Delaying Global Climate Change

Efficiency Lessons from California

CEC/PIER Climate Change Conference
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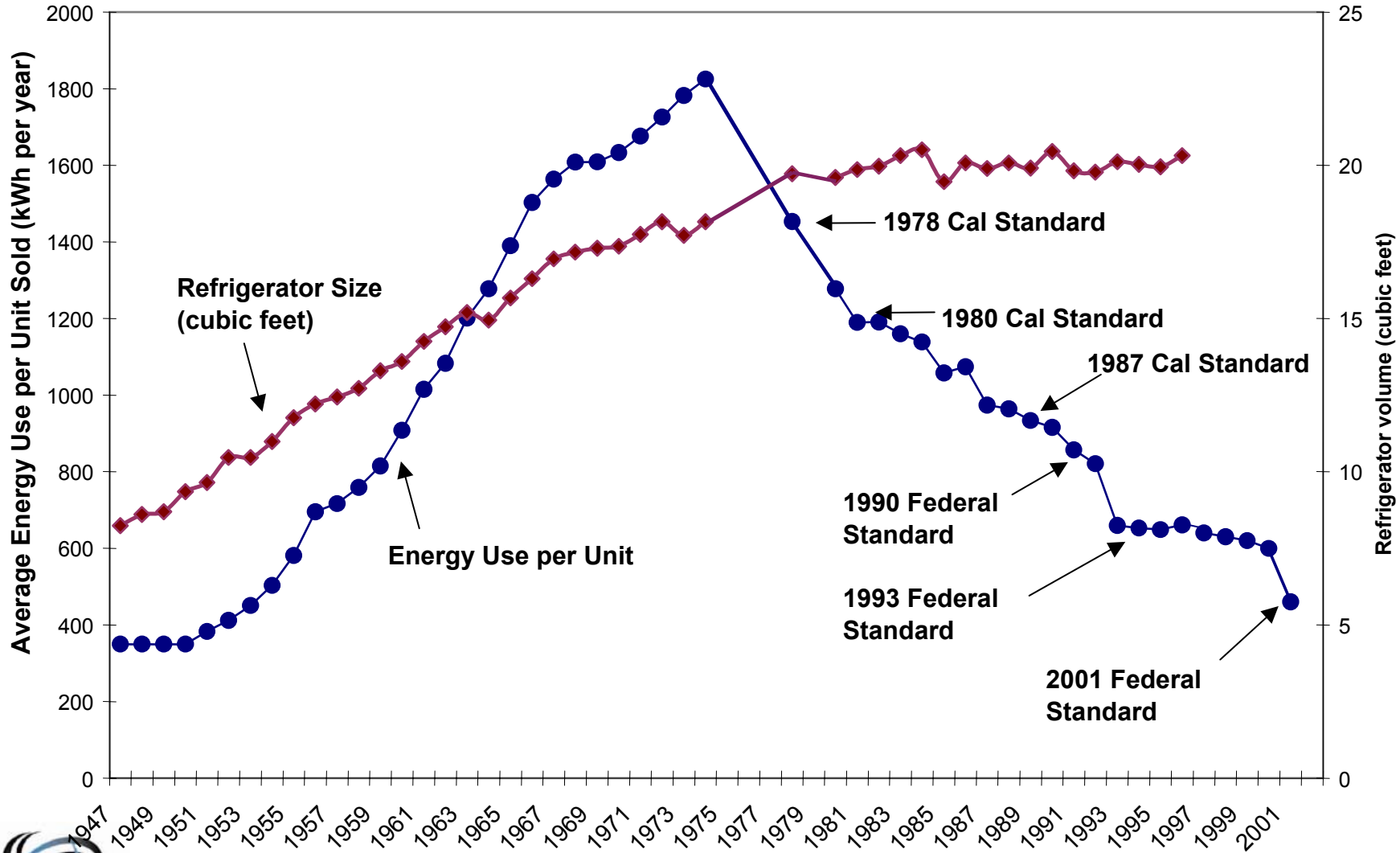
Efficiency

