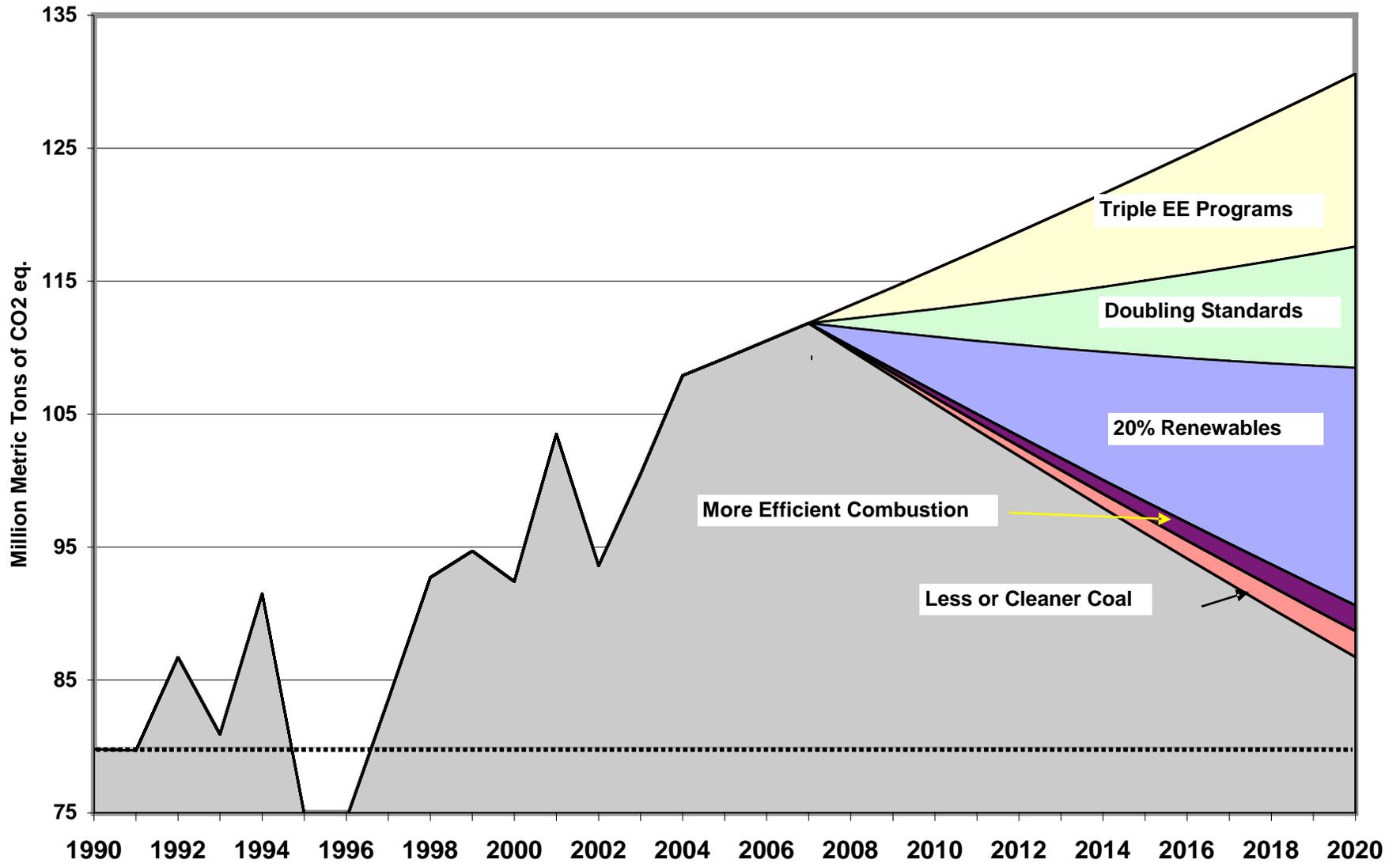
● Approximate abatement required beyond 'business as usual,' 2030



Possible Strategies to Reduce Electricity Sector Carbon Emissions in California, ignoring ramp up times and other implementation issues -- The ELECTRICITY Perspective



Possible Strategies to Reduce Electricity Sector Carbon Emissions in California, ignoring ramp up times and other implementation issues -- The CARBON Perspective



