

# **From the Lab to the Marketplace to Standards**

**Berkeley Energy & Resources Collaborative  
University of California, Berkeley  
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<http://www.energy.ca.gov/commission/commissioners/rosenfeld.html>

or just **Google “Art Rosenfeld”**

# The Economist

JANUARY 27TH - FEBRUARY 2ND 2009 [www.economist.com](http://www.economist.com)

Shake-up in Big Pharma  
China's space blast  
Europe's rotating slump  
Serbia's encouraging election  
Hating Hillary Clinton



## The greening of America

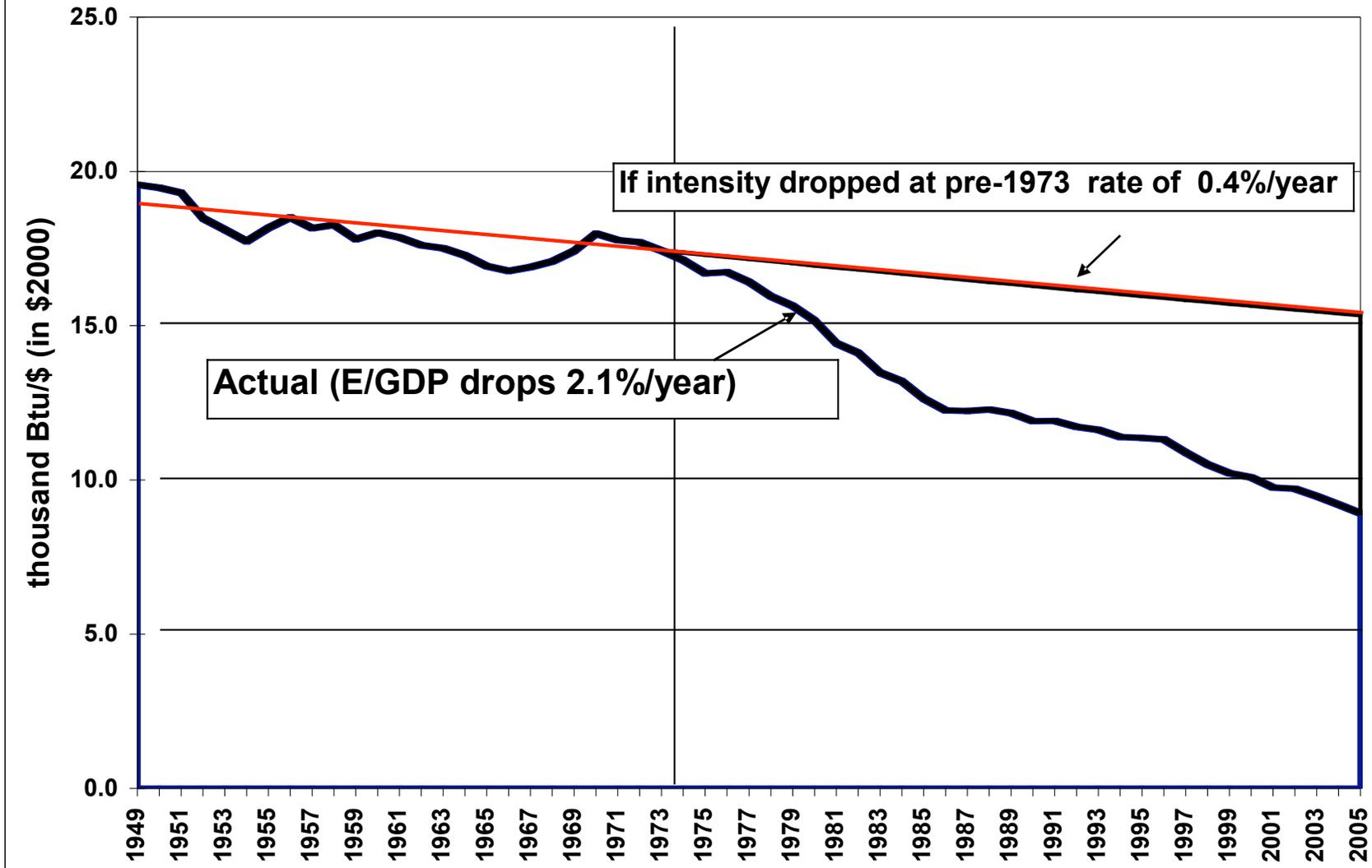
1949

Rosenfeld

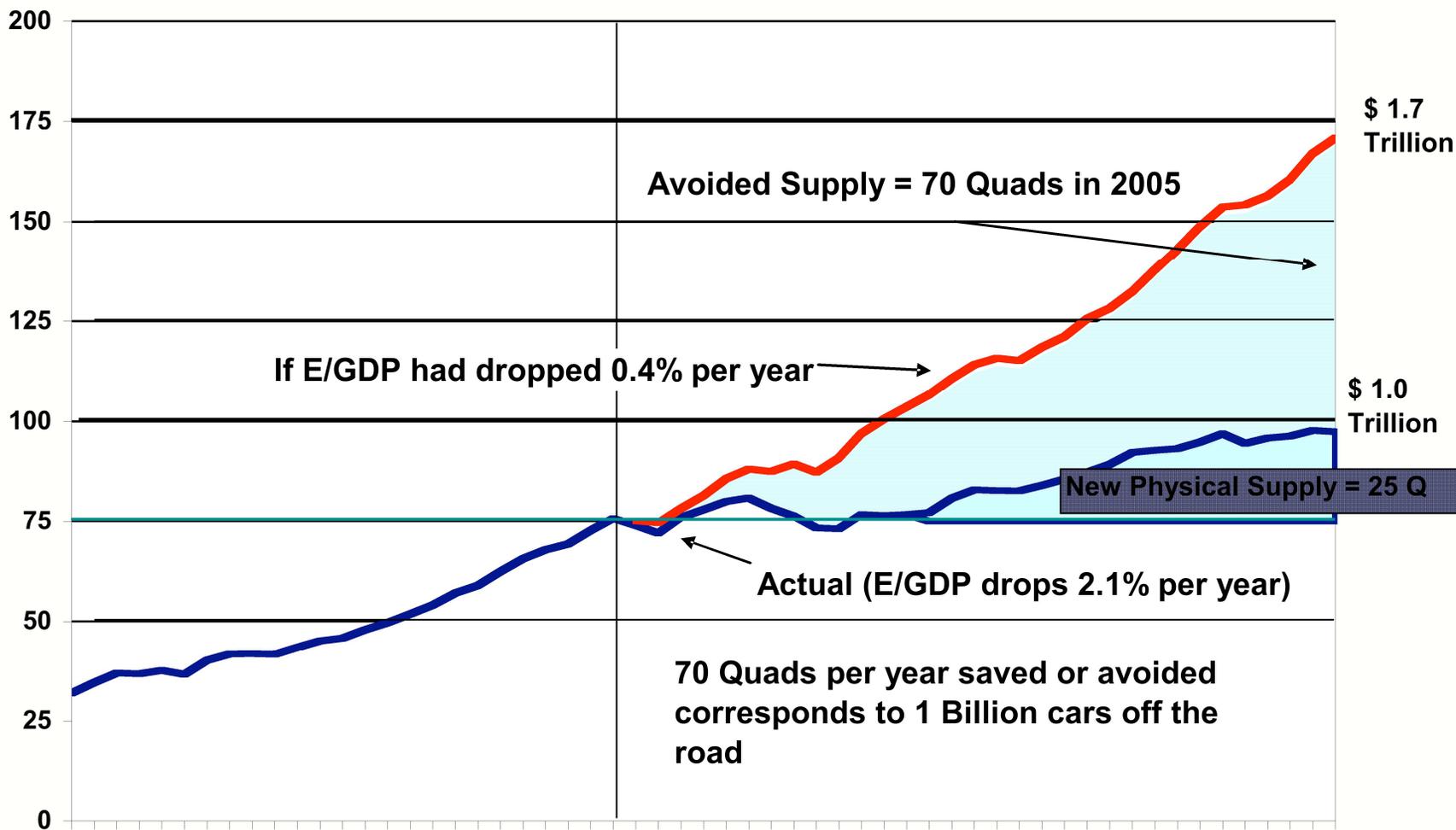
# Nuclear Physics

*A Course Given by* **ENRICO FERMI**  
*at the University of Chicago. Notes Compiled by*  
*Jay Orear, A. H. Rosenfeld, and R. A. Schluter*

# Energy Intensity in the United States 1949 - 2005



# Energy Consumption in the United States 1949 - 2005



## Environmental Equivalent of Avoiding 70 Quads

- ◆ 70 Quads = 33 Mbod (Million barrels of oil per day)  
= 40% of World oil production of 80 Mbod
- ◆ 70 Quads = 1 Billion cars off the road, impressive since there are only 600 million cars on the road

# How Much of The Savings Come from Efficiency?

- ◆ Easiest to tease out is cars
  - In the early 1970s, only 14 miles per gallons
  - Now about 21 miles per gallon
  - If still at 14 mpg, we'd consume **75 billion gallons more** and pay **\$225 Billion more** at 2006 prices
  - But we still pay **\$450 Billion per year**
  - If California wins the “Schwarzenegger-Pavley” suit, and it is implemented nationwide, we'll save **another \$150 Billion per year**
- ◆ Commercial Aviation improvements save another **\$50 Billion per year**
- ◆ Appliances and Buildings are more complex
  - We must sort out true efficiency gains vs. structural changes (from smokestack to service economy).

## How Much of The Savings Come from Efficiency (cont'd)?

- ◆ 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
<b>Total</b>	<b>95</b>

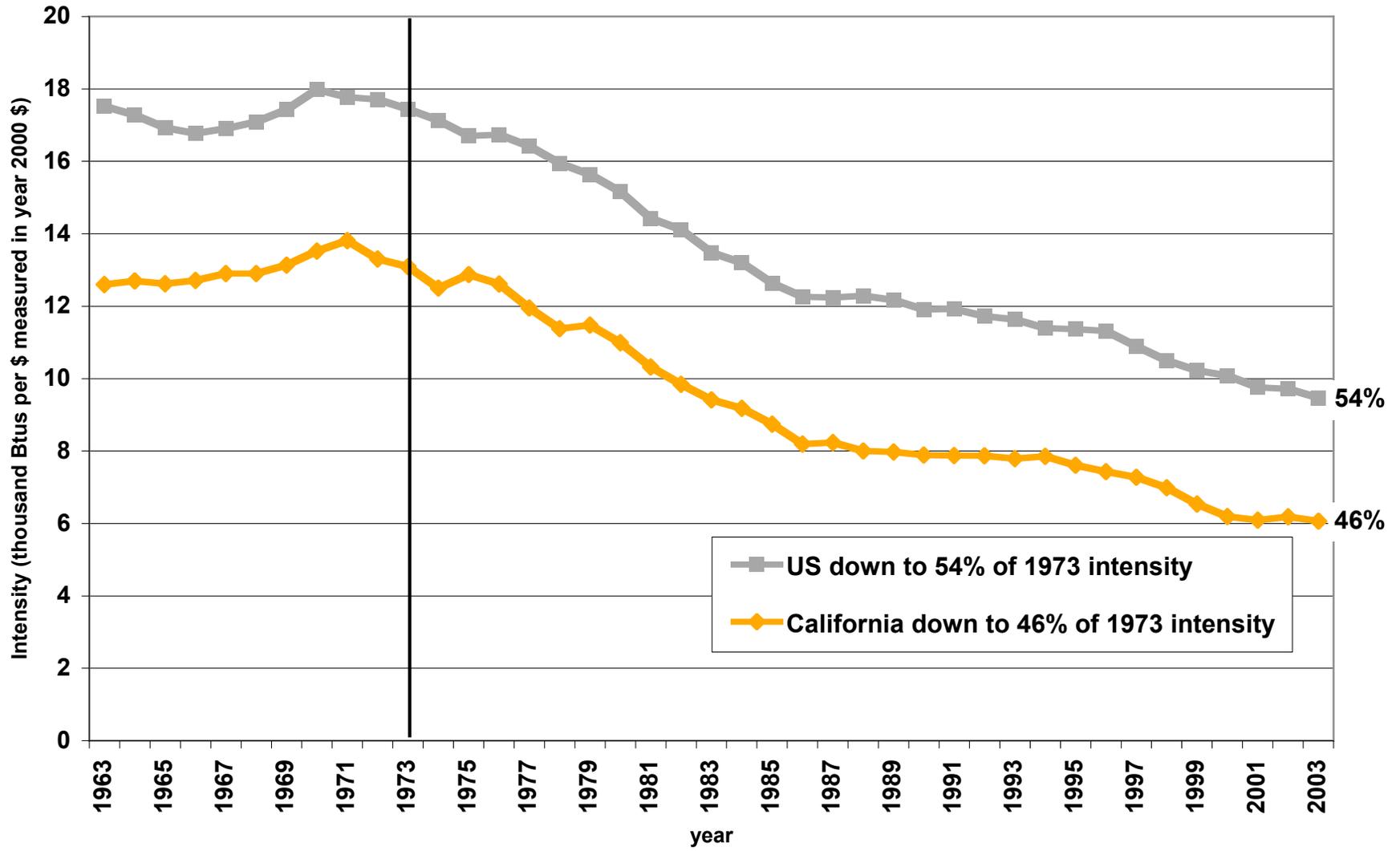
- ◆ Beginning in 2007 in California, reduction of “vampire” or stand-by losses
  - This will save \$10 Billion when finally implemented, nation-wide
- ◆ Out of a total **\$700 Billion**, a crude summary is that 1/3 is structural, 1/3 is from transportation, and 1/3 from buildings and industry.

## A supporting analysis on the topic of efficiency from Vice-President Dick Cheney

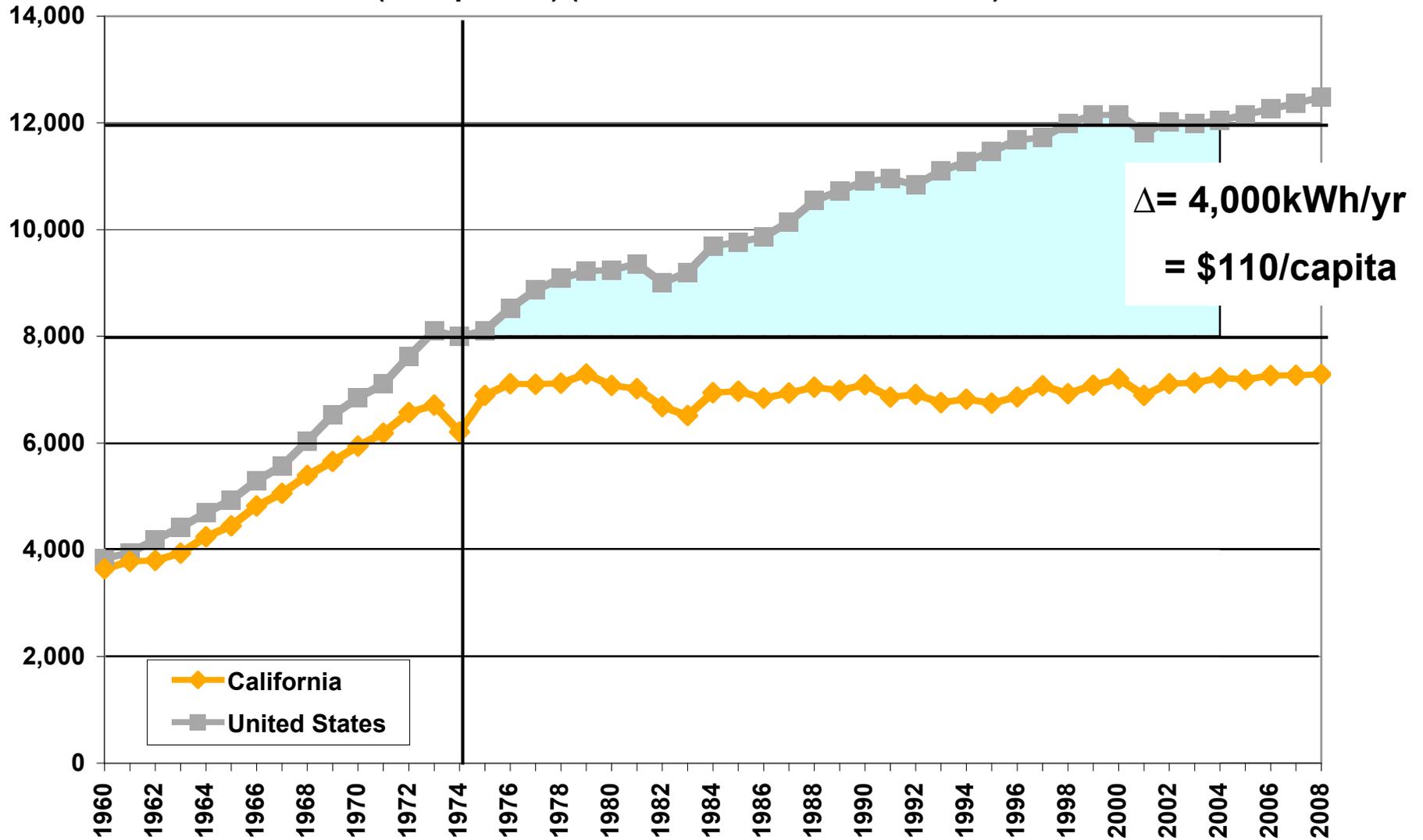
- ◆ “Had energy use kept pace with economic growth, the nation would have consumed 171 quadrillion British thermal units (Btus) last year instead of 99 quadrillion Btus”
- ◆ “About a third to a half of these savings resulted from shifts in the economy. The other half to two-thirds resulted from greater energy efficiency”