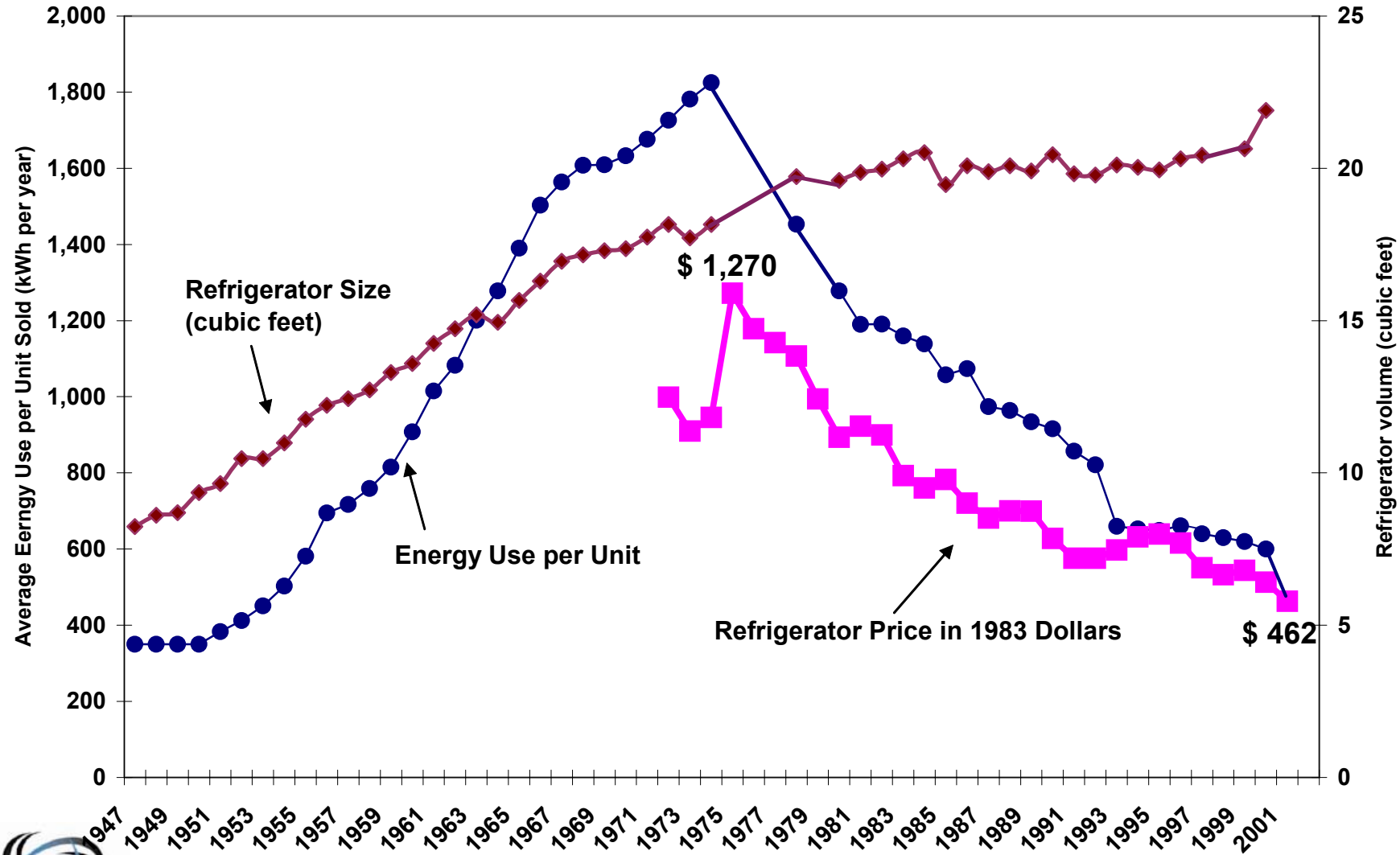
Energy for the Future

United States Refrigerator Use v. Time

Annual drop from 1974 to 2001 = 5% per year



United States Refrigerator Use v. Time

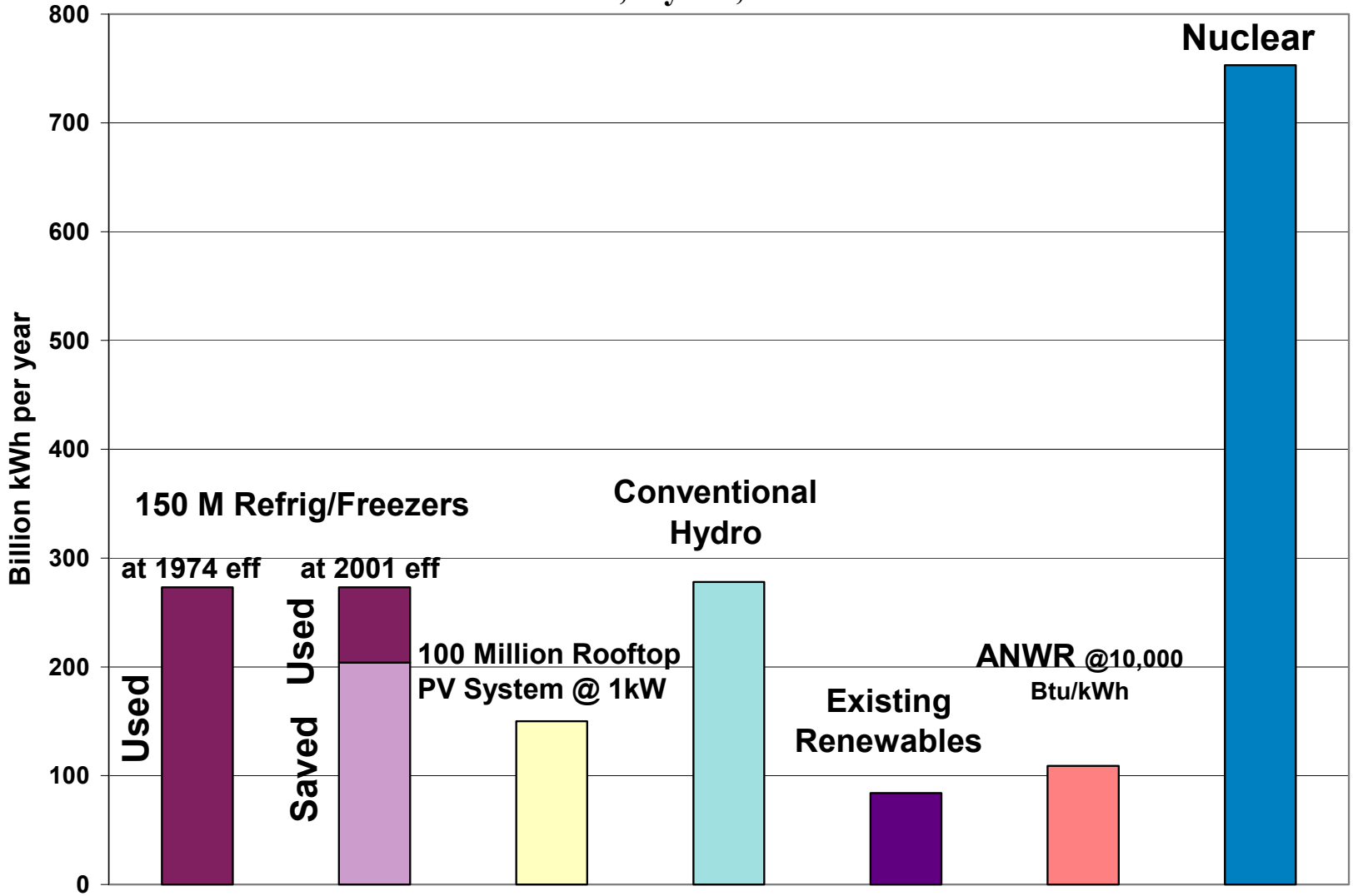


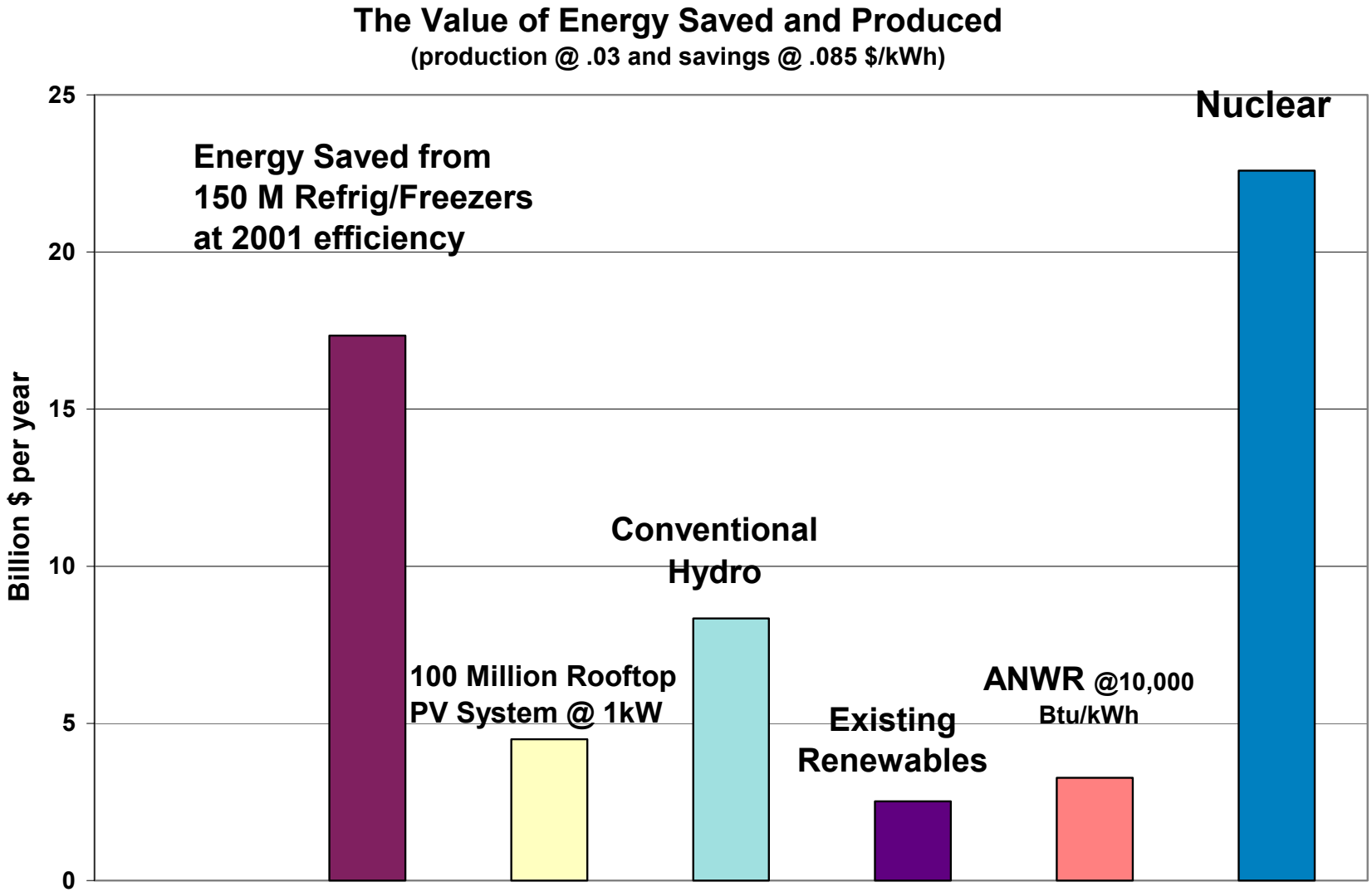
Efficiency

Energy for the Future

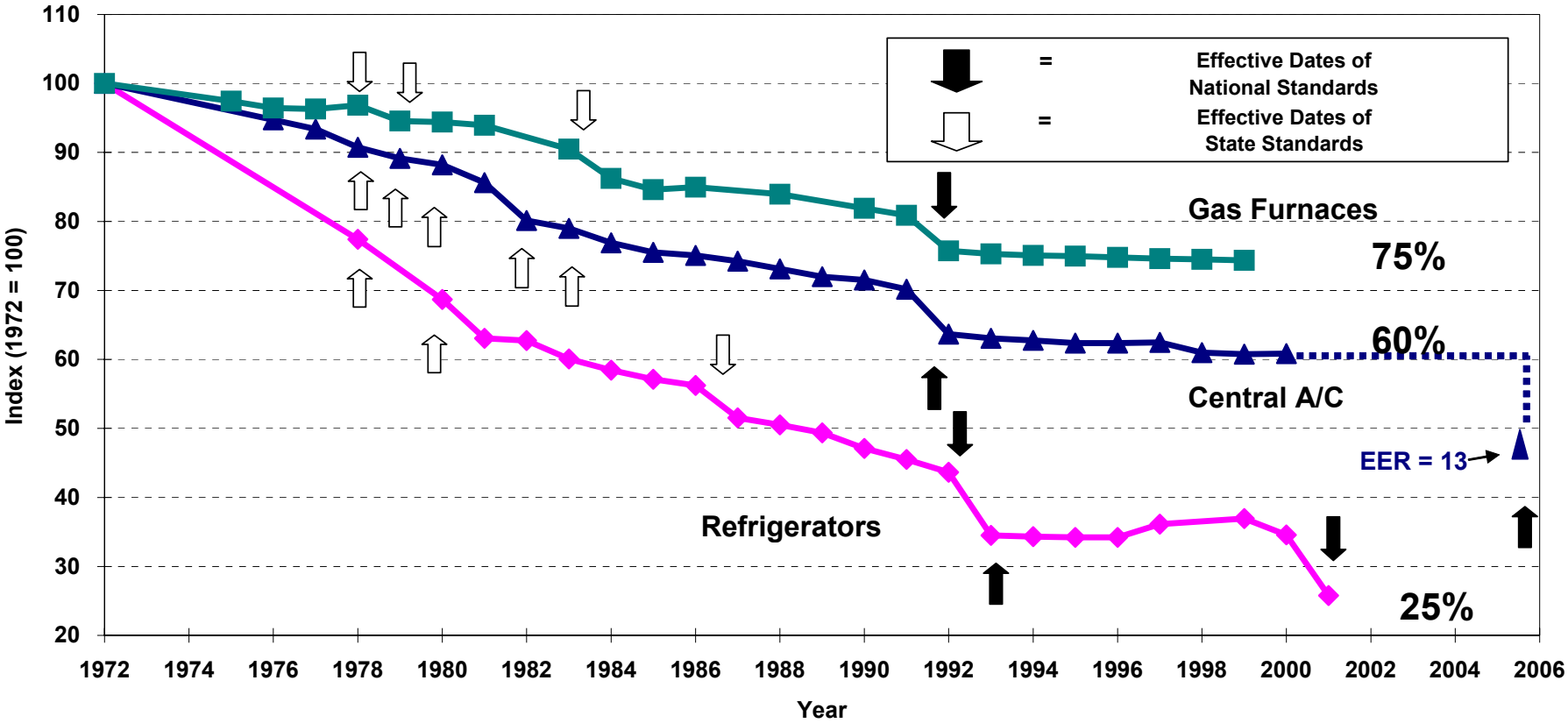
Source: David Goldstein

Electricity Use of Refrigerators and Freezers in the US compared to Generation from Nuclear, Hydro, Renewables and ANWR