Source: Pat McAuliffe, pmcaulif@energy.state.ca.us

- *To be published in Climatic Change 2008.*
- **Global Cooling: Increasing World-wide Urban Albedos to Offset CO2**

July 28, 2008

Hashem Akbari and Surabi Menon
*Lawrence Berkeley National
Laboratory, USA*
H_Akbari@lbl.gov
Tel: 510-486-4287

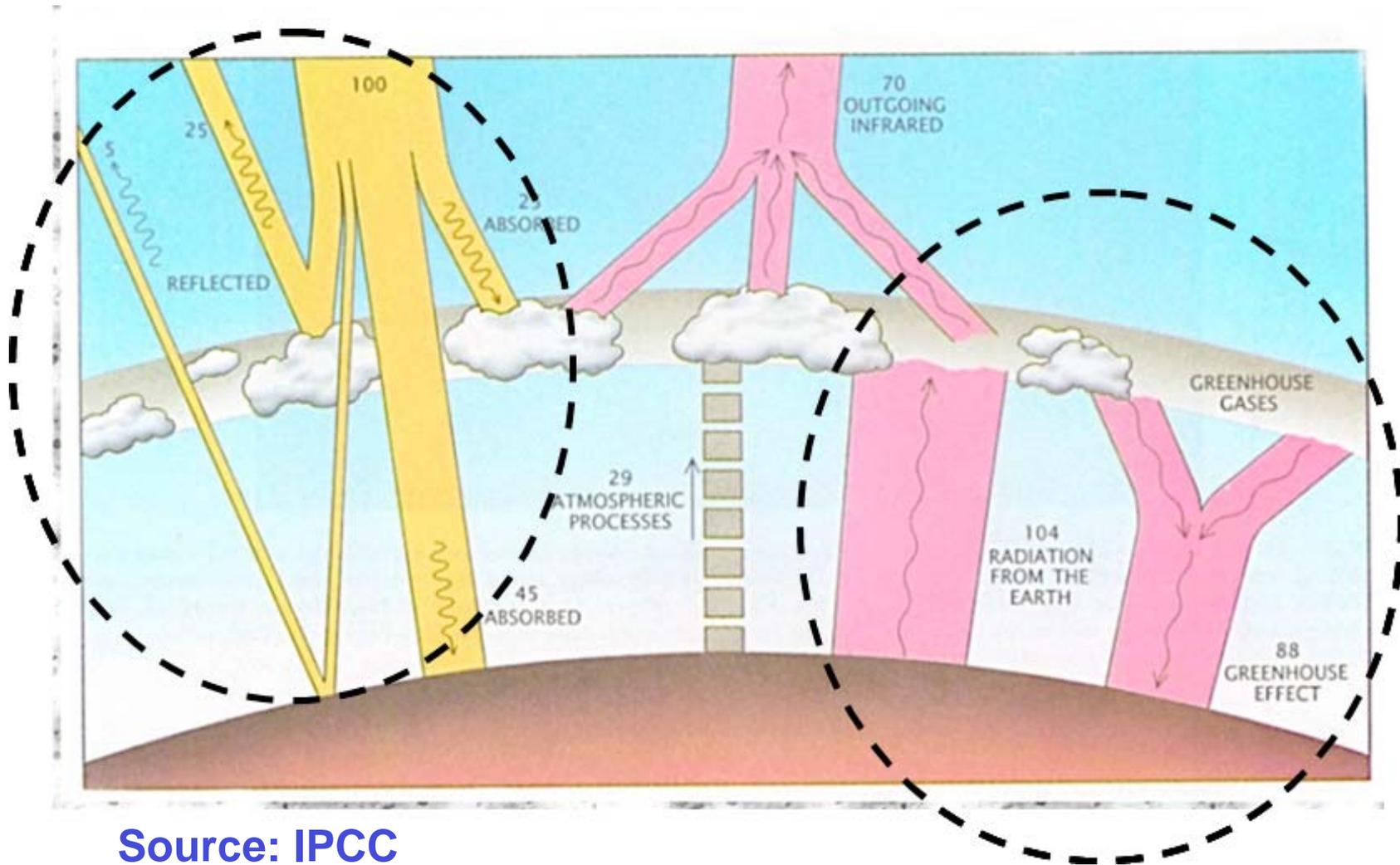
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- **A First Step In Geo-Engineering Which Saves Money and Has Known Positive Environmental Impacts**