***Source: National Energy Policy: Report of the National Energy Policy Development Group, Dick Cheney, et. al., page 1-4, May 2001***

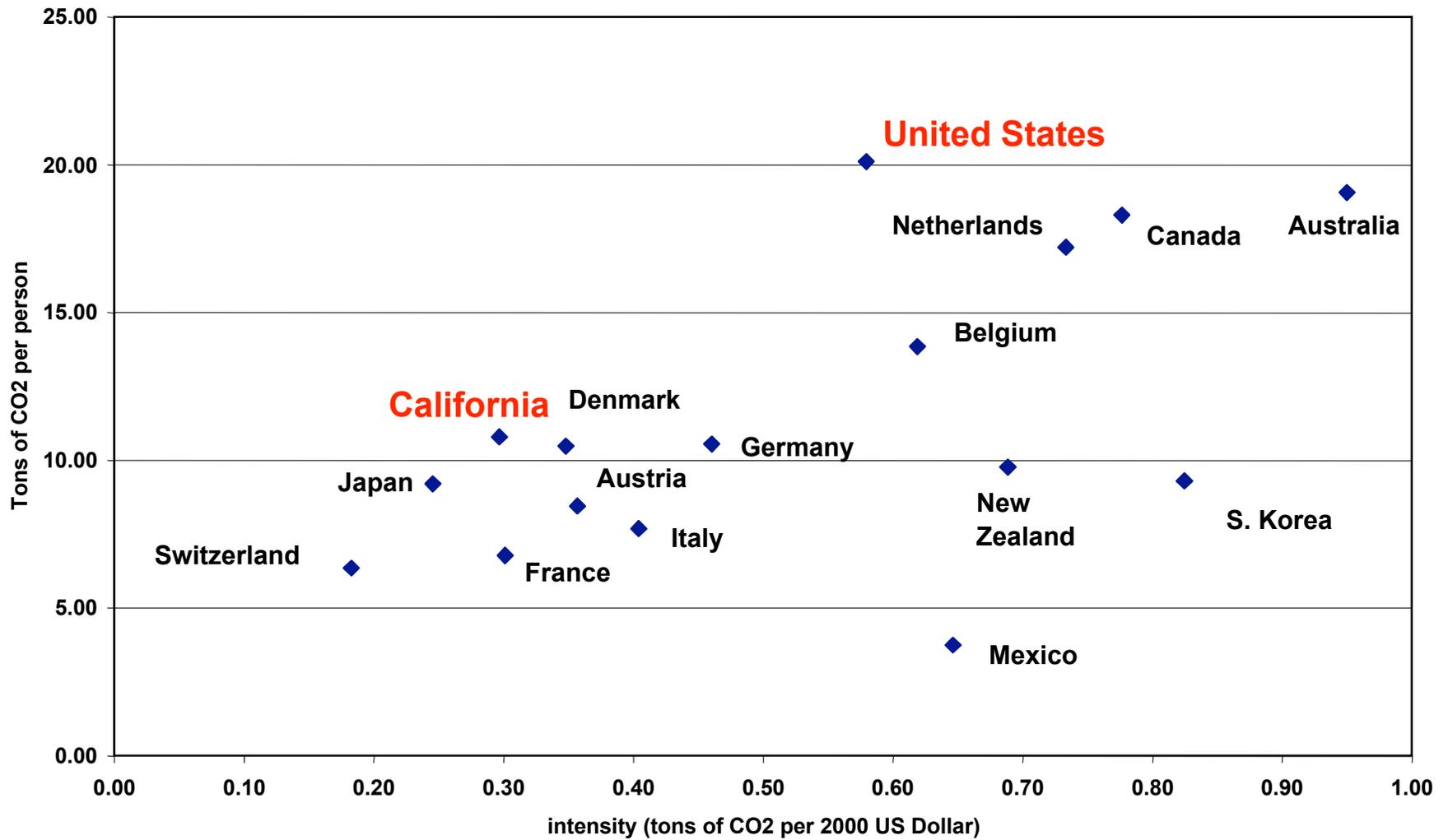
### Energy Intensity -- California and the United States



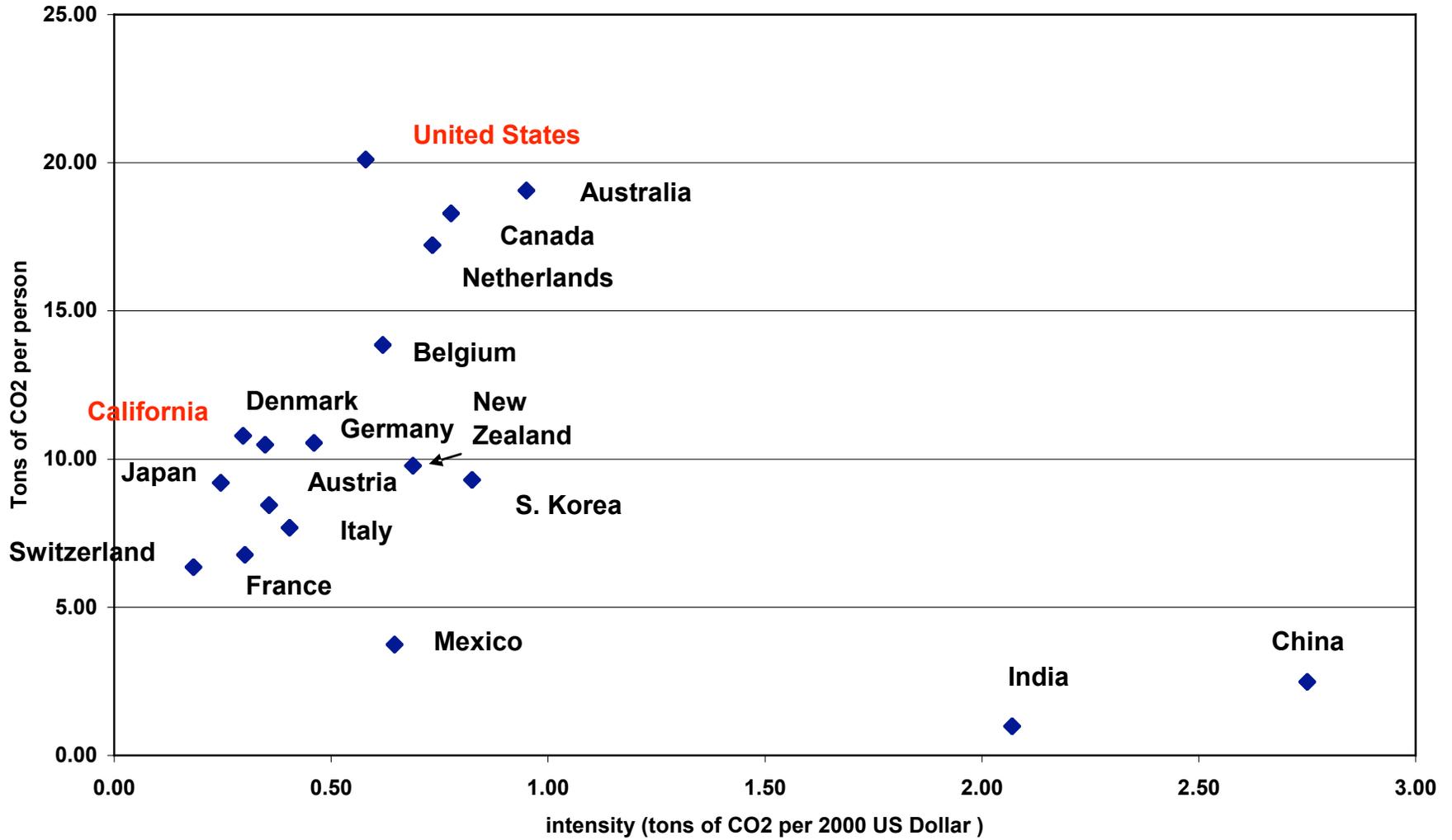
Per Capita Electricity Sales (not including self-generation)  
(kWh/person) (2005 to 2008 are forecast data)



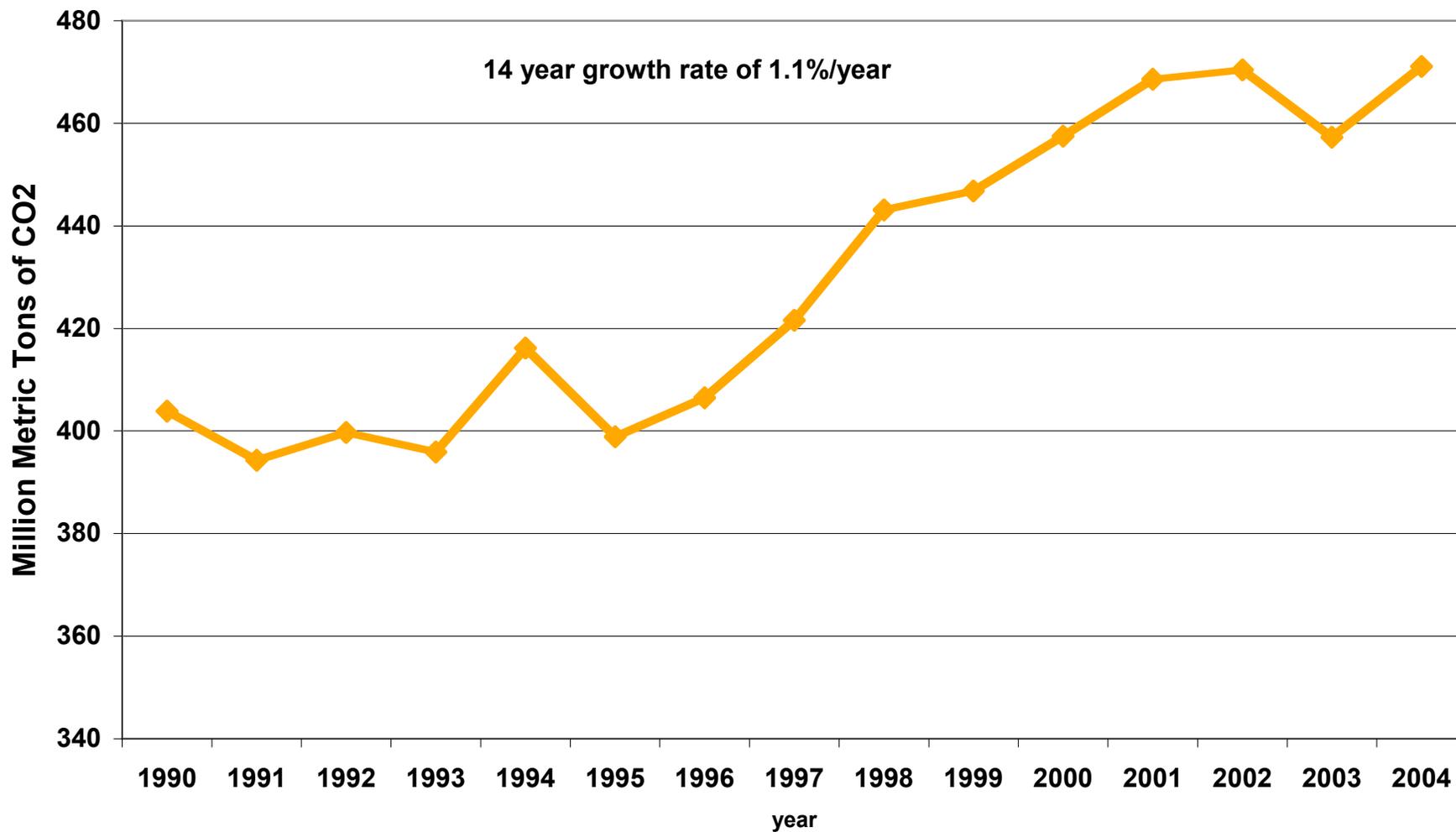
Carbon Dioxide Intensity and Per Capita CO2 Emissions -- 2001  
(Fossil Fuel Combustion Only)



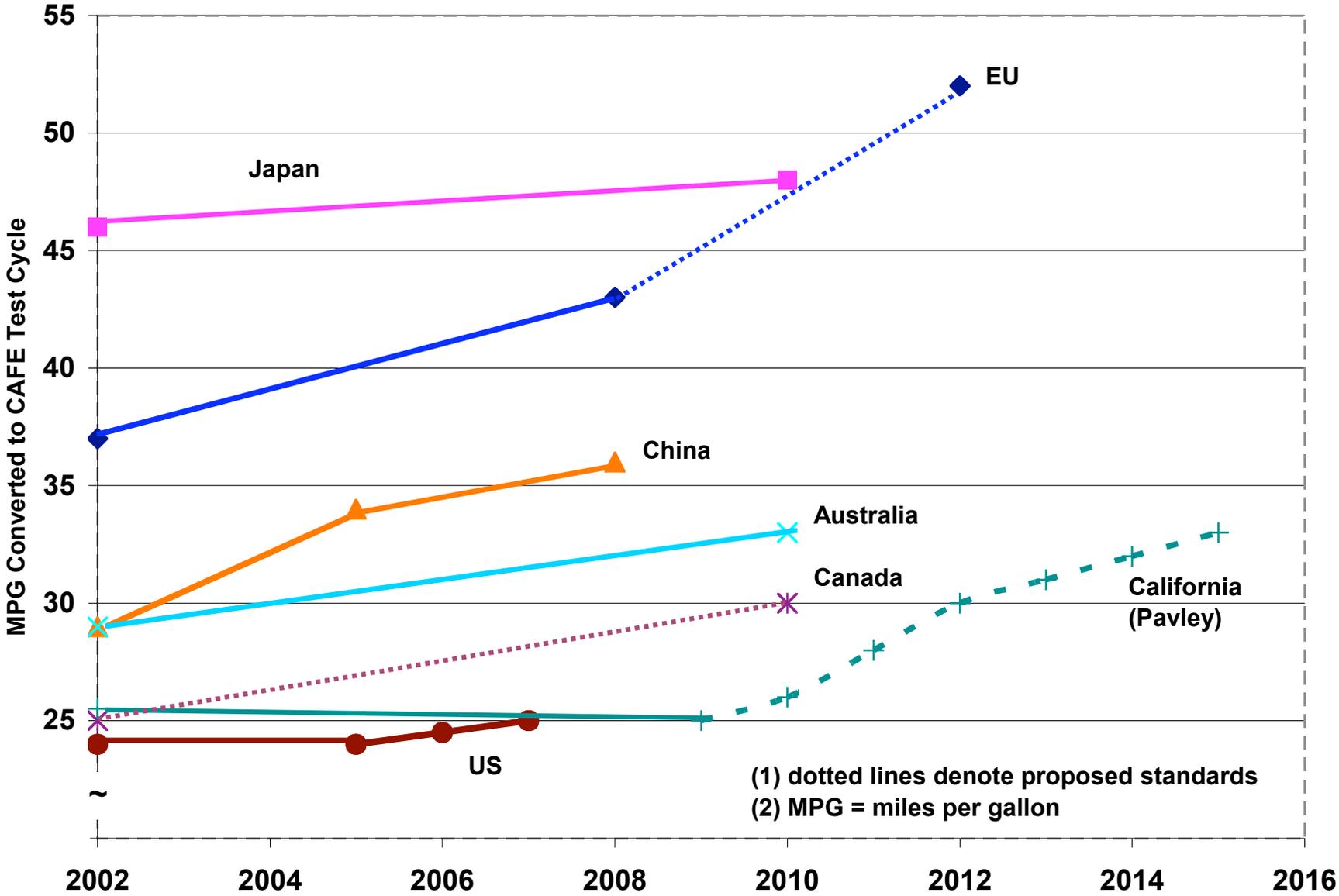
Carbon Dioxide Intensity and Per Capita CO2 Emissions -- 2001  
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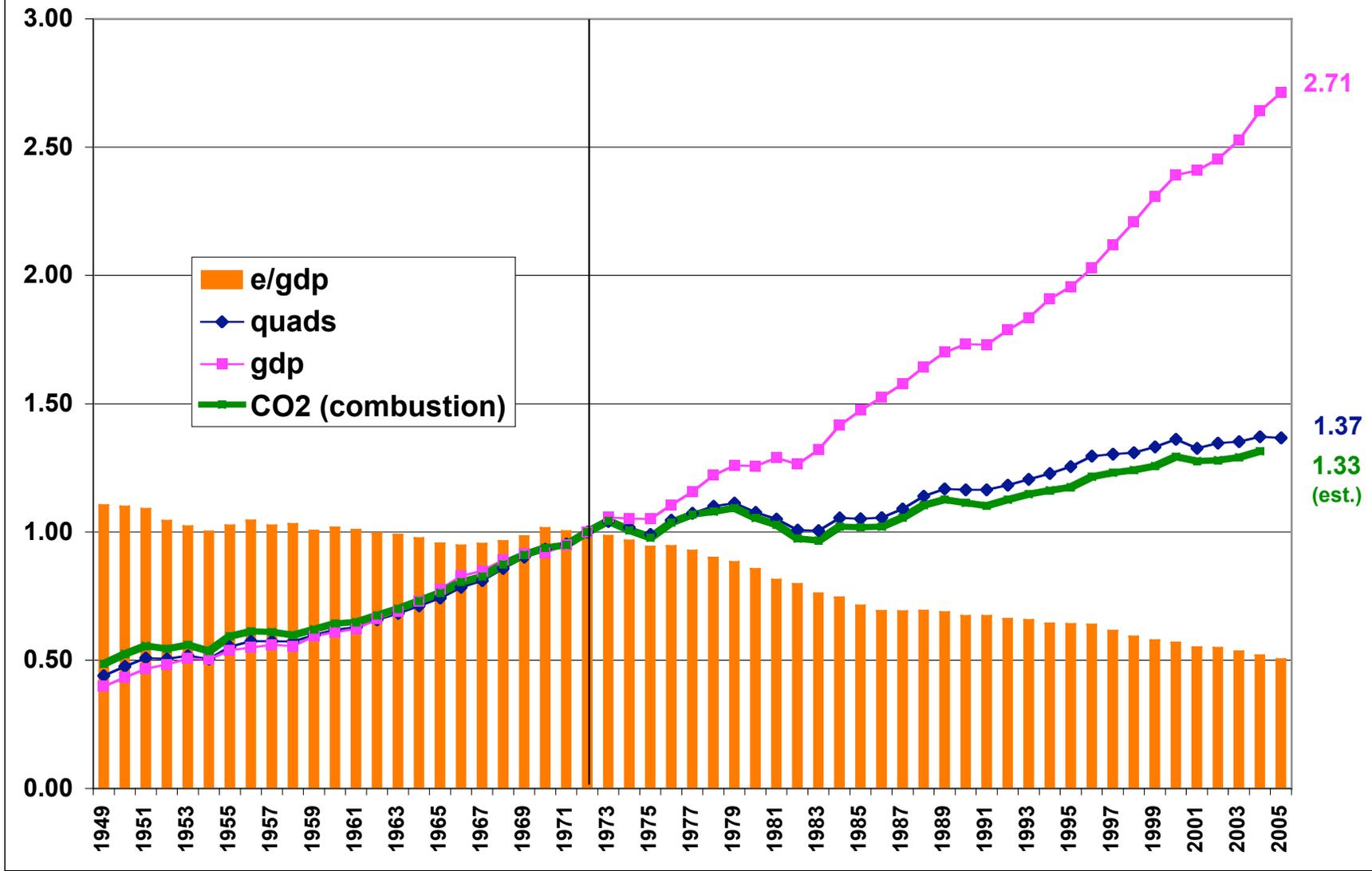
## CO2 Emissions in California Including Electricity Imports 1990 - 2004