The Value of Energy Saved and Produced
(production @ .03 and savings @ .085 $/kWh)
Billion $ per year
25
20
15
10
5
0
Energy Saved from
150 M Refrig/Freezers
at 2001 efficiency
100 Million Rooftop
PV System @ 1kW
Conventional
Hydro
Existing
Renewables
ANWR @10,000
Btu/kWh
Nuclear

Impact of Standards on Efficiency of 3 Appliances

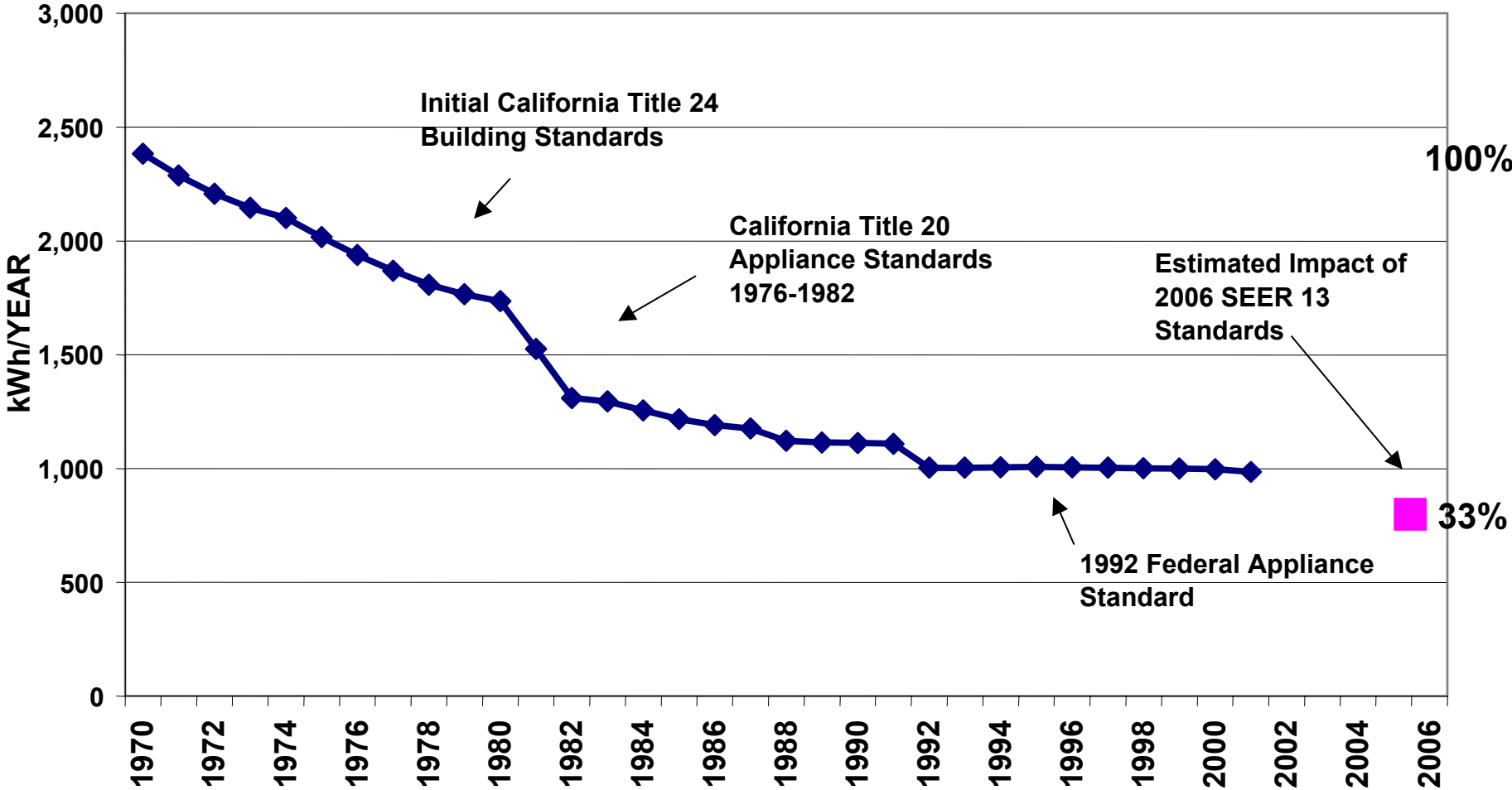


Source: S. Nadel, ACEEE,

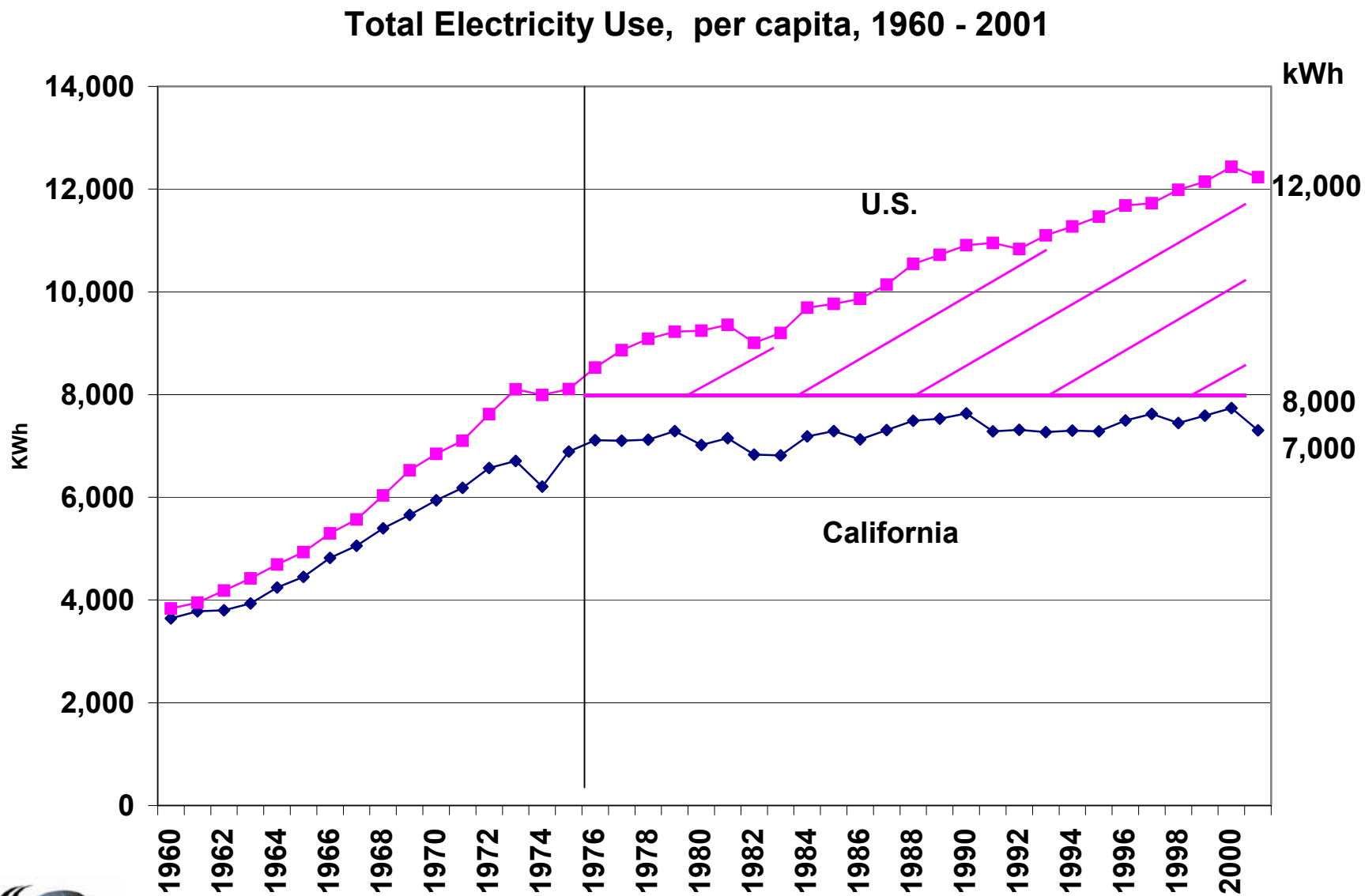
in ECEEE 2003 Summer Study, www.eceee.org