1000 ft² of a white roof, replacing a dark roof, offset the emission of 10 tonnes of CO₂



Solar Reflective Surfaces Also Cool the Globe

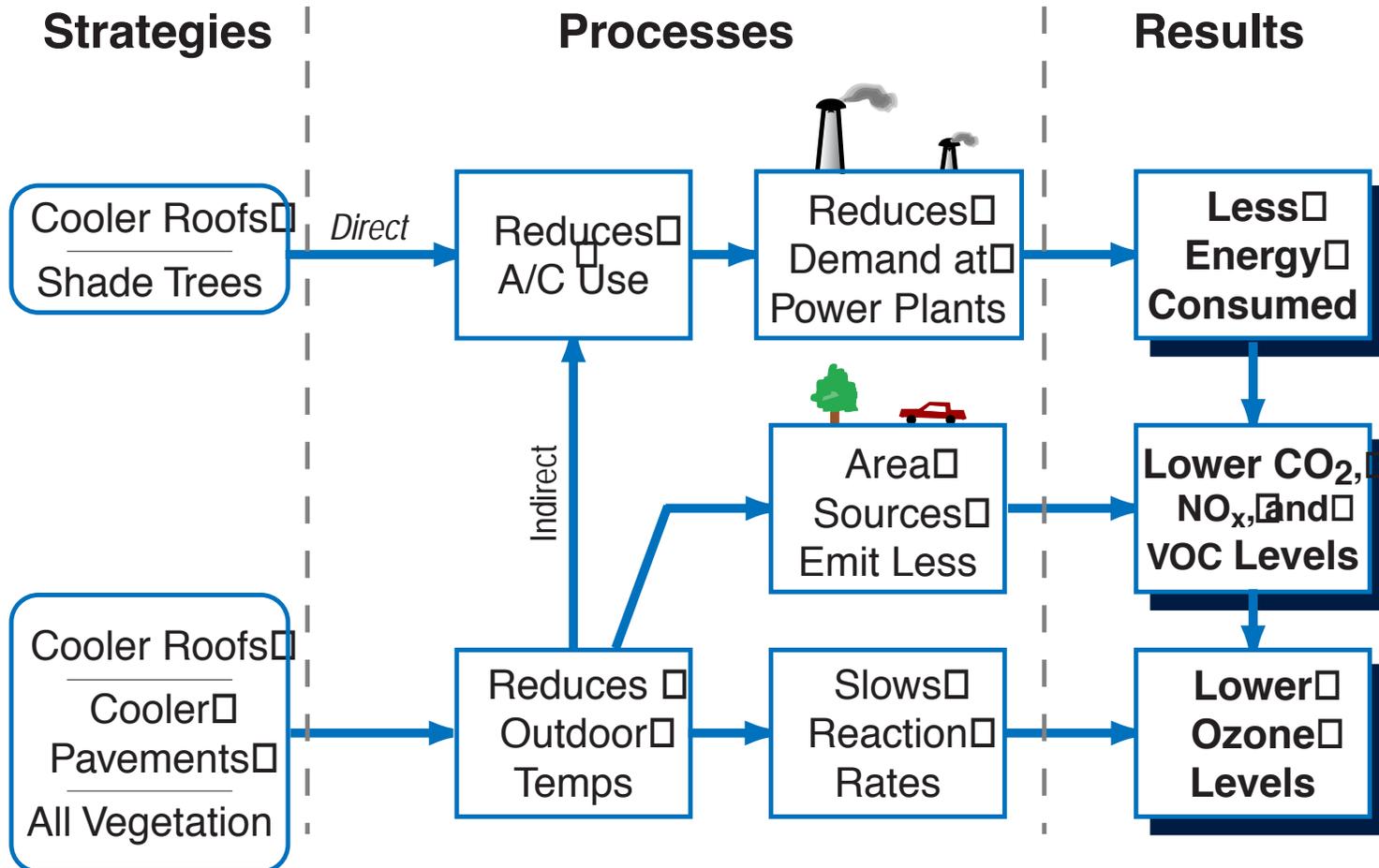


Source: IPCC

CO₂ 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.**