# Comparison of Fuel Economy – Passenger Vehicles

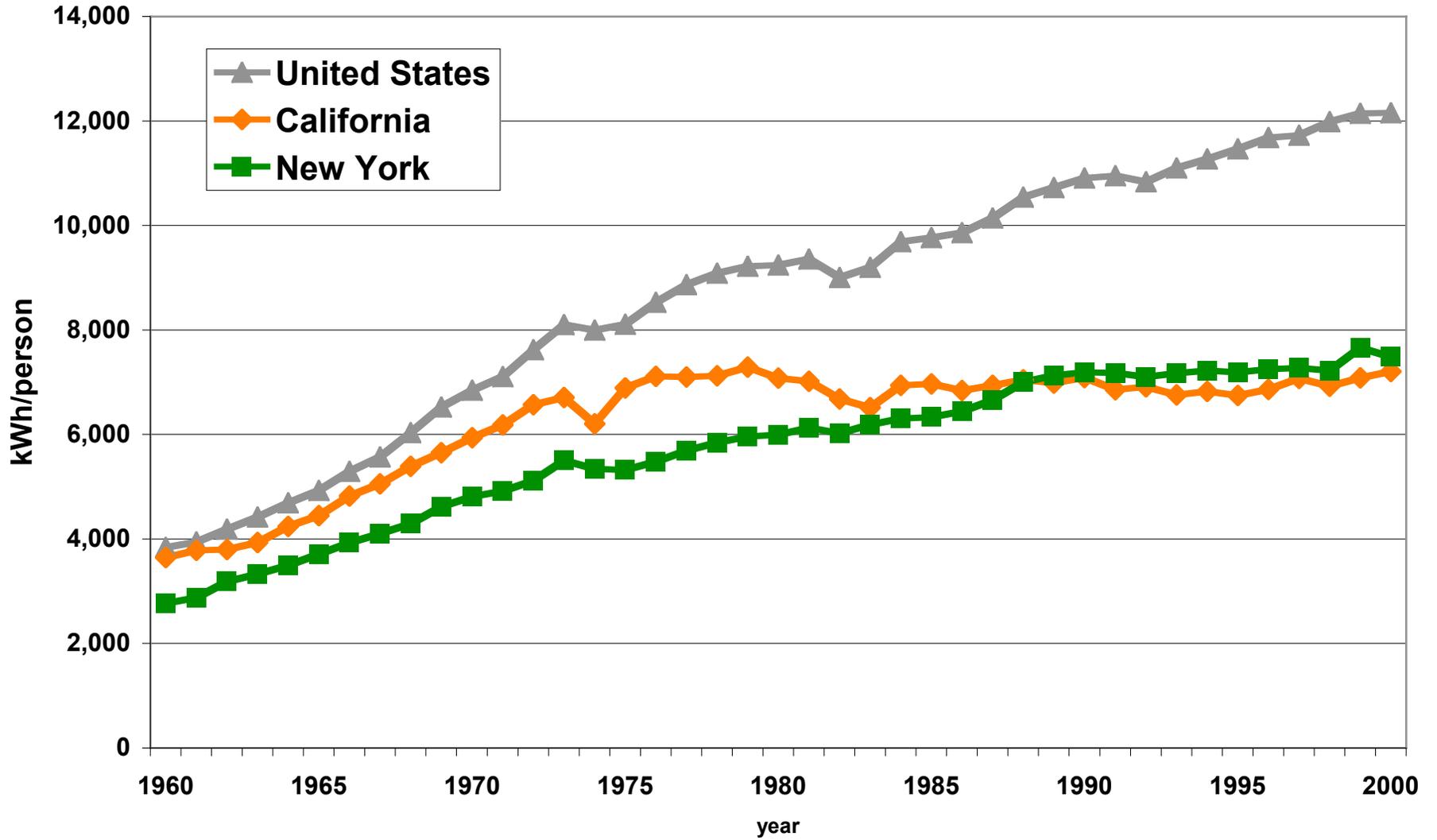


Index (1972 = 1.00) of U.S. Energy Use, GDP, Energy Intensity and Carbon Dioxide  
 last 10-year CO2 growth = 1.3% per year

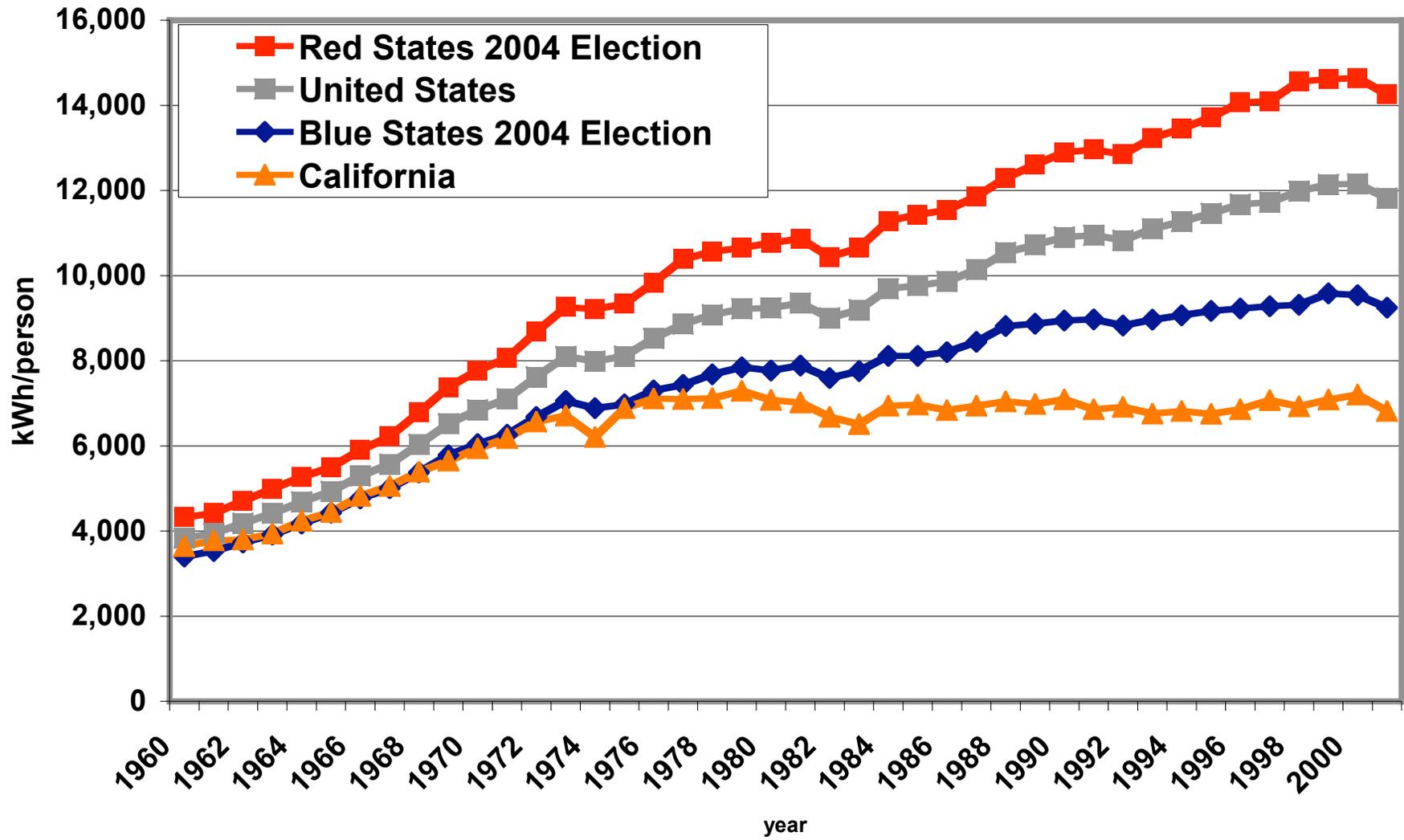


### Per Capita Electricity Consumption

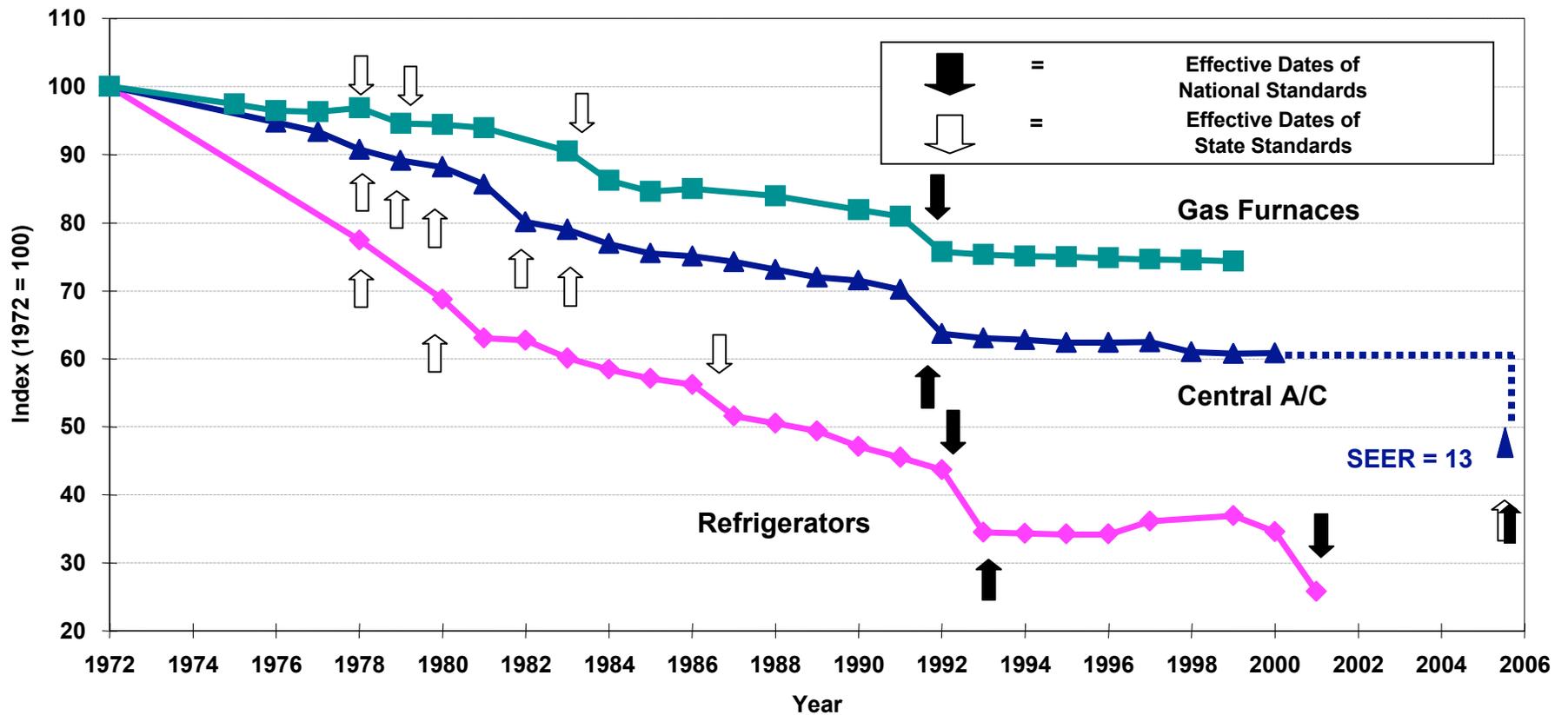
Source: [http://www.eia.doe.gov/emeu/states/sep\\_use/total/csv/use\\_csv](http://www.eia.doe.gov/emeu/states/sep_use/total/csv/use_csv)



### Per Capita Electricity Consumption



# Impact of Standards on Efficiency of 3 Appliances

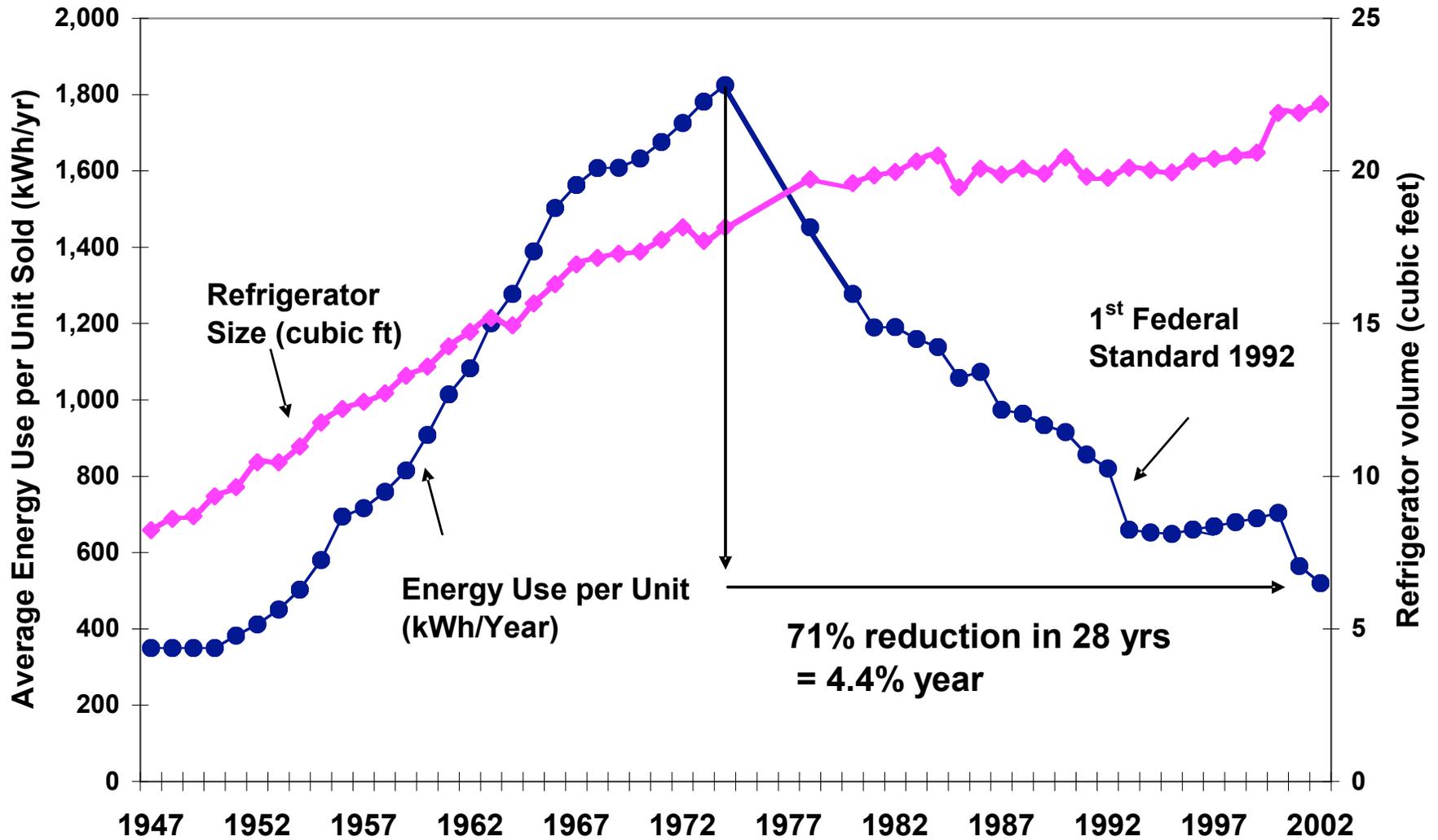


Source: S. Nadel, ACEEE,  
in ECEEE 2003 Summer Study, [www.eceee.org](http://www.eceee.org)