Annual Usage of Air Conditioning in New Homes in California

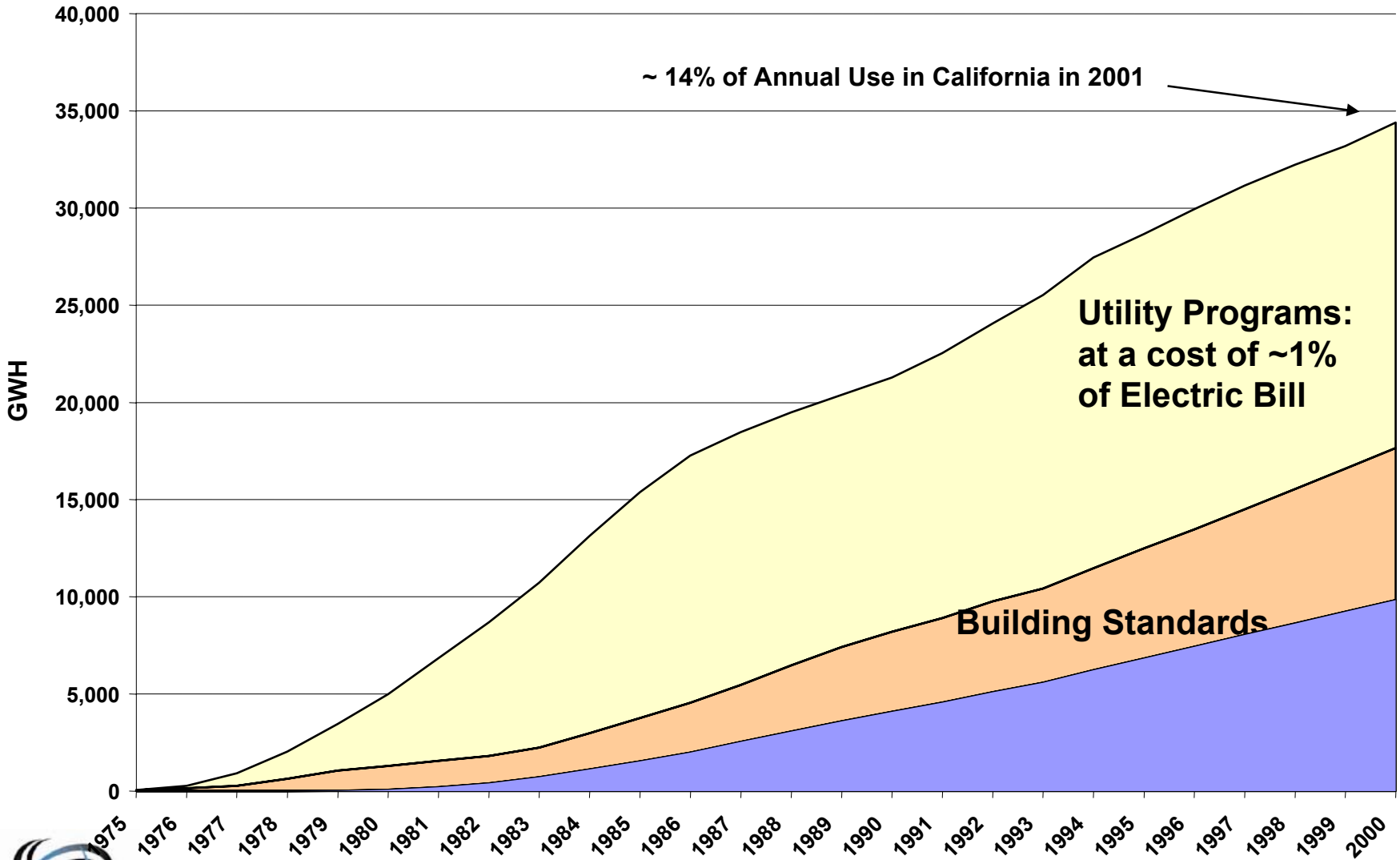
Annual drop averages 4% per year



Source: CEC Demand Analysis Office

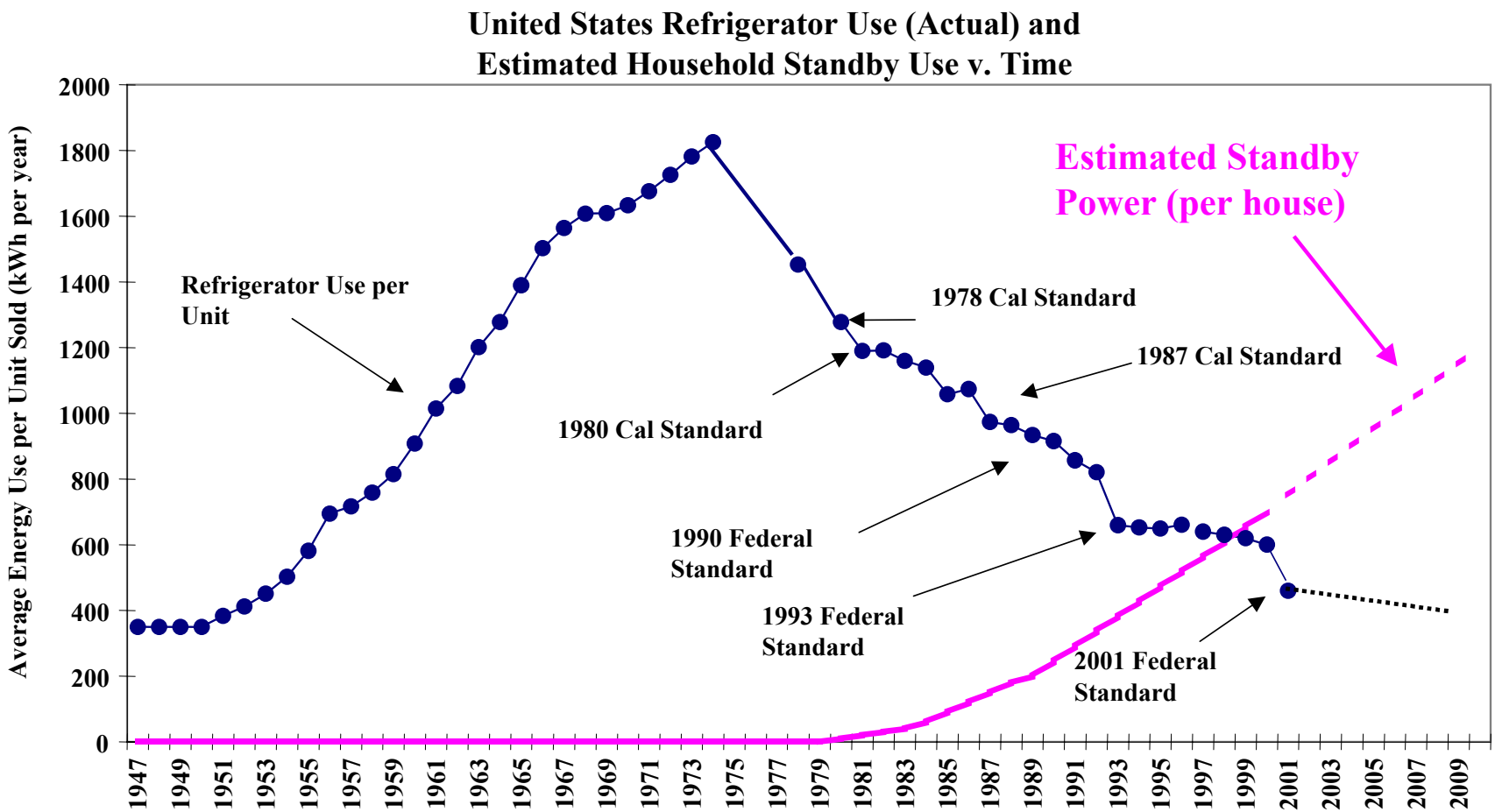

Total Electricity Use, per capita, 1960 - 2001
kWh
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
KWh
U.S.
California
12,000
8,000
7,000
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000

GWH Impacts from Programs Begun Prior to 2001

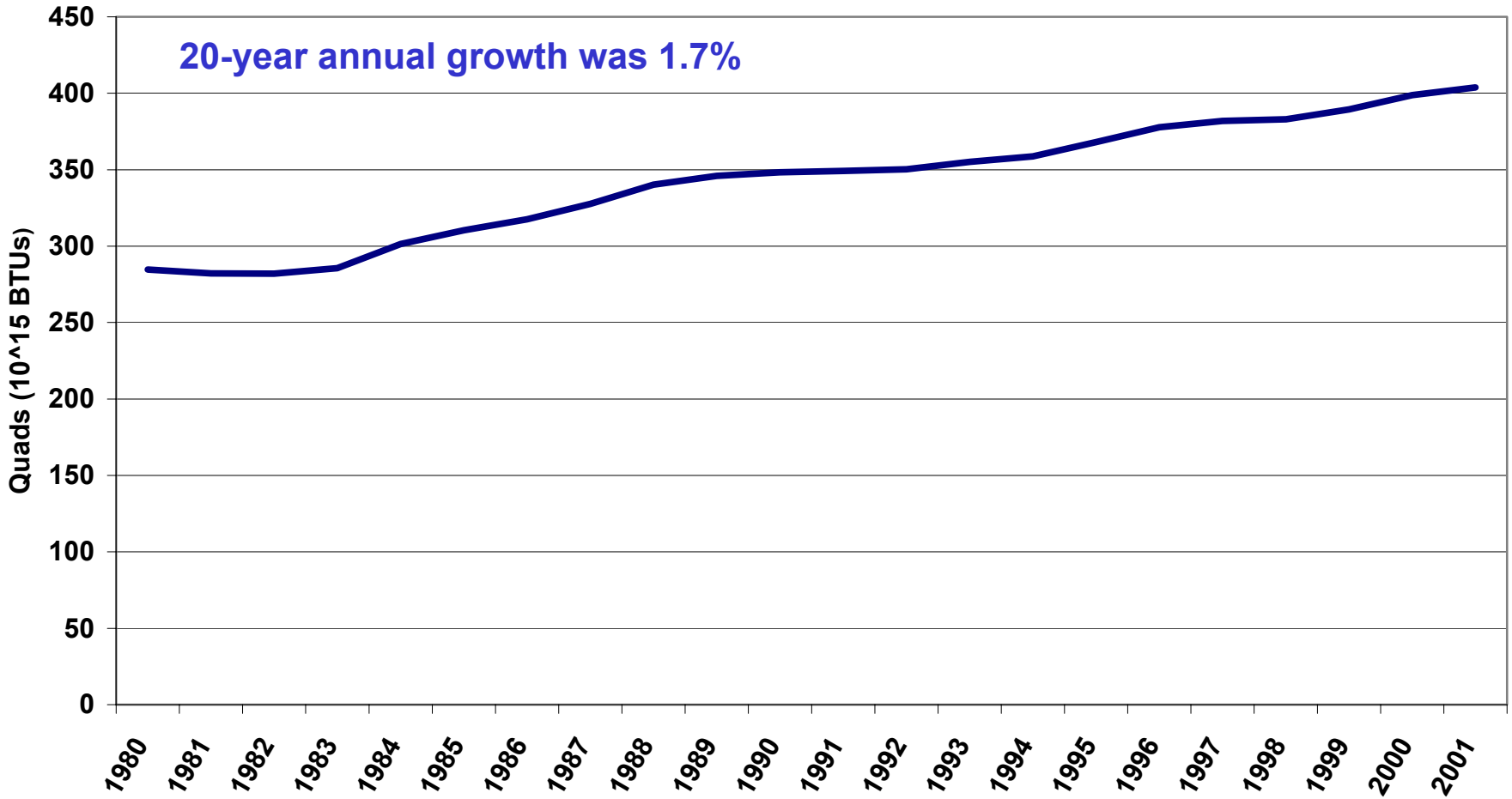


Costs and Pollution saved by avoiding a 50% expansion of Calif. Electric system.