Methodology: Energy and Air-Quality Analysis



White is 'cool' in Bermuda



and in Santorini, Greece



and in Hyderabad, India



Cool Roof Technologies

Old



flat, white



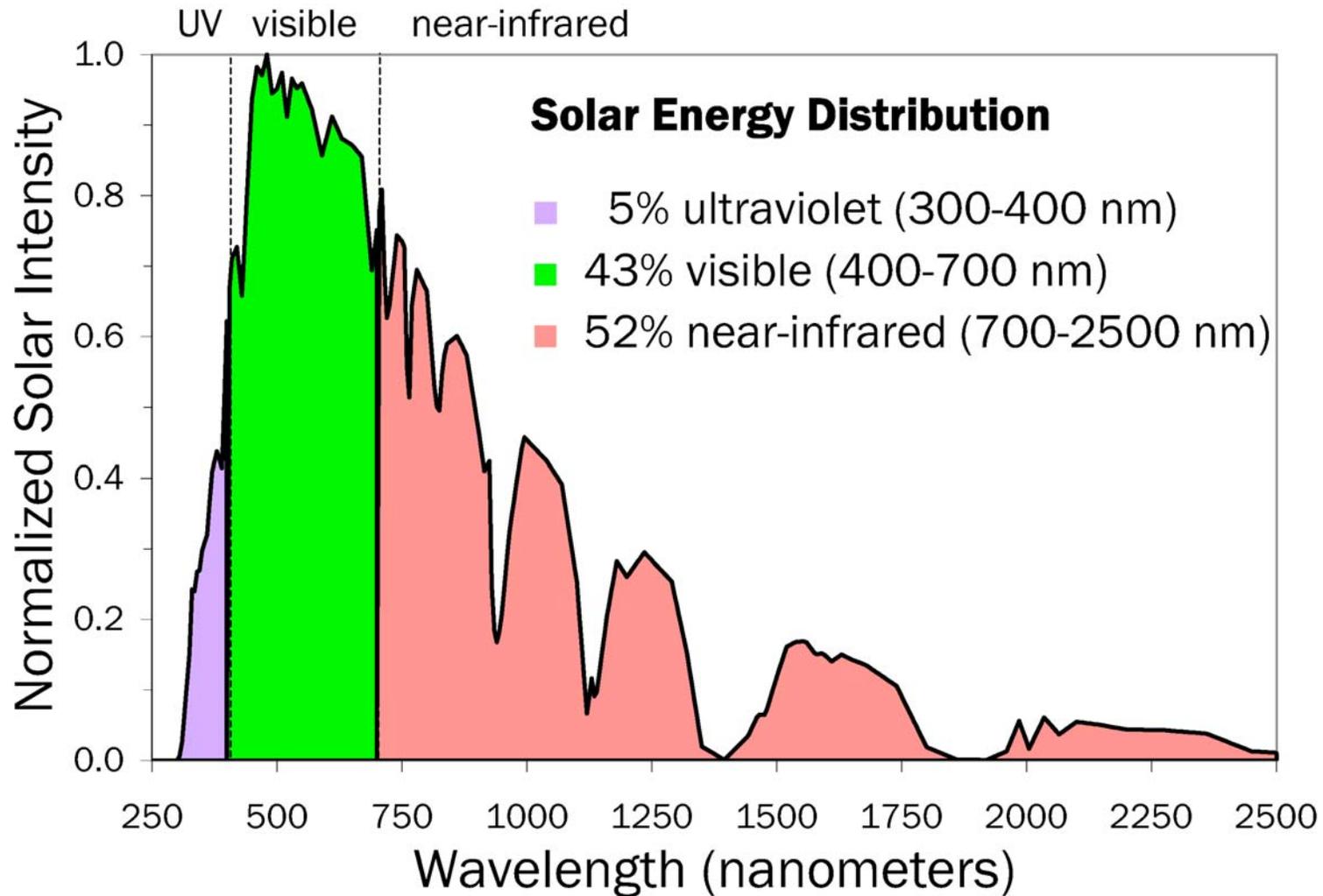
pitched, white

New