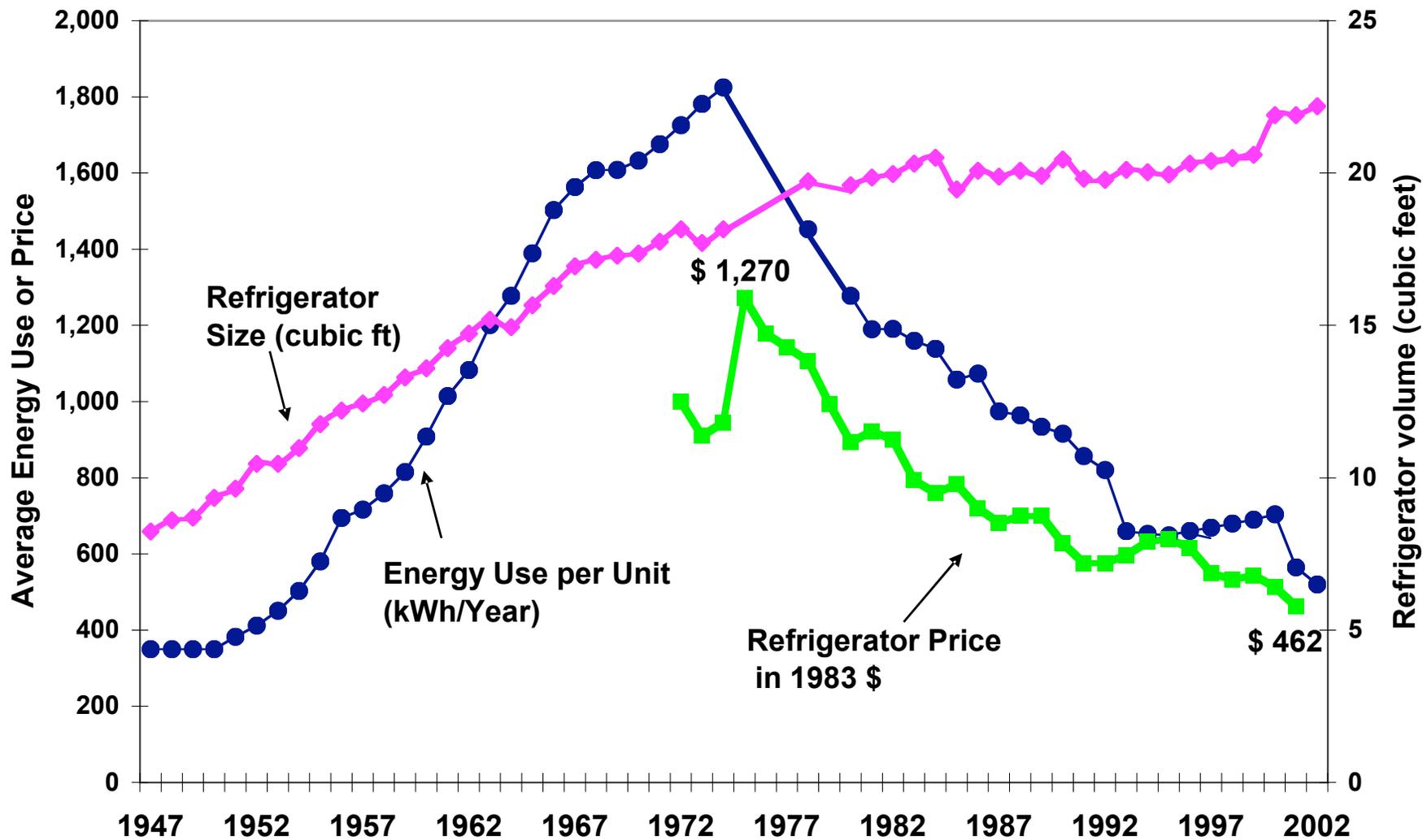
## Impact on Lighting of Building + Appliance Standards

- ◆ **United States Best Practice measured in Watts/Sq. Ft. of Commercial Building floor area.**
- ◆ **In 1974 = 4 Watts/Sq. Ft.**
- ◆ **In 2006 = 0.8 Watts/Sq. Ft.**
- ◆ **An Enlightened reduction to 1/5**
- ◆ **Drivers: Standards, electronic ballasts, and currently, “scotopic” (blue-ish) color, all thanks to LBNL and Sam Berman.**

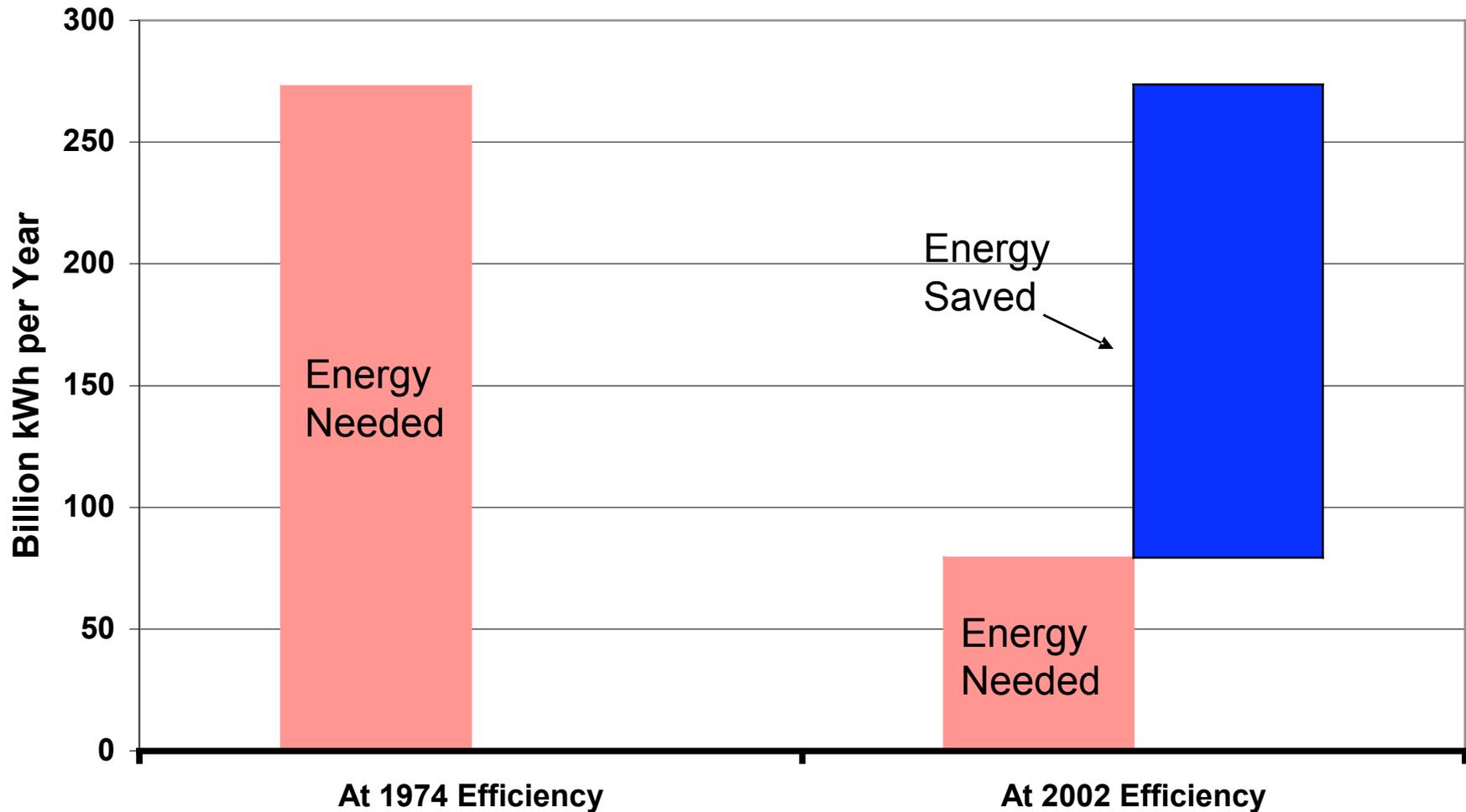
# New United States Refrigerator Use v. Time



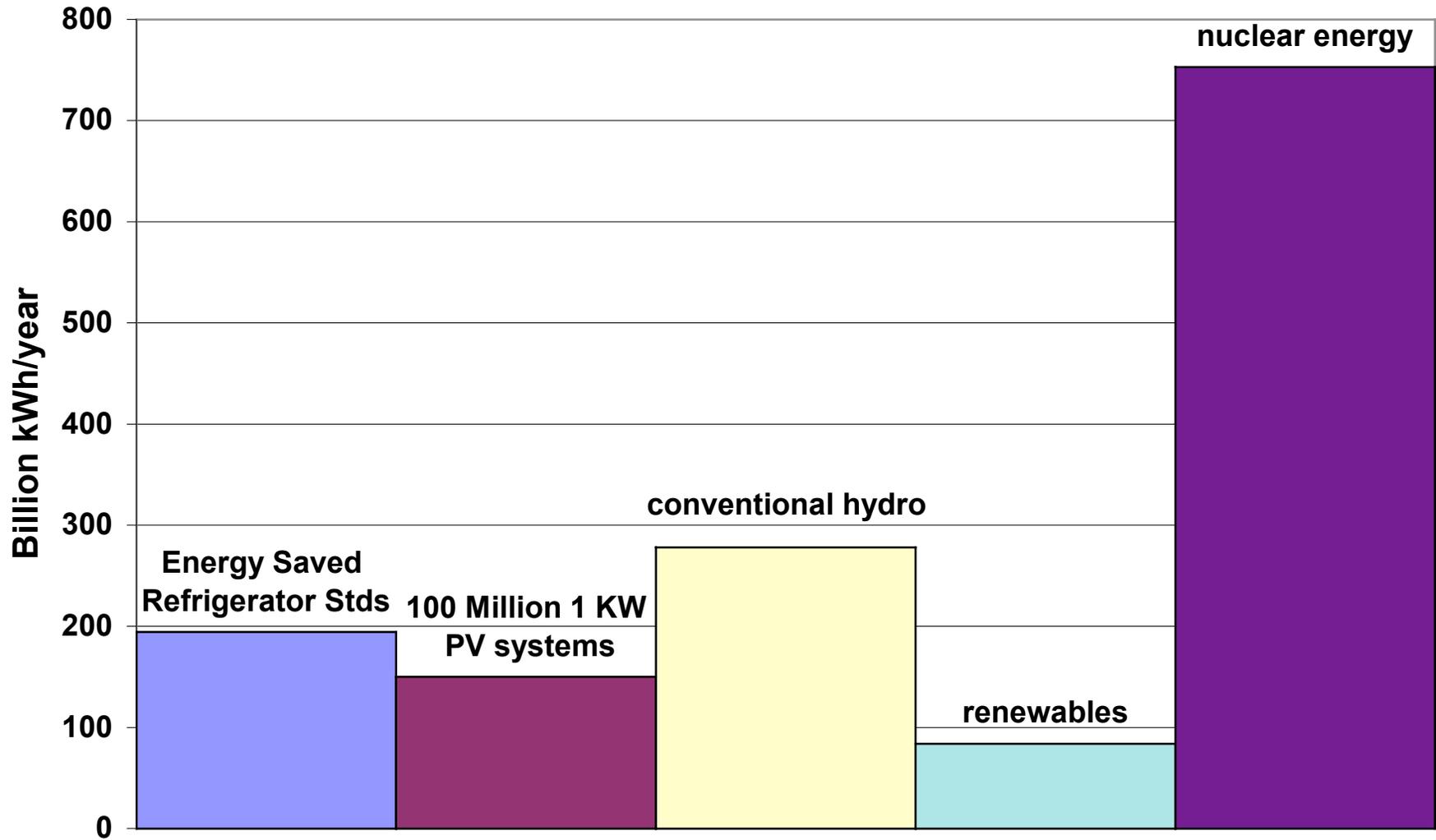
## New United States Refrigerator Use v. Time and Retail Prices



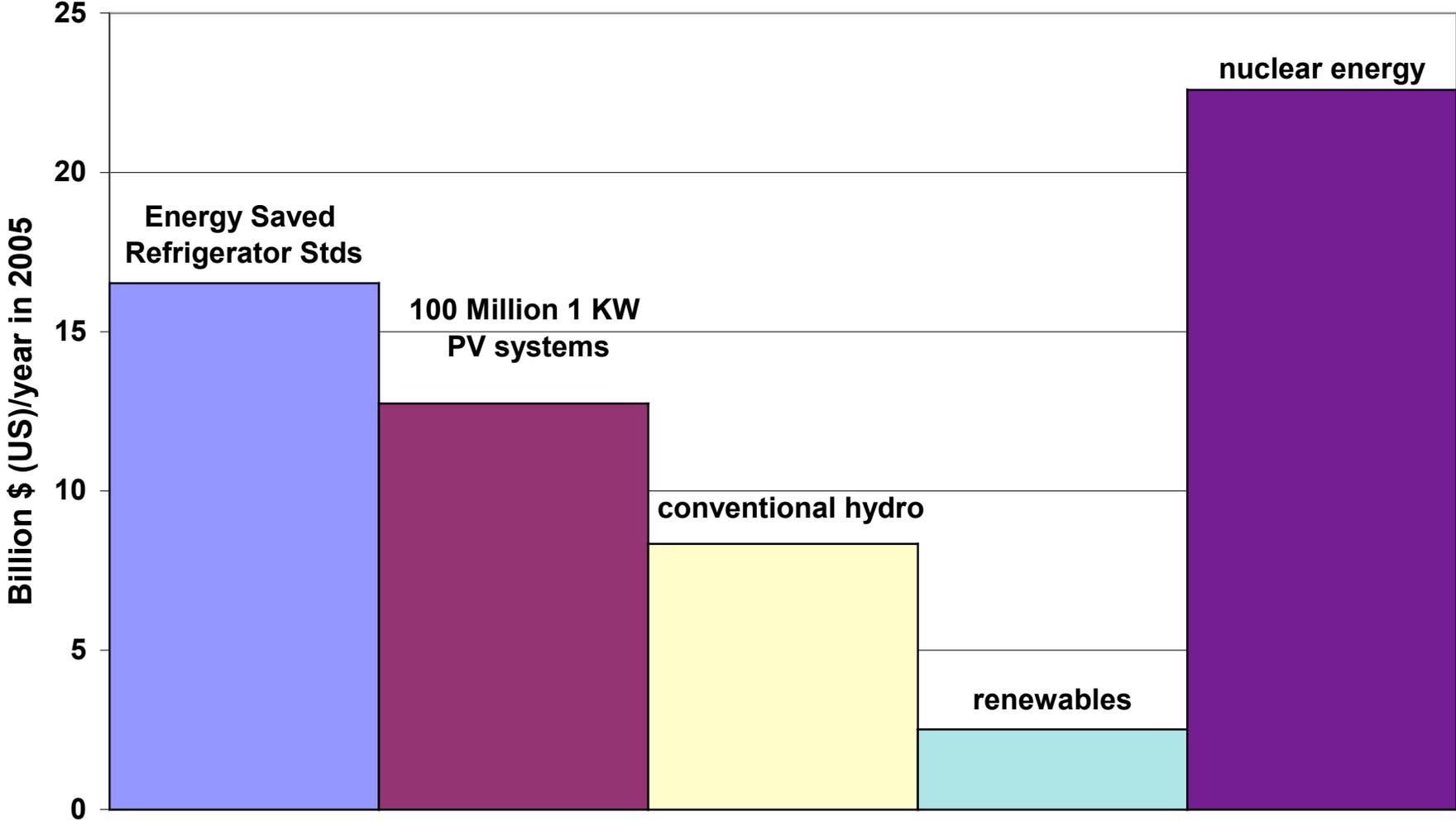
## New Refrigerator Energy Use: 71% will be saved when stock completely turns over to 2001 Standards