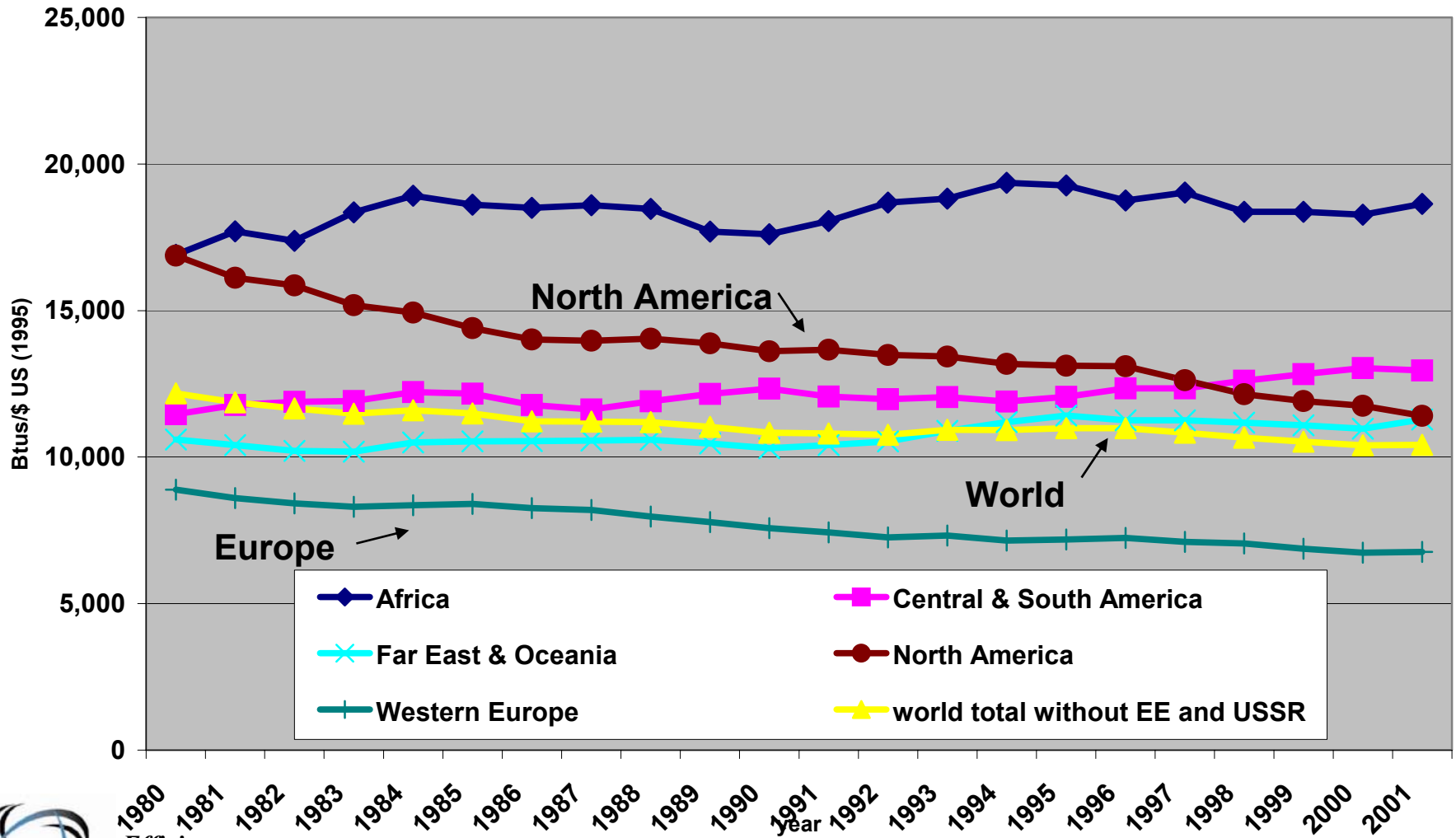
- Avoiding half of Calif electricity avoids 18 M tons/year of carbon, equivalent to getting 12 million cars off the road, along with their NOx, and other criteria emissions.
- California has ~20 M cars, so we've "avoided" another 60%.
- The Pavley bill could reduce carbon pollution from the existing 20 M cars, and so "remove" another 30% of them.


United States Refrigerator Use (Actual) and
Estimated Household Standby Use v. Time
Average Energy Use per Unit Sold (kWh per year)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
1947
1949
1951
1953
1955
1957
1959
1961
1963
1965
1967
1969
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
Estimated Standby Power (per house)
Refrigerator Use per Unit
1978 Cal Standard
1987 Cal Standard
1980 Cal Standard
1990 Federal Standard
1993 Federal Standard
2001 Federal Standard