pitched, cool & colored

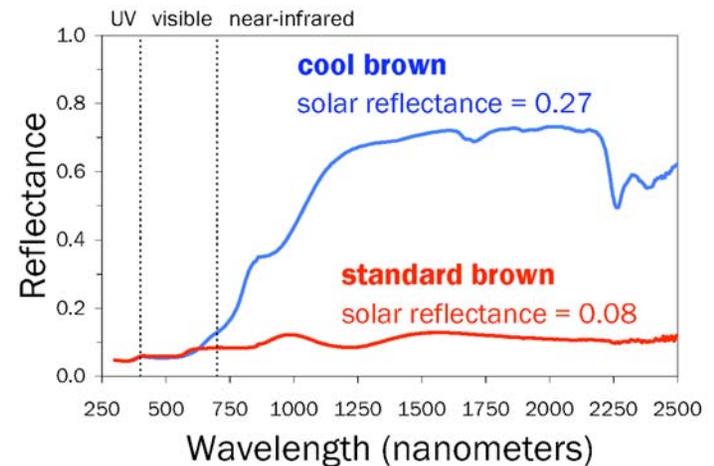
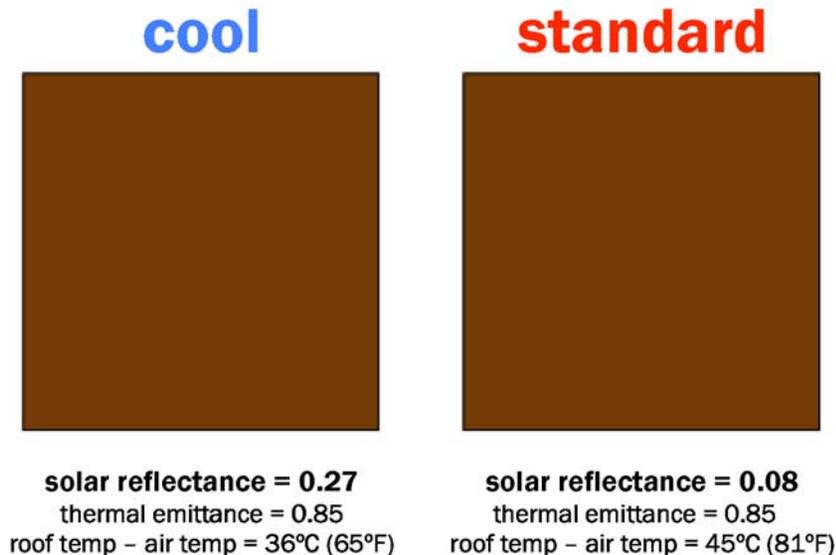
Cool Colors Reflect Invisible Near-Infrared Sunlight



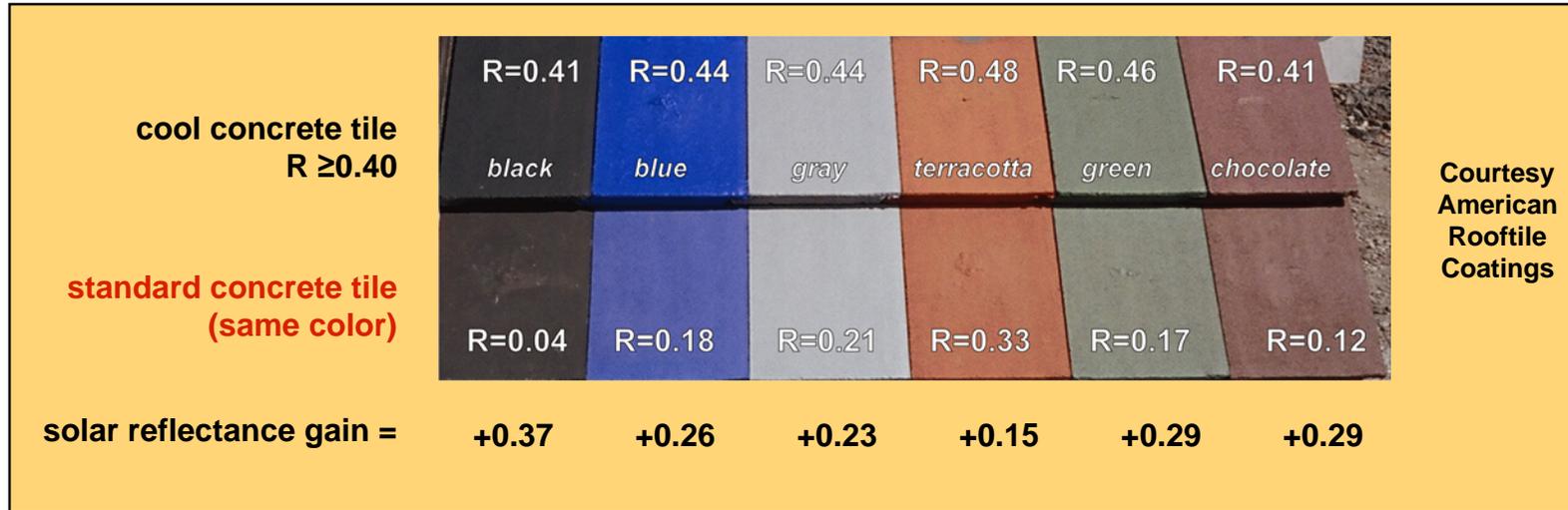
Cool and Standard Brown Metal Roofing Panels