## Annual Energy Saved vs. Several Sources of Supply

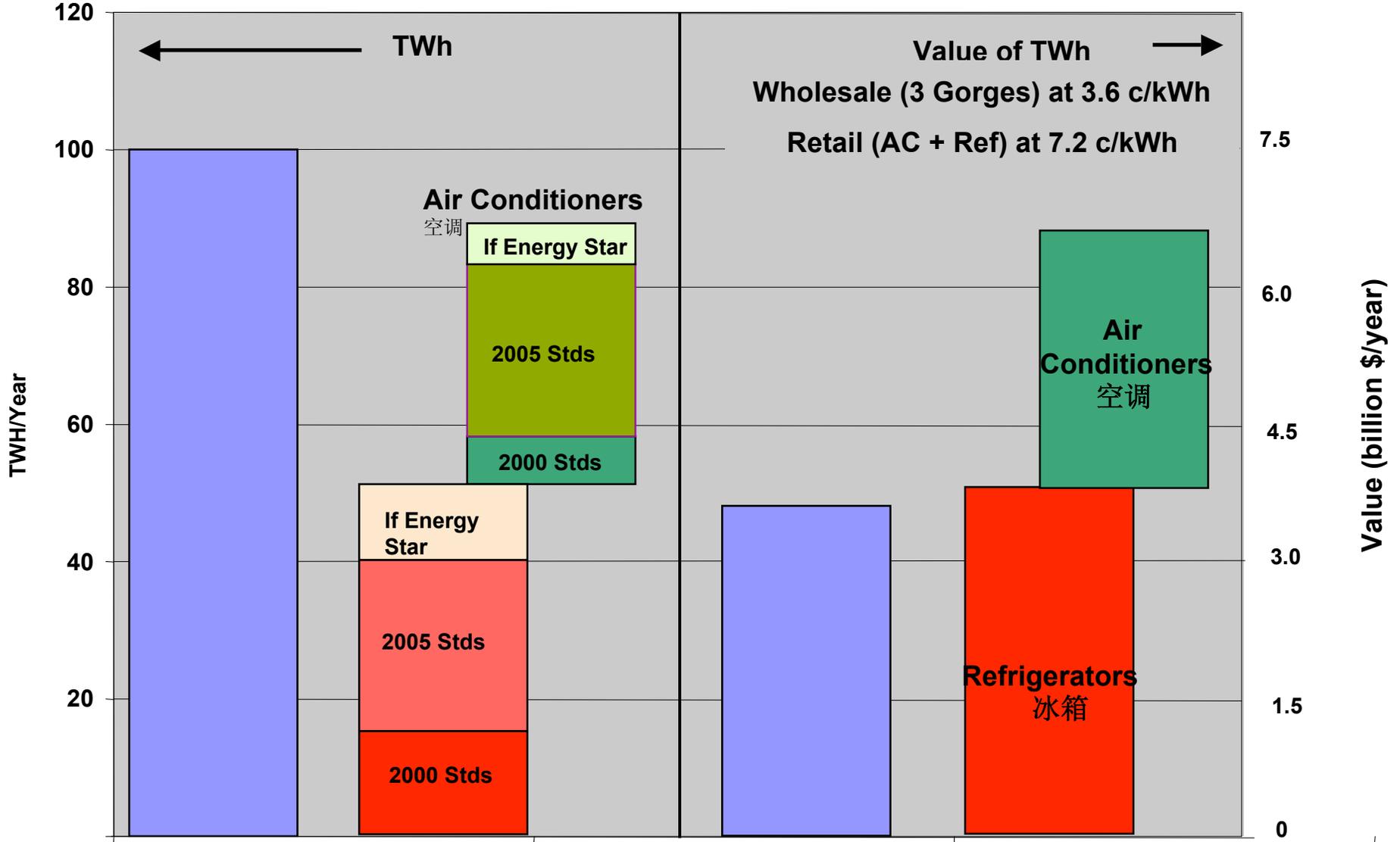


**Value of Energy to be Saved (at 8.5 cents/kWh, retail price) VS.  
Several Sources of Supply in 2005 (at 3 cents/kWh, wholesale price)**



# Comparison of 3 Gorges to Refrigerator and AC Efficiency Improvements

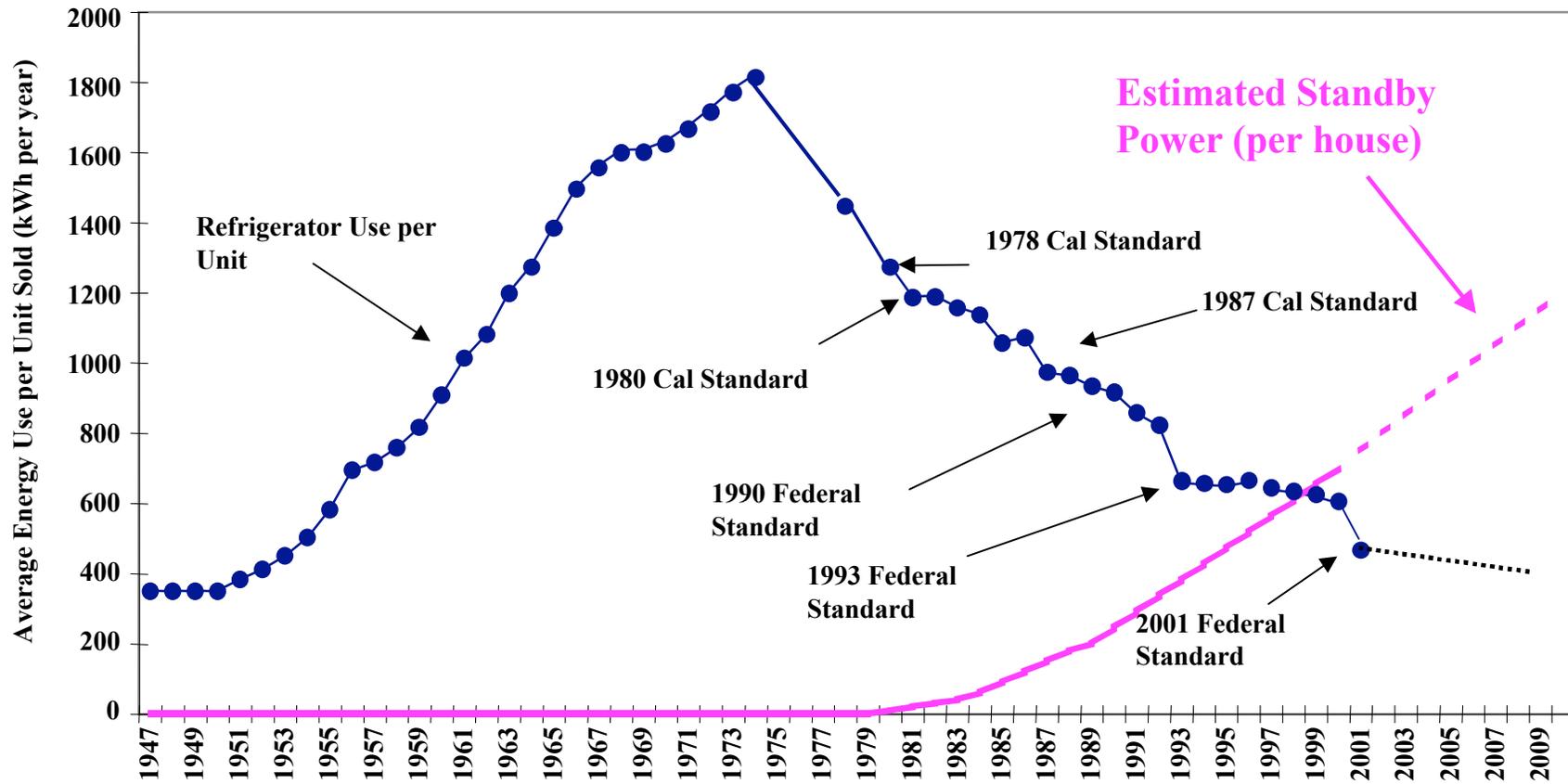
## 三峡电量与电冰箱、空调能效对比



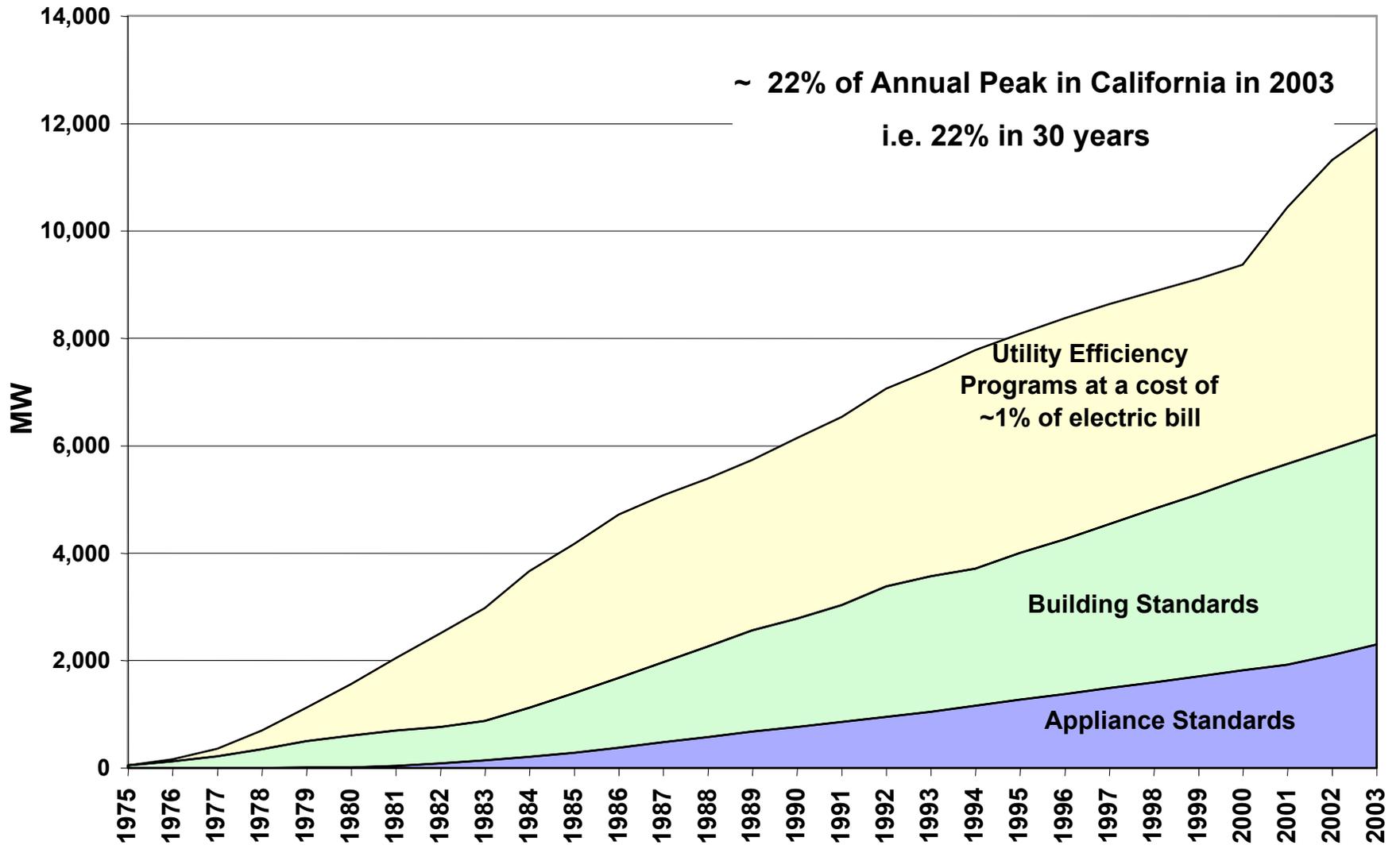
3 Gorges 三峡  
Savings calculated 10 years after standard takes effect. Calculations provided by David Fridley, LBNL

3 Gorges 三峡  
标准生效后, 10年节约电量

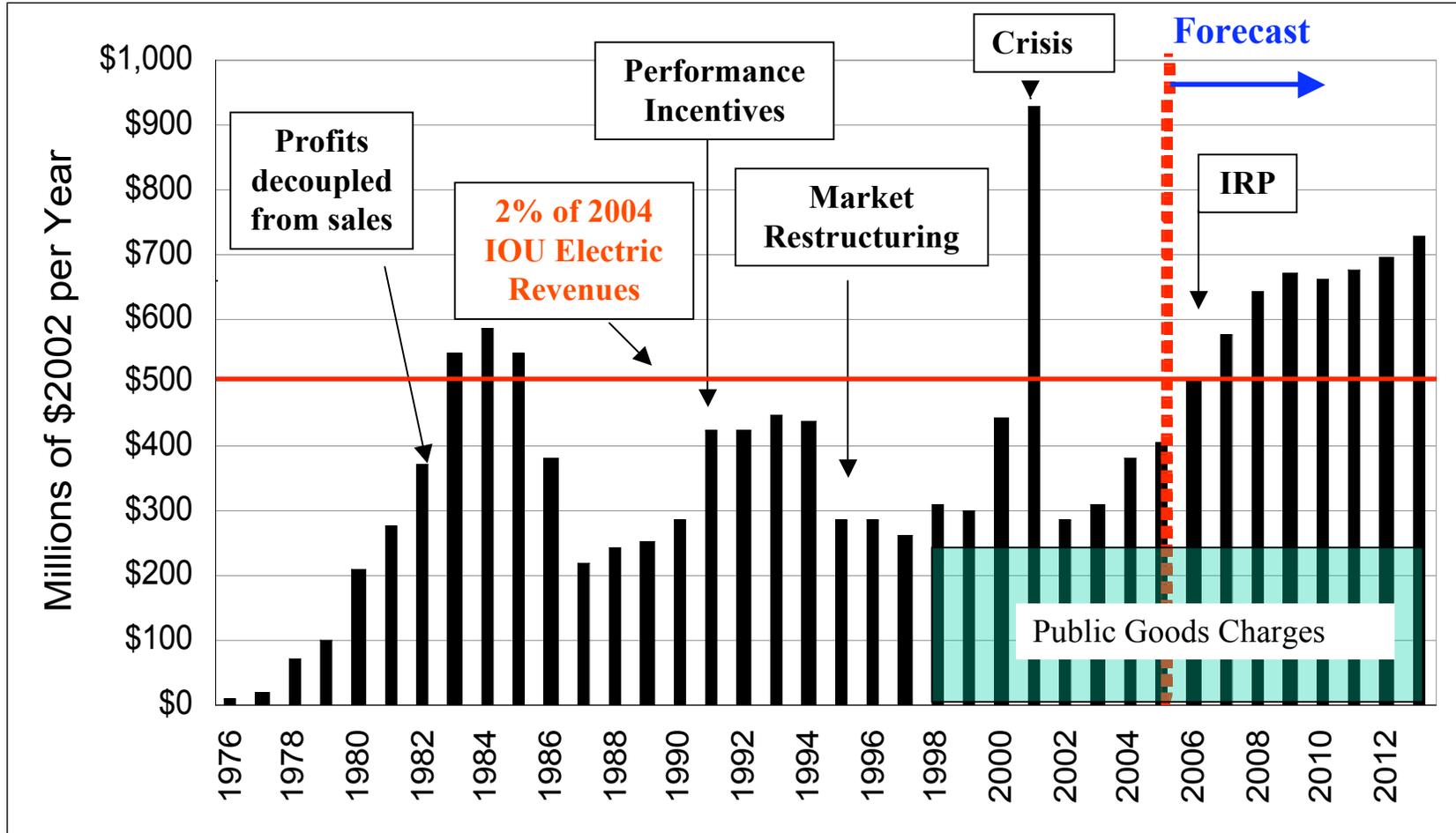
## United States Refrigerator Use, repeated, to compare with Estimated Household Standby Use v. Time