World Primary Energy Consumption
1980 to 2001
Source: EIA

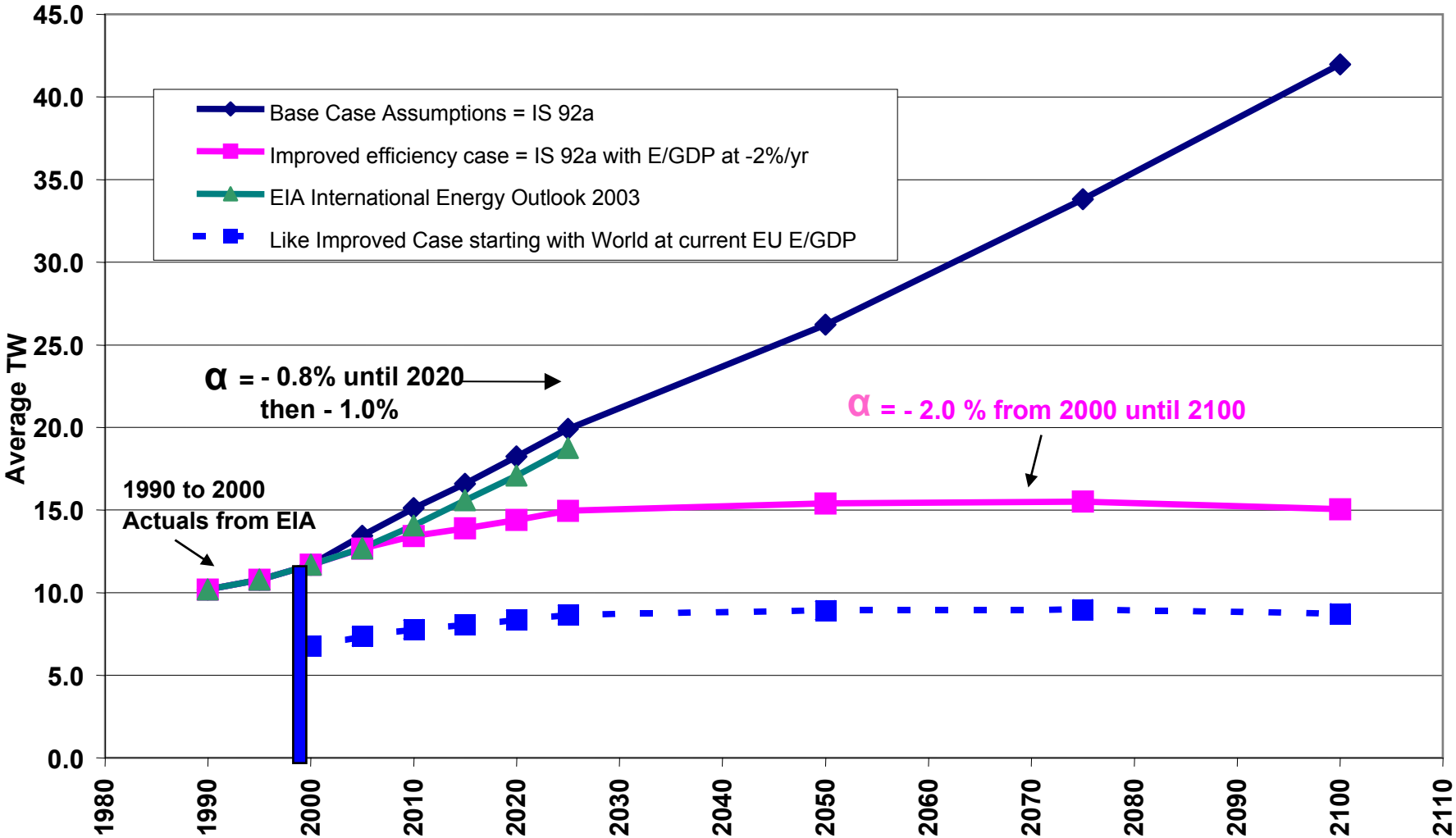


Energy Intensity By Geographic Region 1980 to 2001
(Btus/$US 1995) from EIA data



World Power Demand in IPCC Base Case, and Accelerated Efficiency

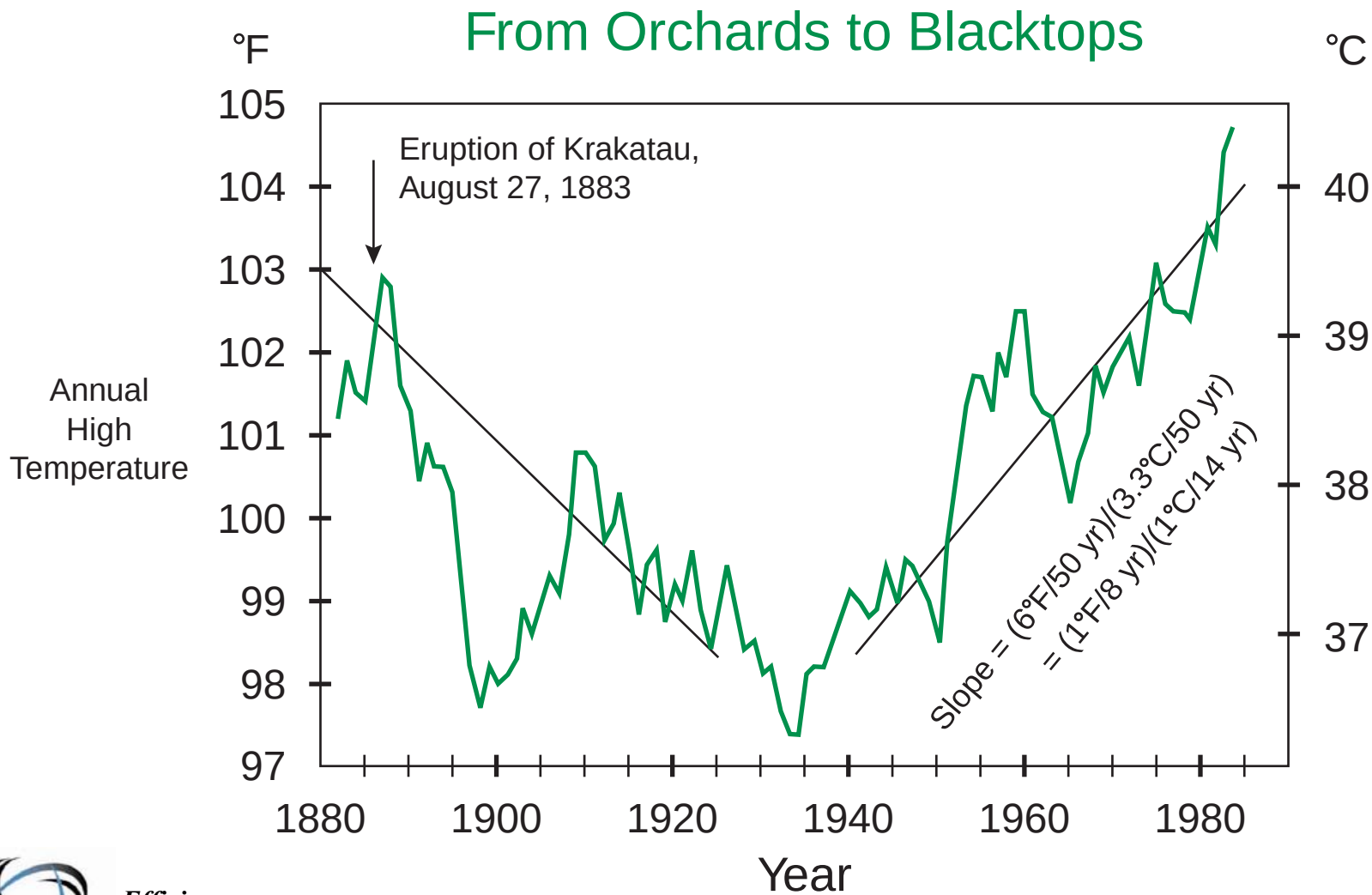
α = Annual change in E/GWP, E= Energy (1TW-year = 30 Quads), GWP=Gross World Product



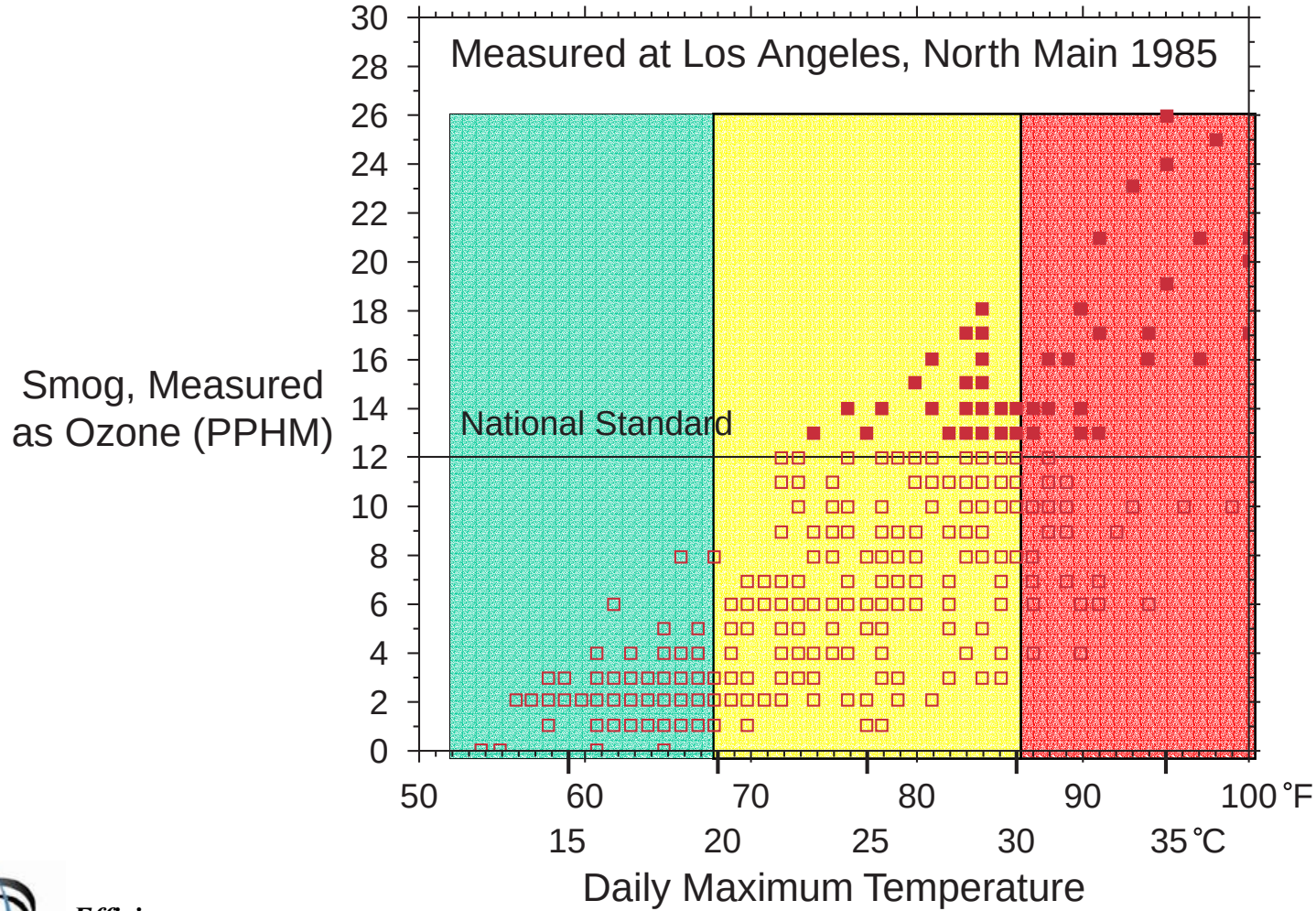
Cool Roofs and Pavements Directly Cool the Earth. Alvia Gaskill wants to cool deserts; I'd first cool 100 megacities.

- Gaskill proposes to cover 4 M mi. sq. w/ white plastic, and thus reduce radiative forcing by 2.7 W/m2.
- [Russell Seitz proposed painting the black rocks of ND.]
- LA has 1000 mi2 of roof + roads. Assume another 100 hot megacities, so 0.1 M mi2 total. Cooling them would mainly save $ for a/c, and reduce ozone, but it would also get us 2.5% of the way to mitigation.