- Solar reflectance ~ 0.2 higher
- Afternoon surface temperature ~ 10°C lower

Courtesy
BASF
Coatings



Designing Cool Colored Roofing



cool clay tile
 $R \geq 0.40$

Courtesy
MCA Clay Tile



Clarendon Green #1274 57.3 (95.4)	State Gray #1103 39 (79.6)
Reefside #1278 57 (97)	Bright Red #1295 36.5 (98.5)
Serra Tan #1217 53.8 (97.6)	Brick Red #1296 35.8 (94.7)
Real Gray #1204 48.7 (91.5)	Medium Bronze #1211 34.5 (91)
Marine Green #1002 41 (91.8)	State Blue #1285 34.4 (91.5)
Palma Green #1205 41 (99.2)	State Bronze #1173 33.8 (94.6)

cool metal
 $R \geq 0.30$

Courtesy
BASF Industrial
Coatings



cool fiberglass asphalt shingle

$R \geq 0.25$

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)

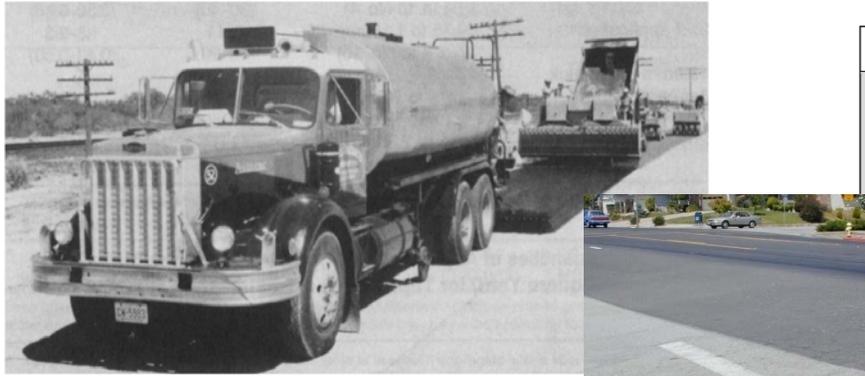
The End

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						
	$\rho=0.44$	$\rho=0.34$	$\rho=0.14$	$\rho=0.43$	$\rho=0.24$	$\rho=0.25$