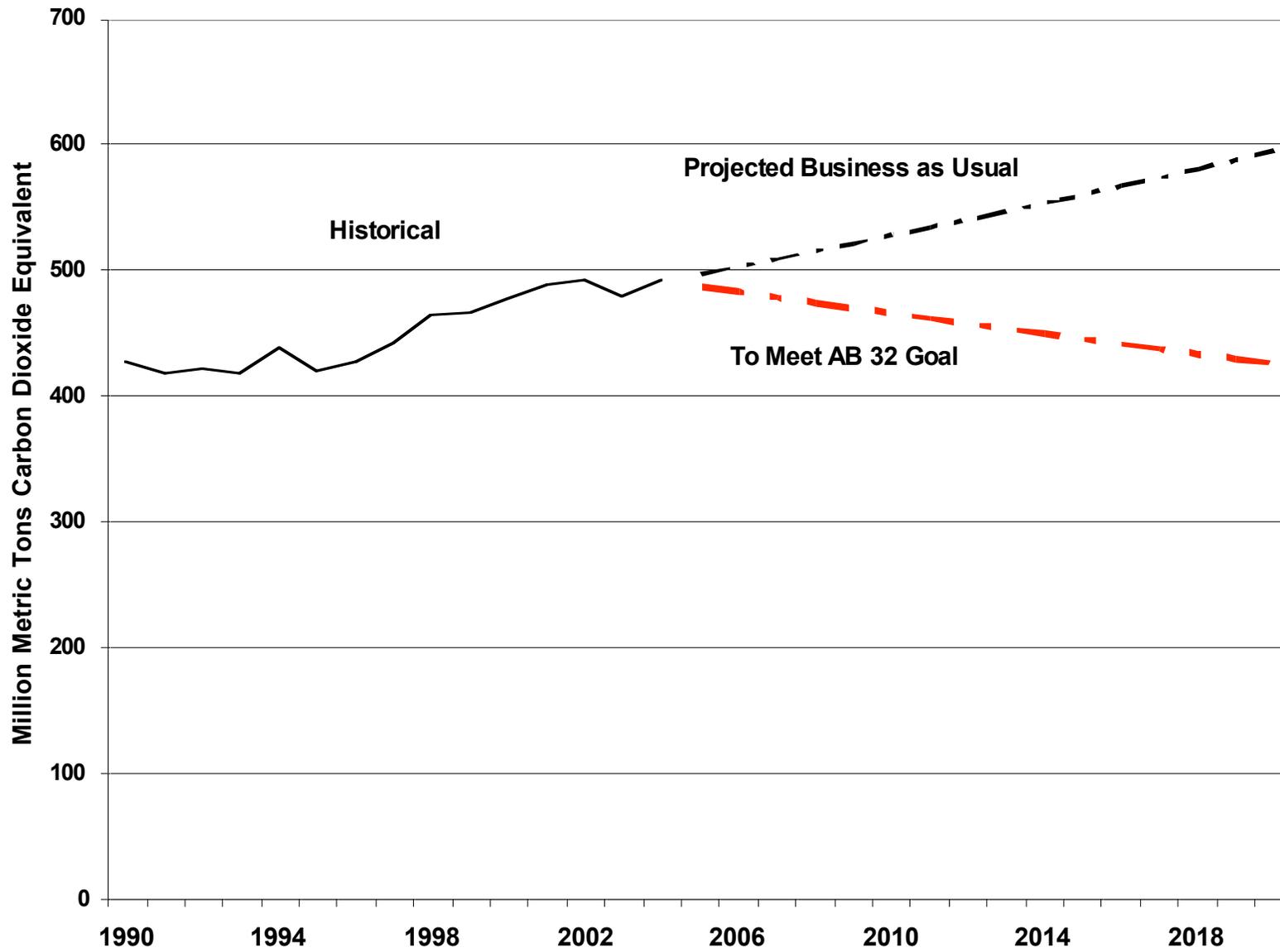
### Annual Peak Savings from Efficiency Programs and Standards



# California IOU's Investment in Energy Efficiency

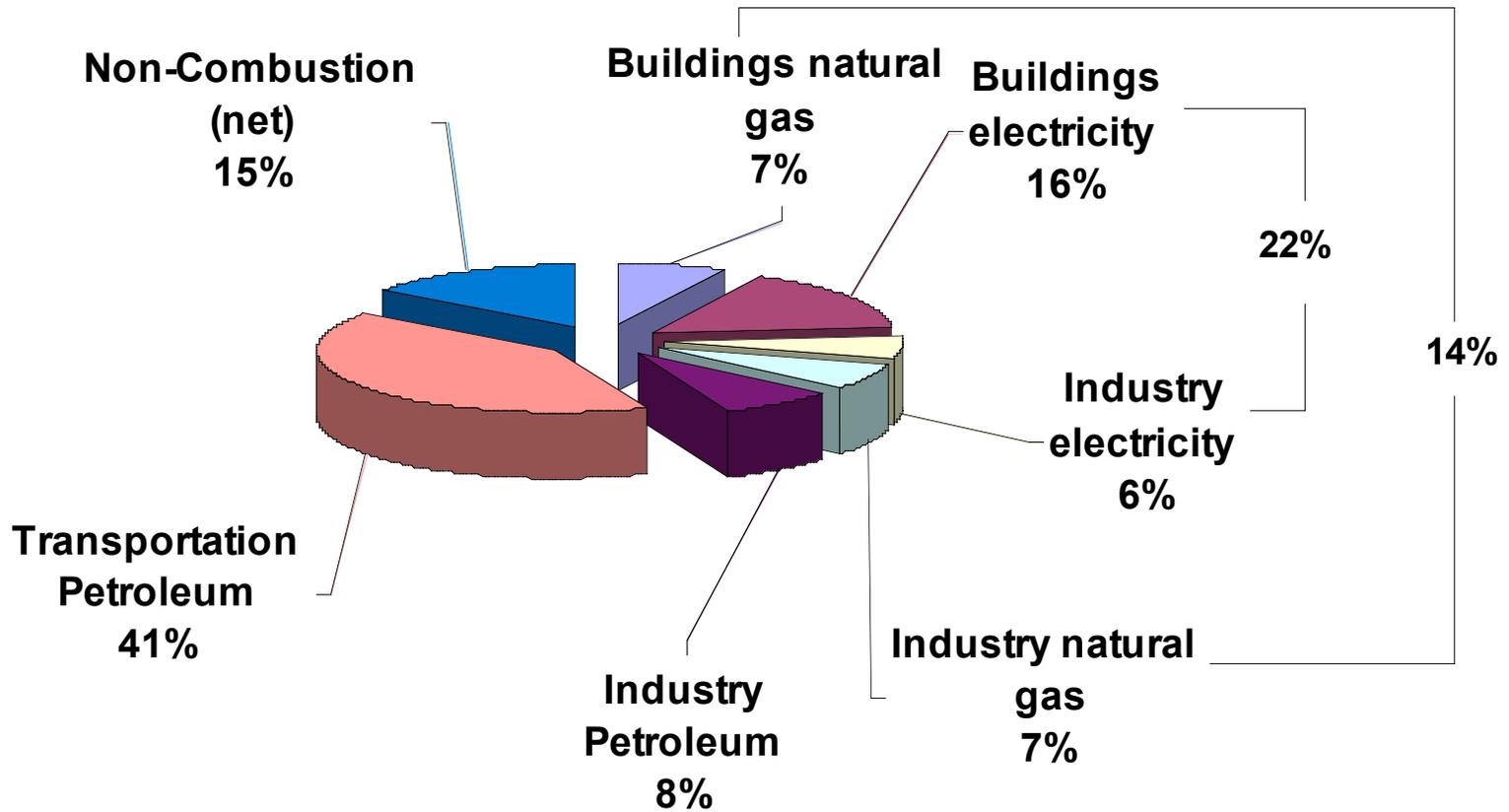


# CO2 Emissions in California: Historical and Projected



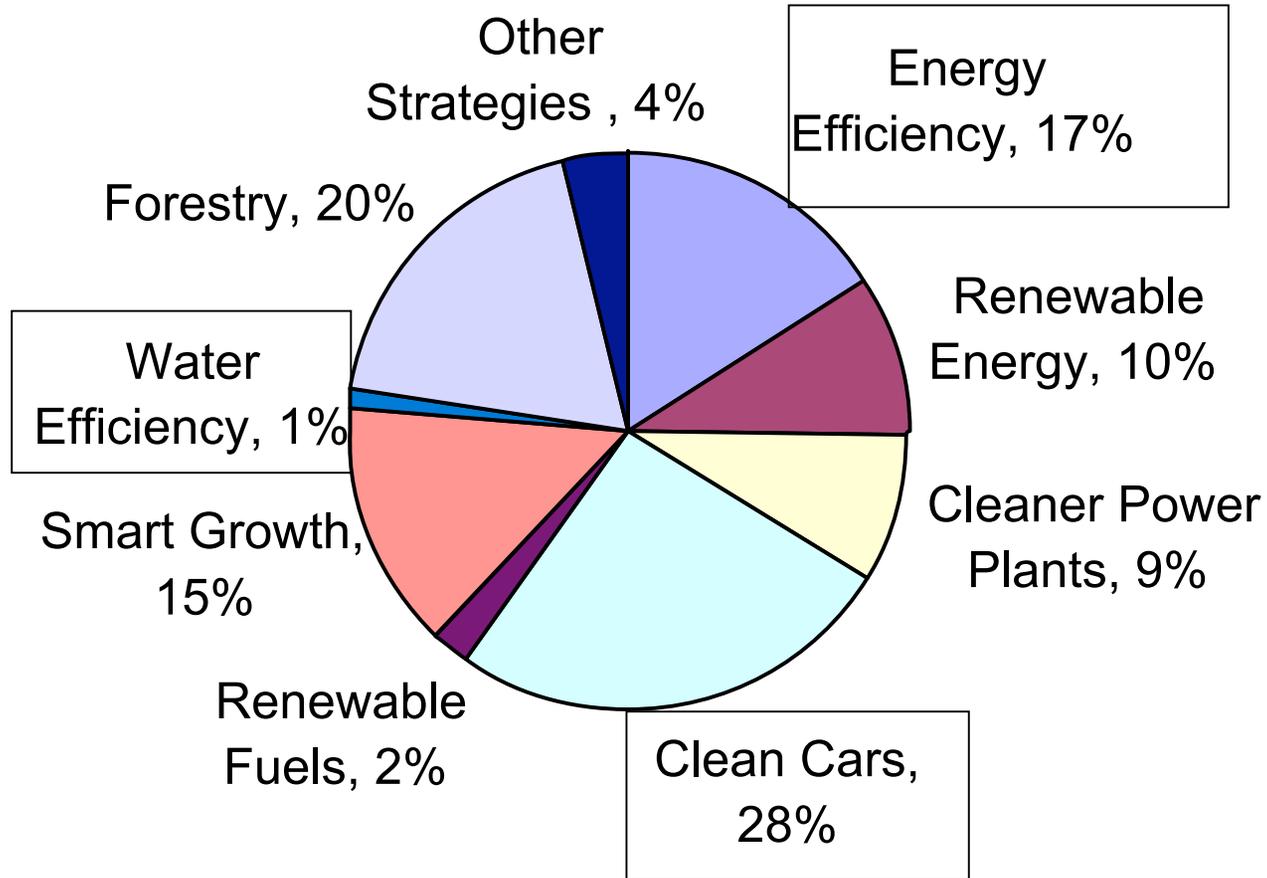
# Emissions of CO2 in California by End Use in 2004

Total Emissions = 490 Million metric tons CO2 equivalent

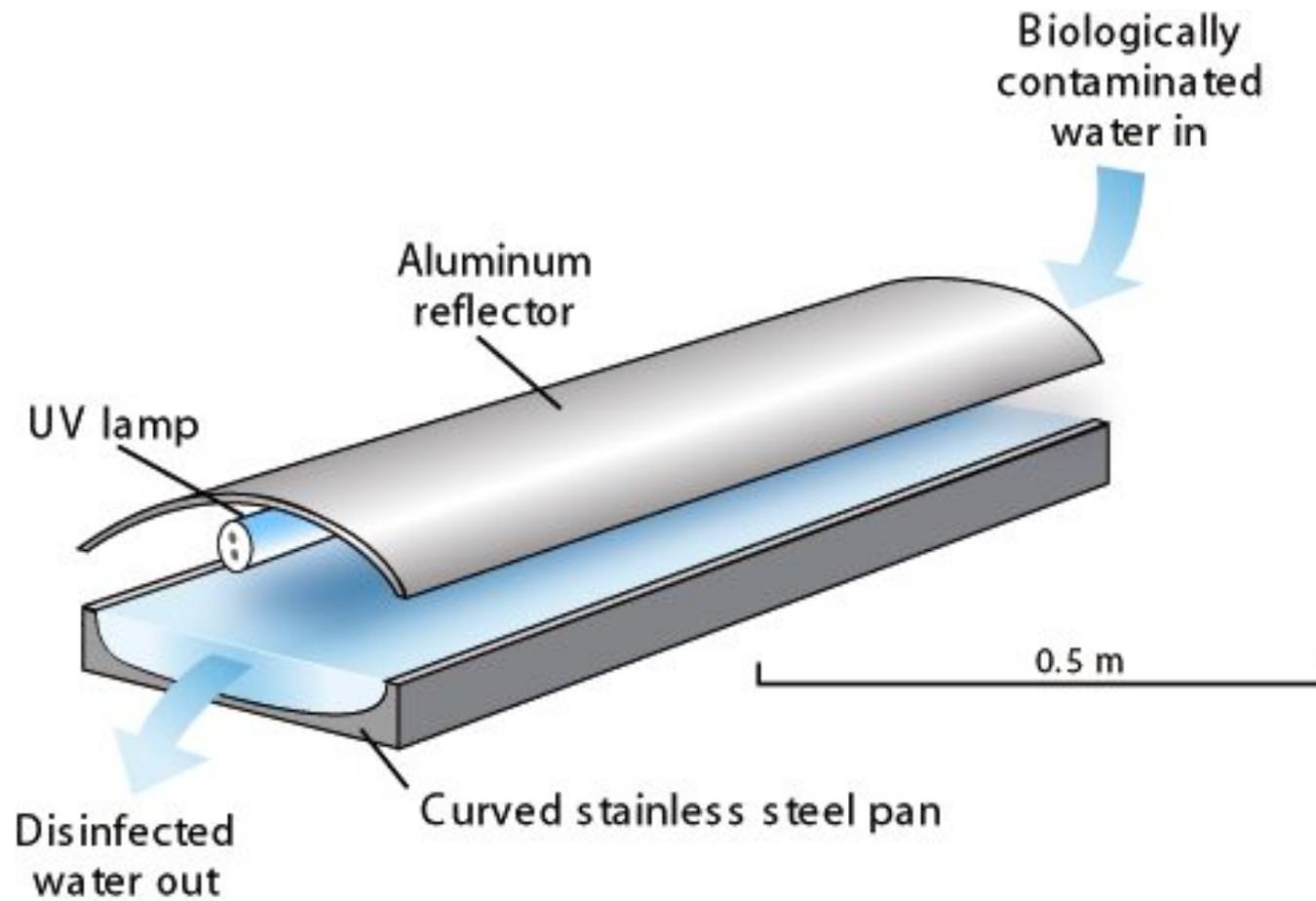


## Strategies for Meeting California's CO2 Goals in 2020

Total Reductions = 174 Million metric Tons CO2 equivalent



# UV Water Purification



## Kothapeta (Dec. 2005) commissioning test





Typical interior layout of  
the WaterHealth  
Community System  
Installation  
in Kothapeta

**Source: Dr. Ashok Gadgil,  
LBNL**

## Ultra Violet Water Purification for Villages in Developing World

Ashok Gadgil at LBNL points out if UV treatment replaces boiling 10 tons of water per day, each system avoids 3 tons of CO<sub>2</sub> per day. An American car emits only 4 tons of CO<sub>2</sub> per YEAR

UVW meets / exceeds WHO and US EPA purification criteria

- ◆ Energy efficient: 60 watts disinfects 1 ton / hour
- ◆ **Low cost: price, including profit, is under 1 cent (US)/gallon**
- ◆ Reliable, Mature components
- ◆ Can treat un-pressurized water
- ◆ Rapid throughput: 12 seconds under lamp
- ◆ Low maintenance: once every three months
- ◆ >50 units now operating in India and Philippines, adding one village/week
- ◆ <http://www.waterhealth.com/>
- ◆ *If 1 Billion villagers can avoid boiling 10 liters/day of water (by burning kerosene), the avoided CO<sub>2</sub> is equivalent to 5 million barrels/day of gasoline, which is more than half of all US gasoline use.*

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- ◆ This talk available on my web page