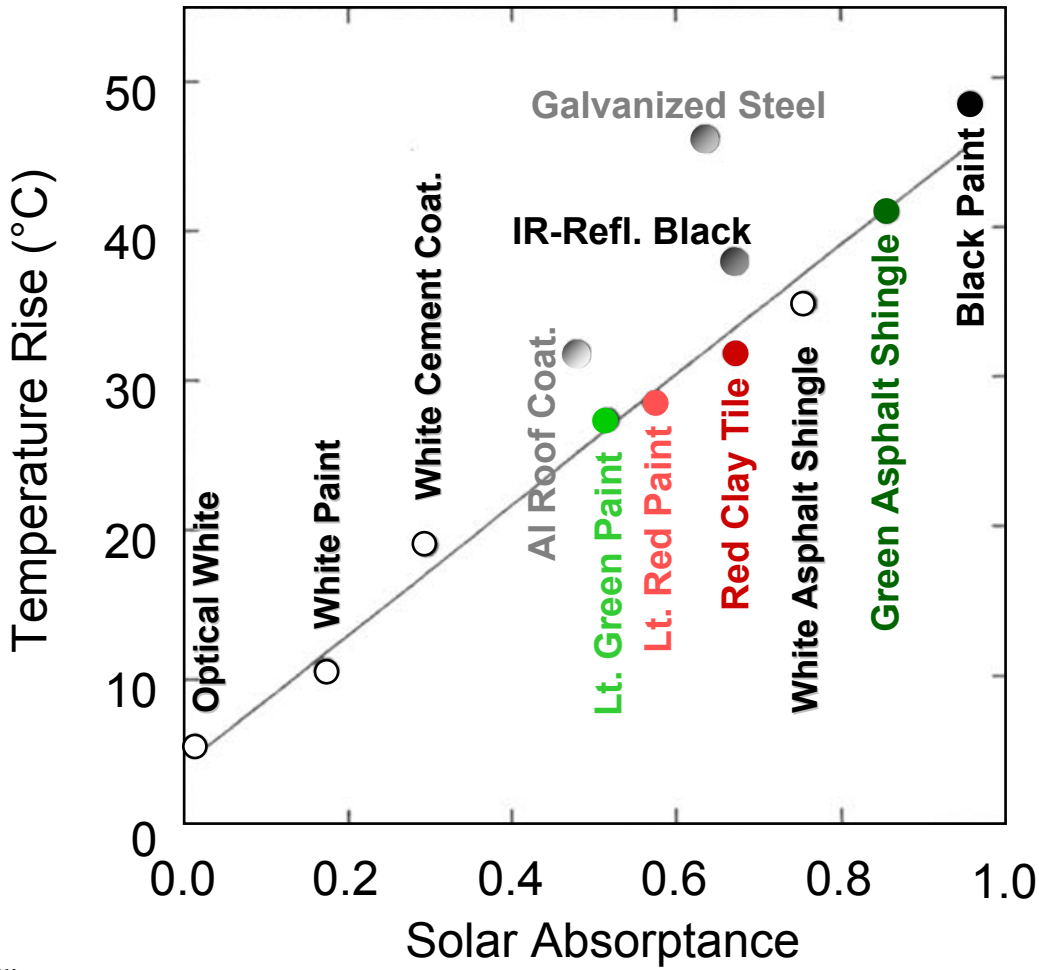
Temperature Trends in Downtown Los Angeles



Effect of Temperature Rise on Peak Ozone Concentration

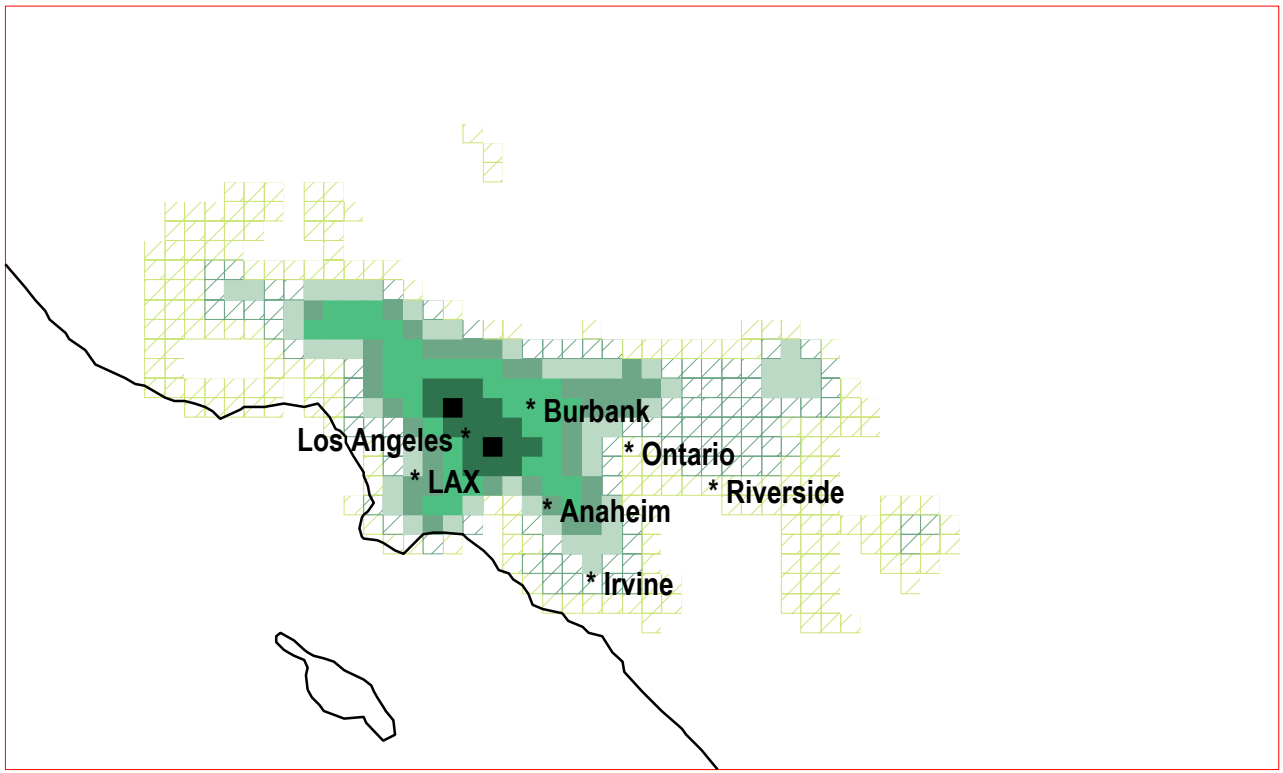


Temperature Rise of Various Materials in Sunlight



Simulated Air Temperature Difference: Adding 11 M Trees

Los Angeles, 3 p.m., August 28

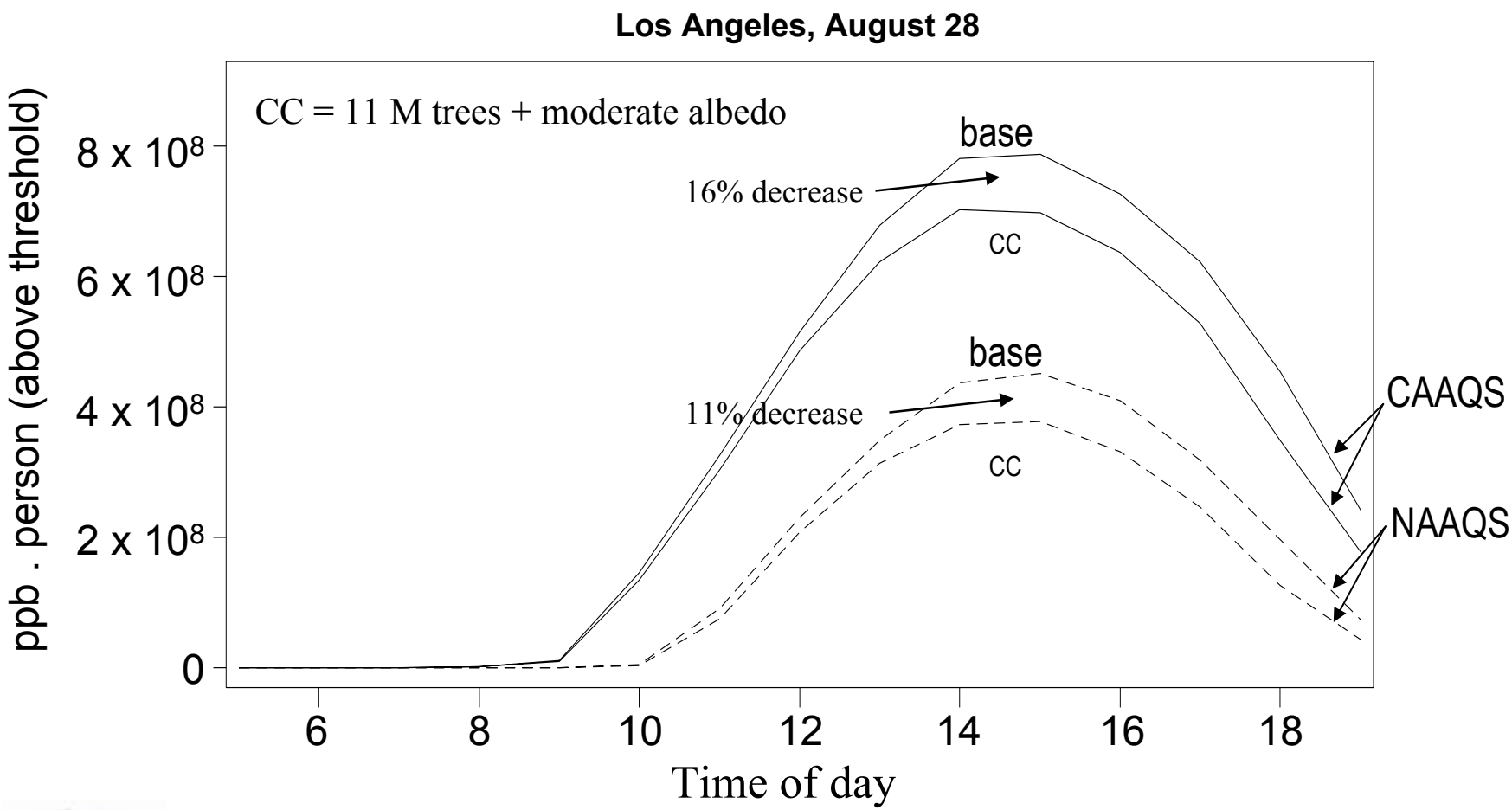


Temperature difference (°C)