Reflective Pavements are Cooler

- **Fresh asphalt**

Albedo: **0.05**

Temperature: **123°F**

- **Aged asphalt**

Albedo: **0.15**

Temperature: **115°F**

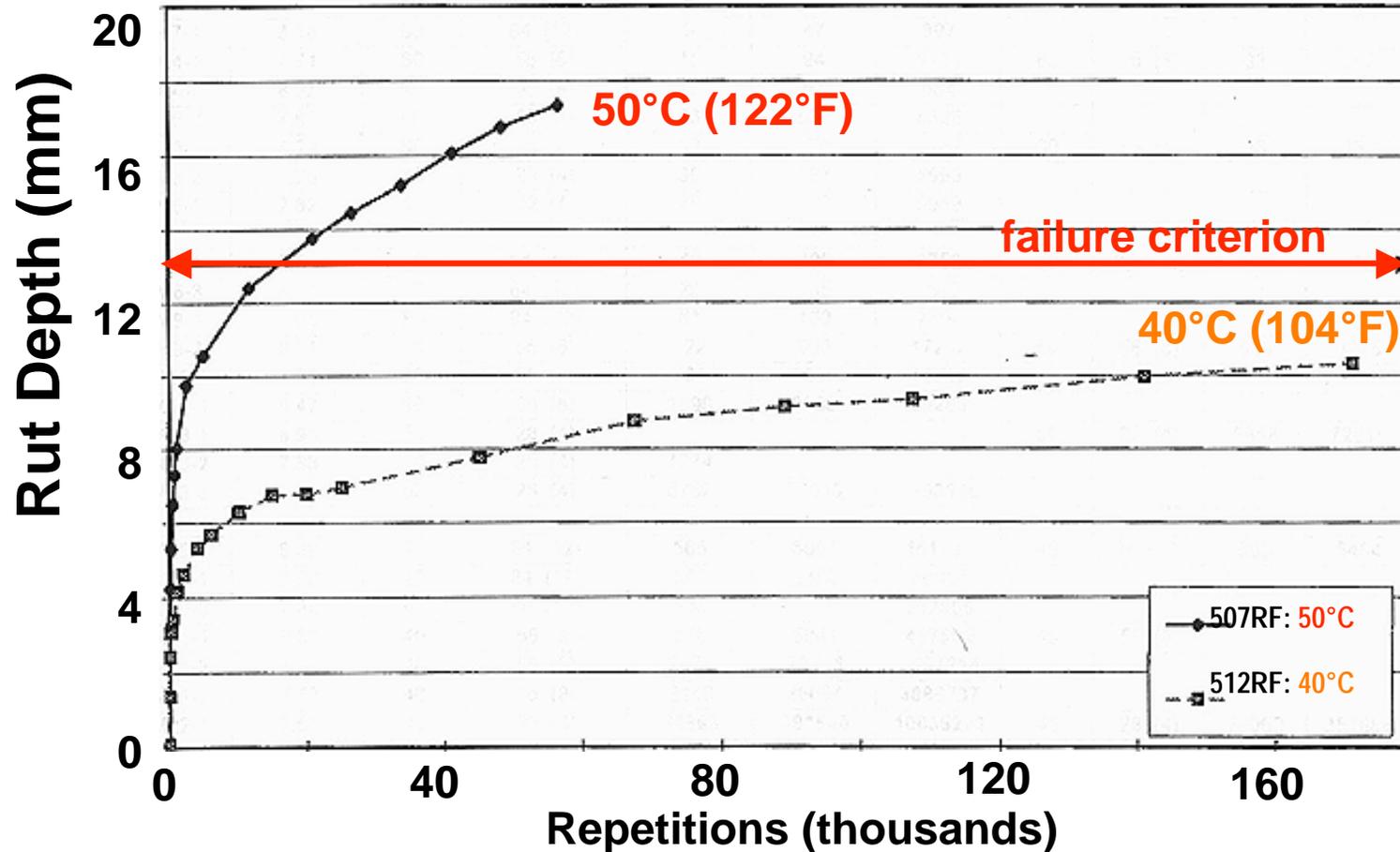
- **Prototype
asphalt coating**

Albedo: **0.51**

Temperature: **88°F**



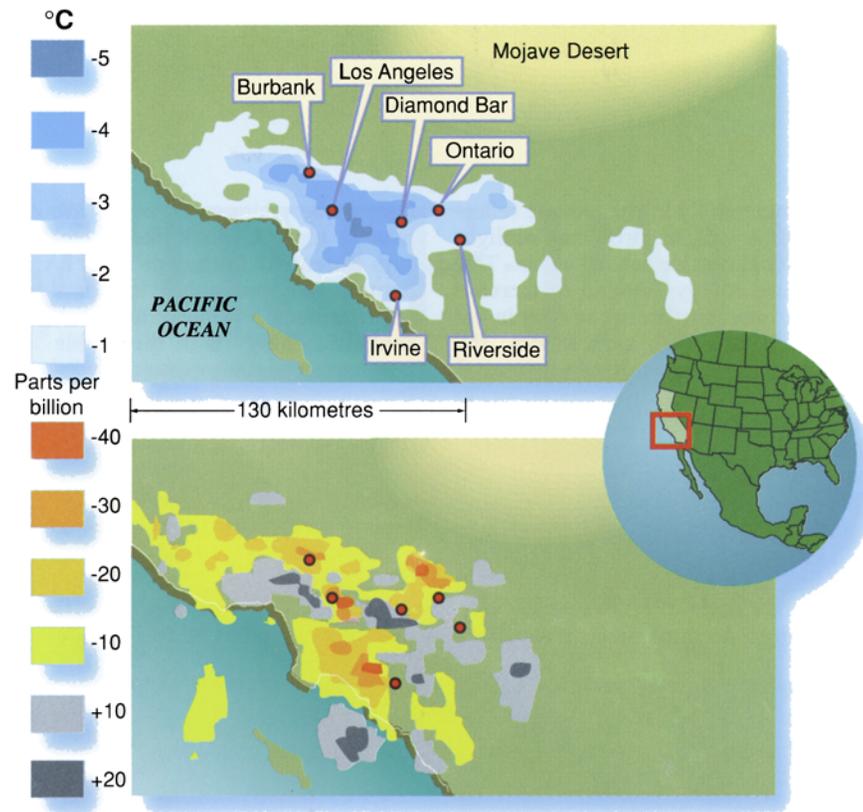
Temperature Effect on Rutting



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

Simulated Meteorology and Air-quality Impacts in LA

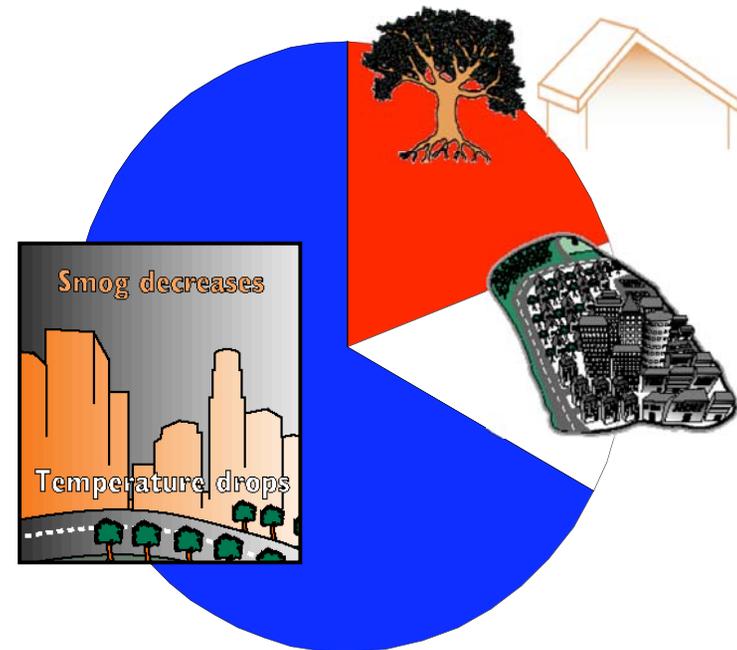
Temperature Change



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**



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 m² of roofs by 0.40 (white roof) is equivalent to offsetting 63 kg CO₂ emissions
(10 m² of white roof = 1 T CO₂ emission offset)
- Increasing the solar reflectance of a m² of roofs by 0.25 (cool roof) is equivalent to offsetting 63 kg CO₂ emissions
(16 m² of cool roof = 1 T CO₂ emission offset)
- Increasing the solar reflectance of a m² of paved surfaces by 0.15 is equivalent to offsetting 38 kg CO₂ emissions
- Total world-wide emission offset from cool roofs and cool pavements is 44 GT CO₂
- 44 GT CO₂ is over one year of the world 2025 emission of 37 GT CO₂
- CO₂ emissions currently trade at ~\$25/T; 44 GT CO₂ worth \$1100 billion

A Global Action Plan: The Big Picture

- Develop an international to install cool roof/pavement in world's 100 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