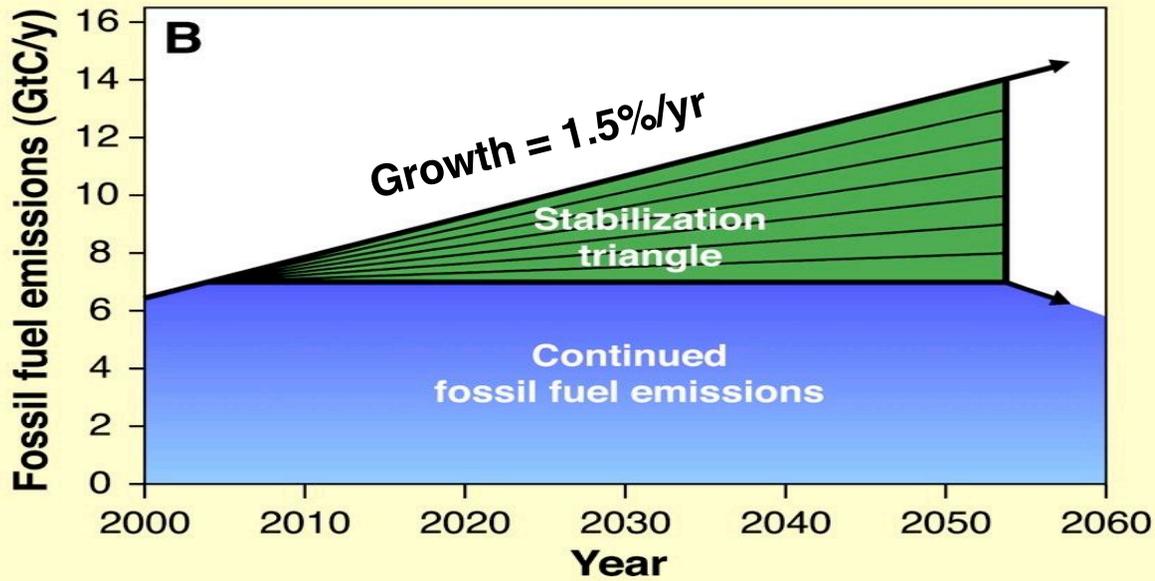
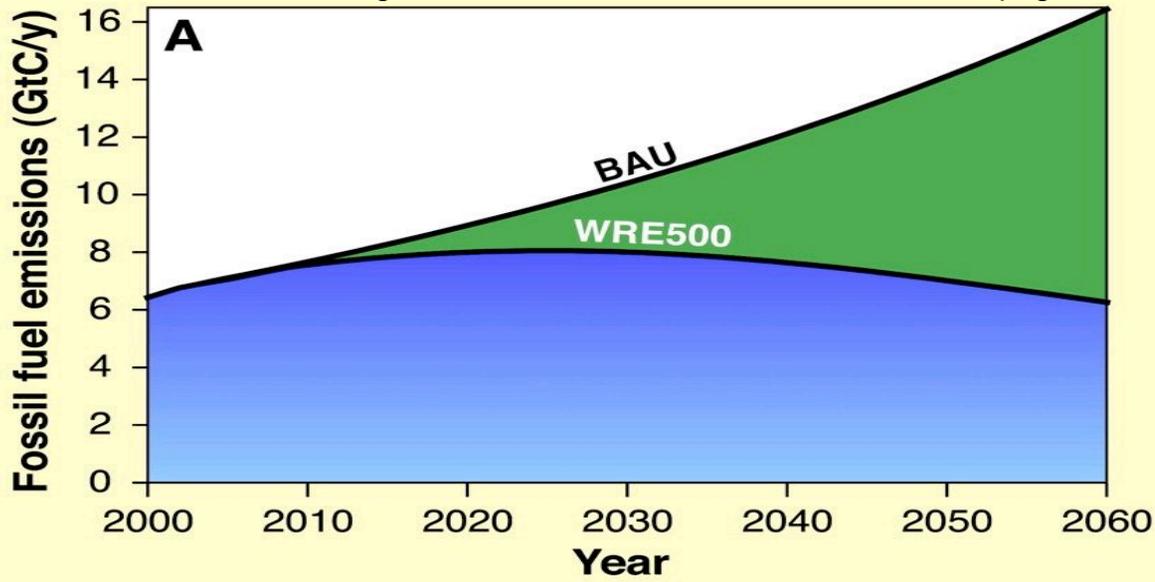
- ◆ Just Google

“Art Rosenfeld”

# Initiatives in Efficiency

- ◆ “Fleet” Average for Lighting Efficiency to reduce incandescent share
  - Measured in lumens/watt
- ◆ Air conditioning standards. We can save 20% at almost no cost.
  - U.S. split into regions based on type of weather
  - Hot/dry west differs from warm/wet southeast
  - With peak load as the focus, not seasonal efficiency— “SEER”
- ◆ White roofs on existing buildings
- ◆ Benchmarking of Commercial Buildings
  - Fine tuning of energy management systems

Source: Stabilization Wedges: Pacala and Socolow, Science Vol 305, page 968



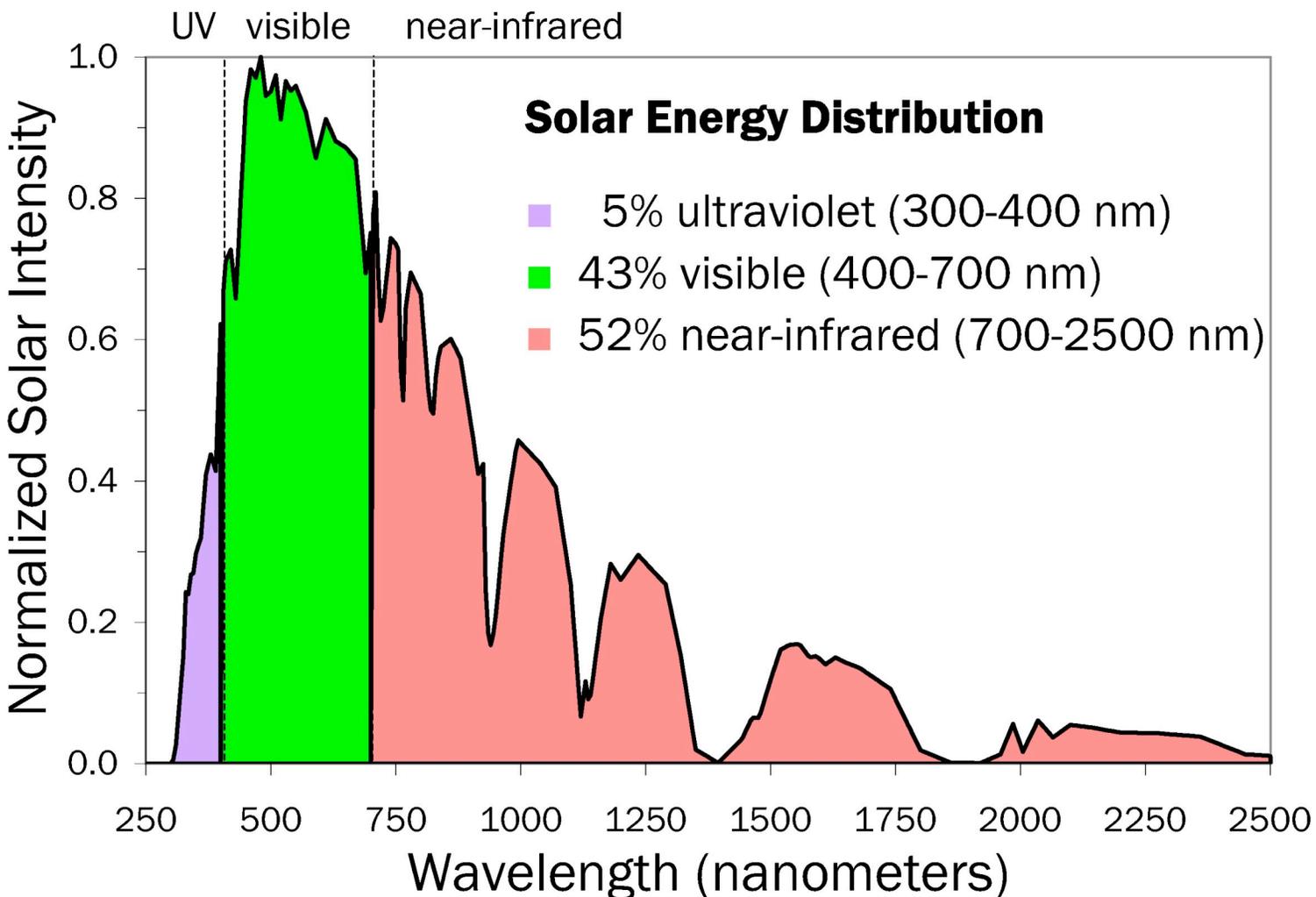
## Illuminating Space vs. the Street

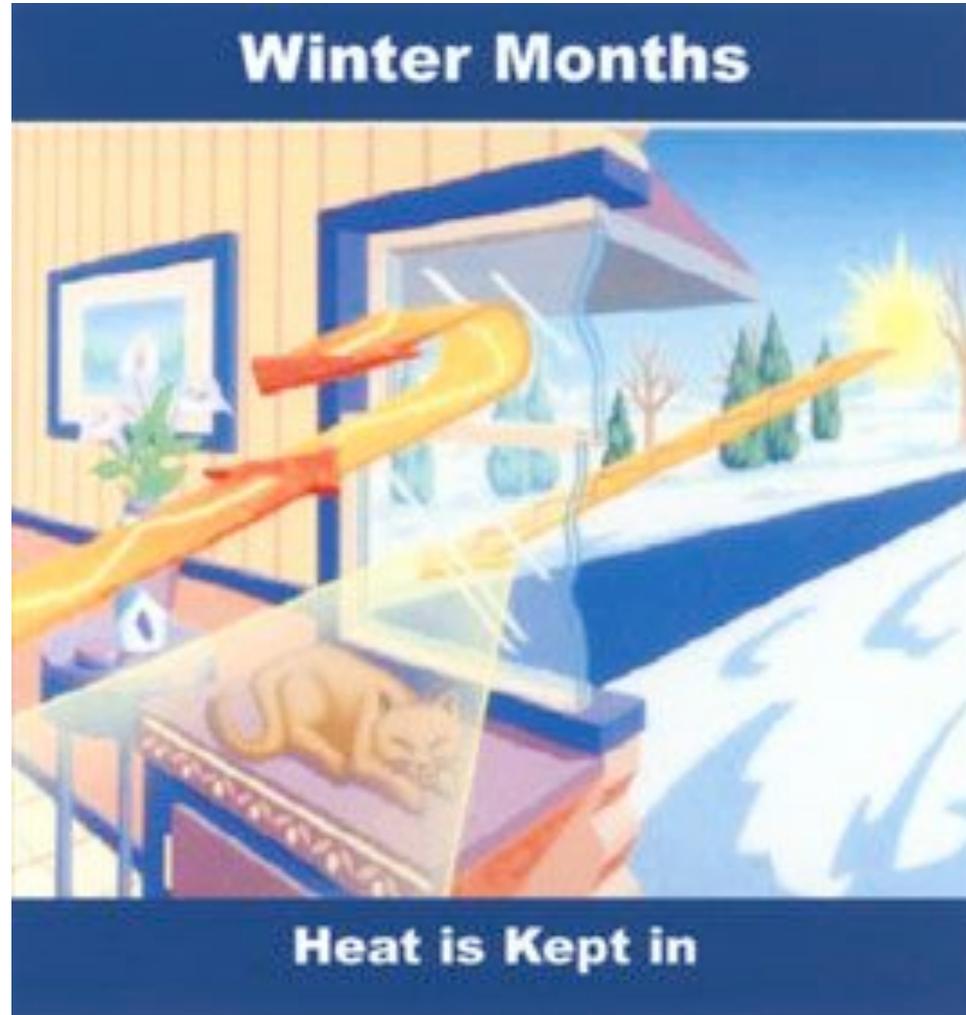


## Heat Mirror Windows – Steve Selkowitz, LBNL

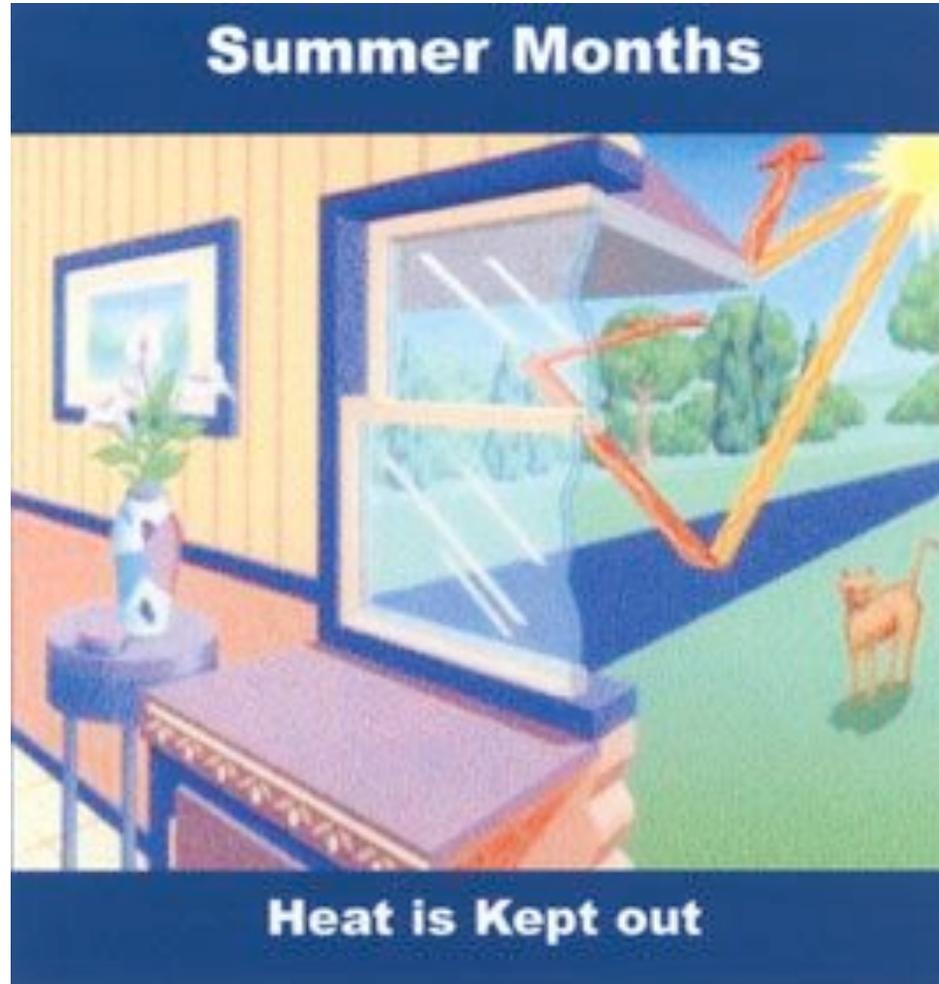
- ◆ Low Emissivity films are required by building standards world-wide. They reflect far infrared radiation. Retain indoor heat in winter, reflect outdoor heat in summer. They double the R-value of double glazing, and the inside pane is warm to the touch – more comfortable
- ◆ Before low-E, windows were 30% of the heat load of a home – now 15%.
- ◆ During a Montana winter, a north-facing low-E window, facing a snowy sunlit slope, is a net energy gainer.
- ◆ “Selective film are required for Commercial Buildings in California. They reflect far- and near-infrared radiation, and halve the solar gain through windows; including car windshields in BMW’s etc.
- ◆ **Modern windows save ~1 Mbod of oil equivalent, = Alaskan oil.**

# Cool Colors Reflect Invisible Near-Infrared Sunlight





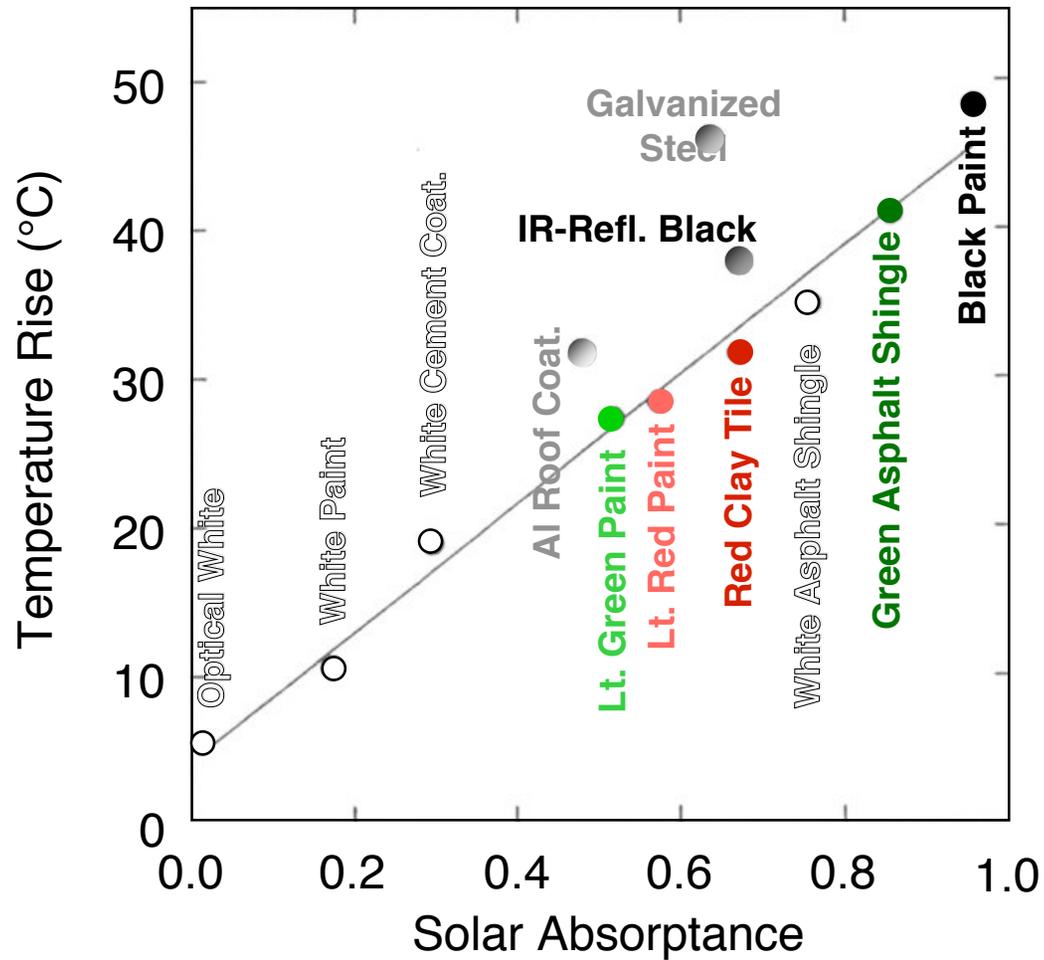
[http://www.nwhi.net/Vinyl\\_Windows/Low\\_E\\_Glass.htm](http://www.nwhi.net/Vinyl_Windows/Low_E_Glass.htm)



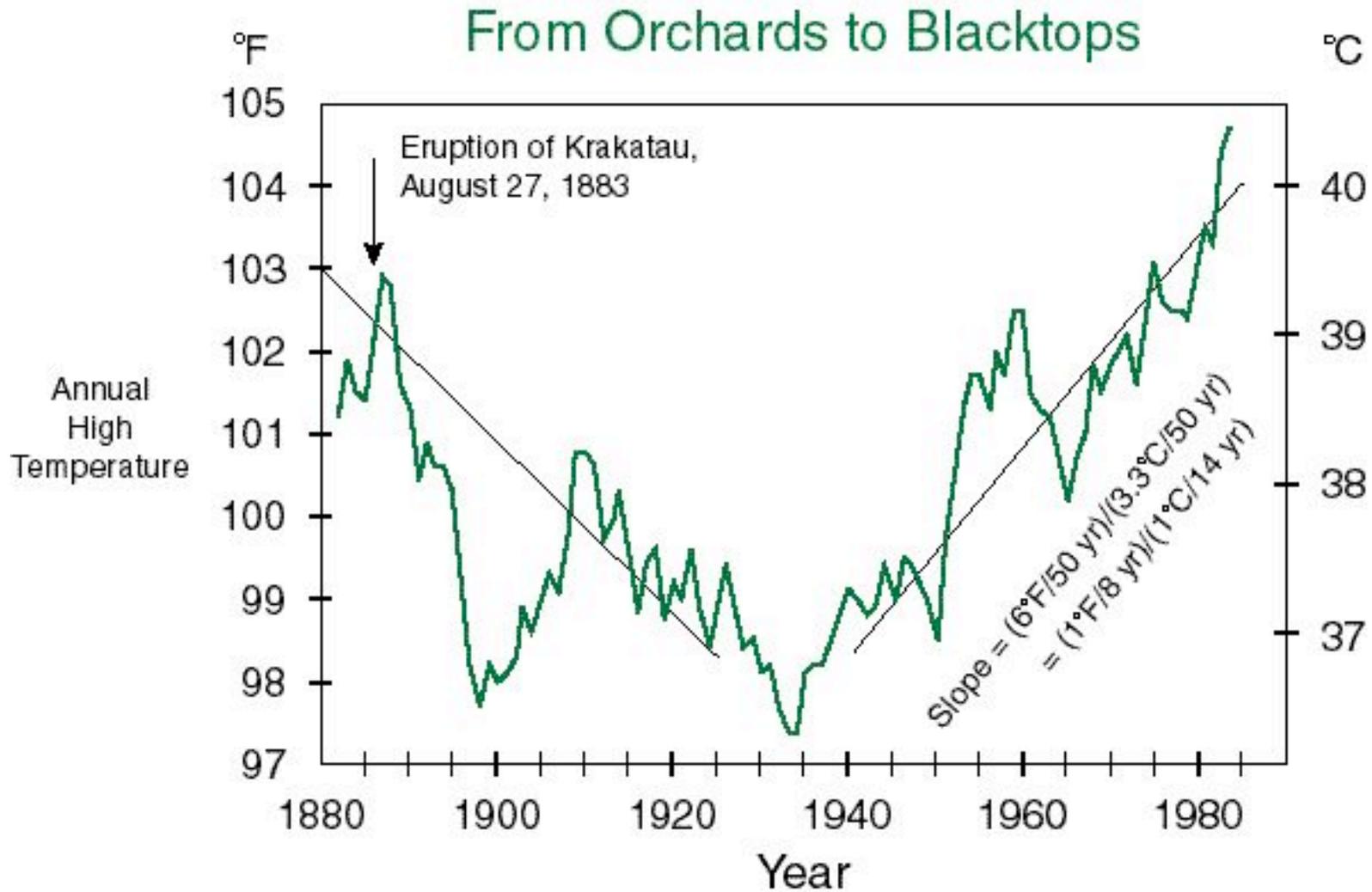
[http://www.nwhi.net/Vinyl\\_Windows/Low\\_E\\_Glass.htm](http://www.nwhi.net/Vinyl_Windows/Low_E_Glass.htm)

# Temperature Rise of Various Materials in Sunlight

Dr. Hashem Akbari, LBNL Heat Island Group



# Temperature Trends in Downtown Los Angeles



## Potential Savings in LA

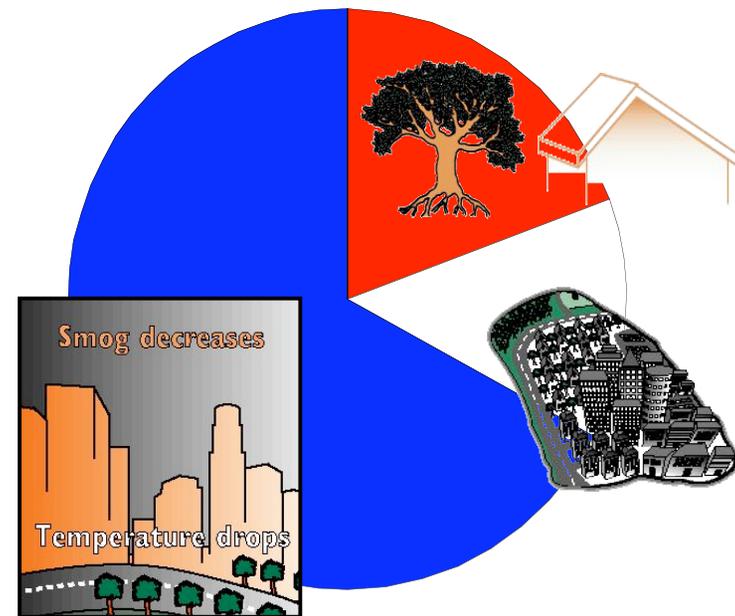
### ◆ Savings for Los Angeles

- Direct, \$200M/year
- Indirect, \$140M/year

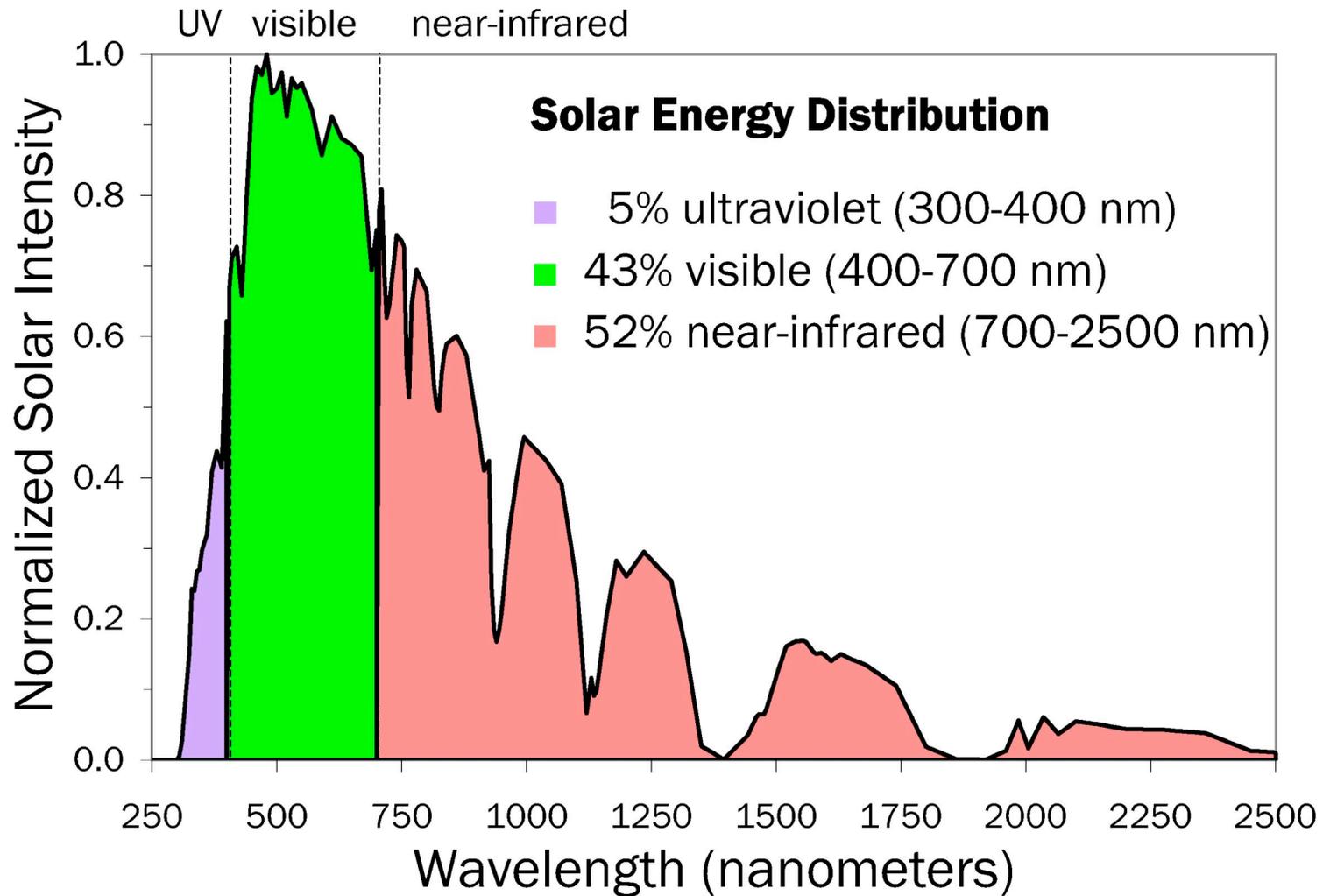
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- Smog, \$360M/year

### ◆ Estimate of national potential savings: \$5B/year



# Cool Colors Reflect Invisible Near-Infrared Sunlight



## From Cool Color Roofs to Cool Color Cars



- ◆ Toyota experiment (surface temperature 10K cooler)
- ◆ Ford and Fiat are also working on the technology

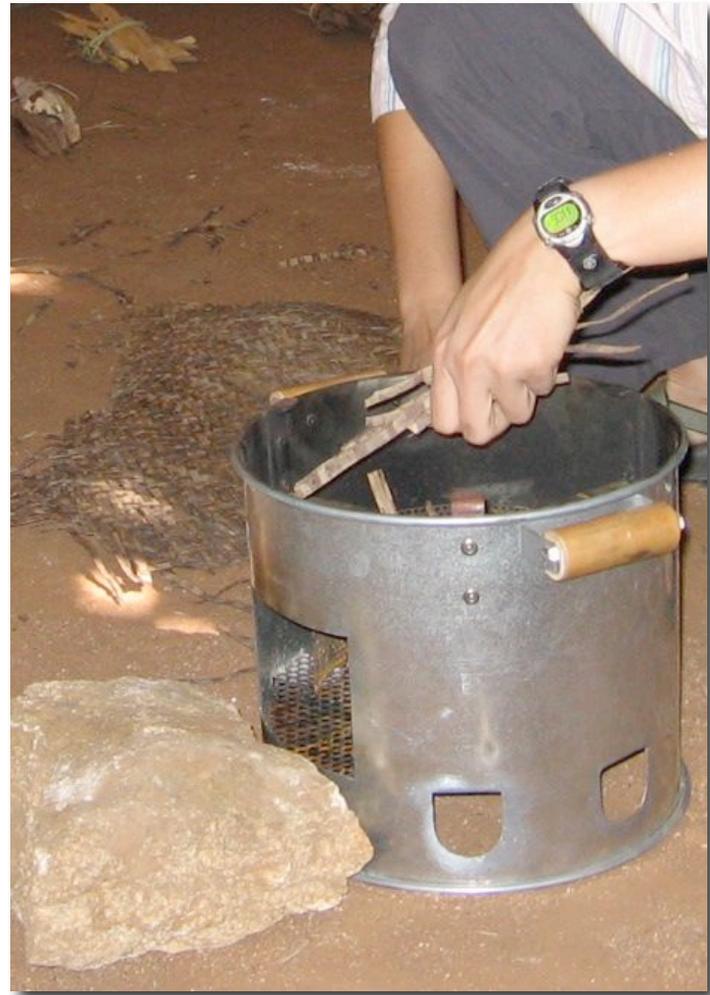
## Dr. Ashok Gadgil's Darfur Cookstove Project

In Nov.-Dec. 2005, he visited Darfur camps, and showed that with a \$10 metal stove, and training to use it, only half the fuelwood is needed.

The stove saves fuelwood worth \$160 annually for a refugee family

Since that time, Ashok Gadgil has improved stove efficiency by another factor of two

<http://www.osti.gov/bridge/servlets/purl/878538-hMpqN3/878538.PDF>



# Contact information

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Lawrence Berkeley National Laboratory  
Emills@lbl.gov  
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<http://www.ifc.org/led>



## LEDs Powered with Photovoltaics

- ◆ Evan Mills at LBNL points out the following:
- ◆ If 1.6 billion people could replace kerosene lamps with LEDs, emissions would drop by the equivalent of 1.3 million barrels of petroleum per day
- ◆ [http://eetd.lbl.gov/emills/PUBS/Fuel\\_Based\\_Lighting.html](http://eetd.lbl.gov/emills/PUBS/Fuel_Based_Lighting.html)
- ◆ The above estimate was for residential lamps only
- ◆ Including commercial uses, Mills estimates > 2 Mbod
- ◆ For comparison, U.S. gasoline use is 9 Mbod

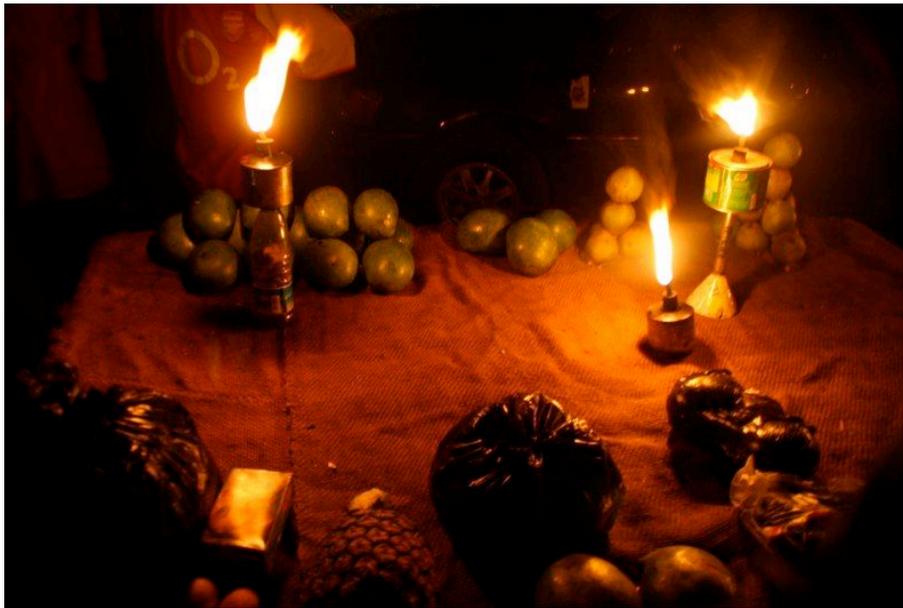
# Hurricane lanterns

- ◆ Teachers grading homework with light levels 1% of western standards



Tanzania (teachers' home)

## Productive uses



**Tanzania: fruit seller - flame [left]; 1-watt white LED [right]**

## Productive uses: big market driver



**Tanzania: shoe seller - flame [left]; 1-watt white LED [right]**

Source: Stabilization Wedges: Pacala and Socolow, Science Vol 305, page 968