-3.5 -3.0 -2.5 -2.0

-1.5 -1.0 -0.5

Simulated Population-Weighted Exceedence Exposure to Ozone



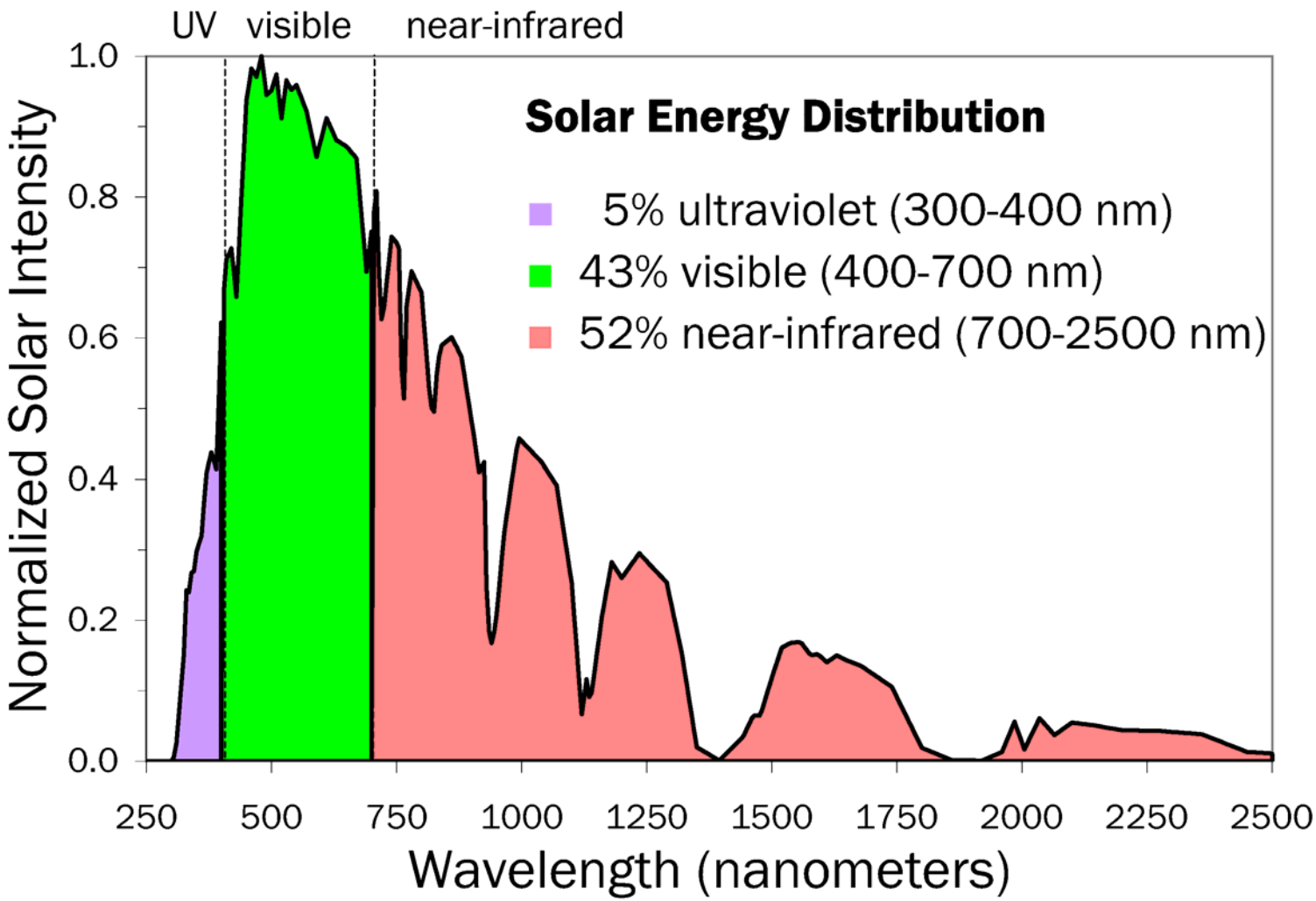
Cool benefits in LA

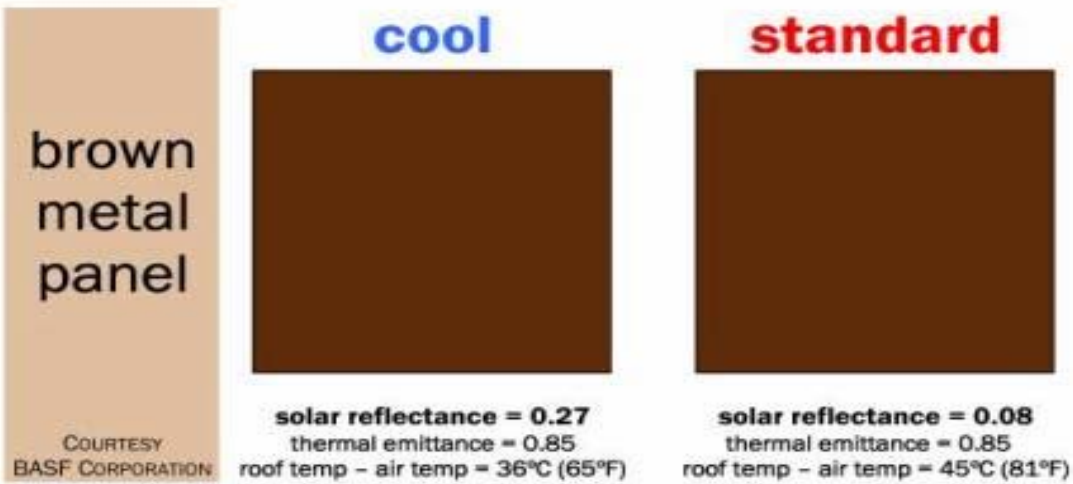
($ Millions/Year)

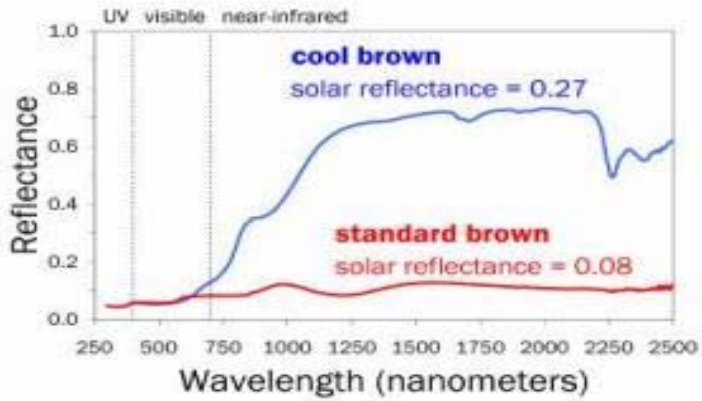
Source	Cool Roofs	Trees	Pavements	Total
Building Savings	**46**	**58**	**0**	**104**
Cooler Urban Air	**21**	**35**	**15**	**71**
Improved Human Health (from reduced ozone)	**104**	**180**	**76**	**360**
Total	**171**	**273**	**91**	**535**

National Savings extrapolate to ~ 5 B/yr

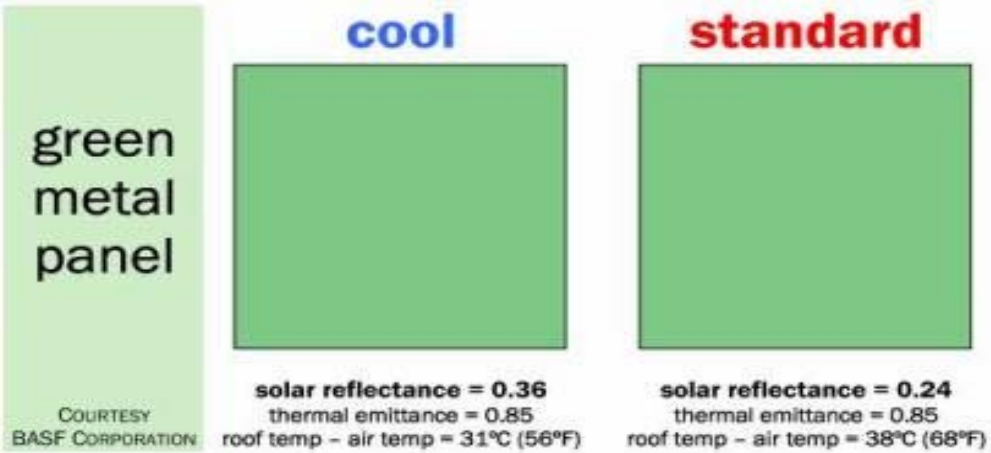
Source: Rosenfeld, et.al., Energy and Buildings 28(1998) 51-62

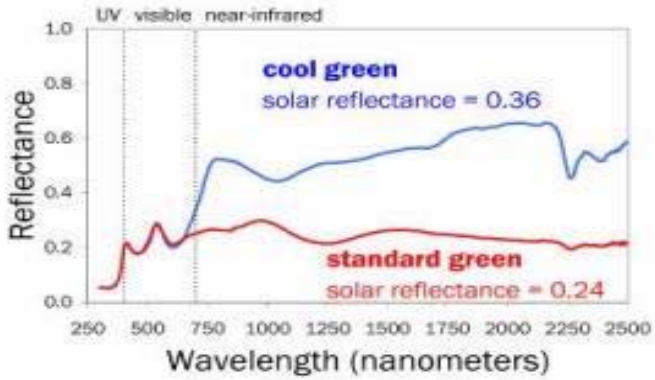

UV
visible
near-infrared
Solar Energy Distribution
5% ultraviolet (300-400 nm)
43% visible (400-700 nm)
52% near-infrared (700-2500 nm)
Normalized Solar Intensity
1.0
0.8
0.6
0.4
0.2
0.0
250
500
750
1000
1250
1500
1750
2000
2250
2500
Wavelength (nanometers)



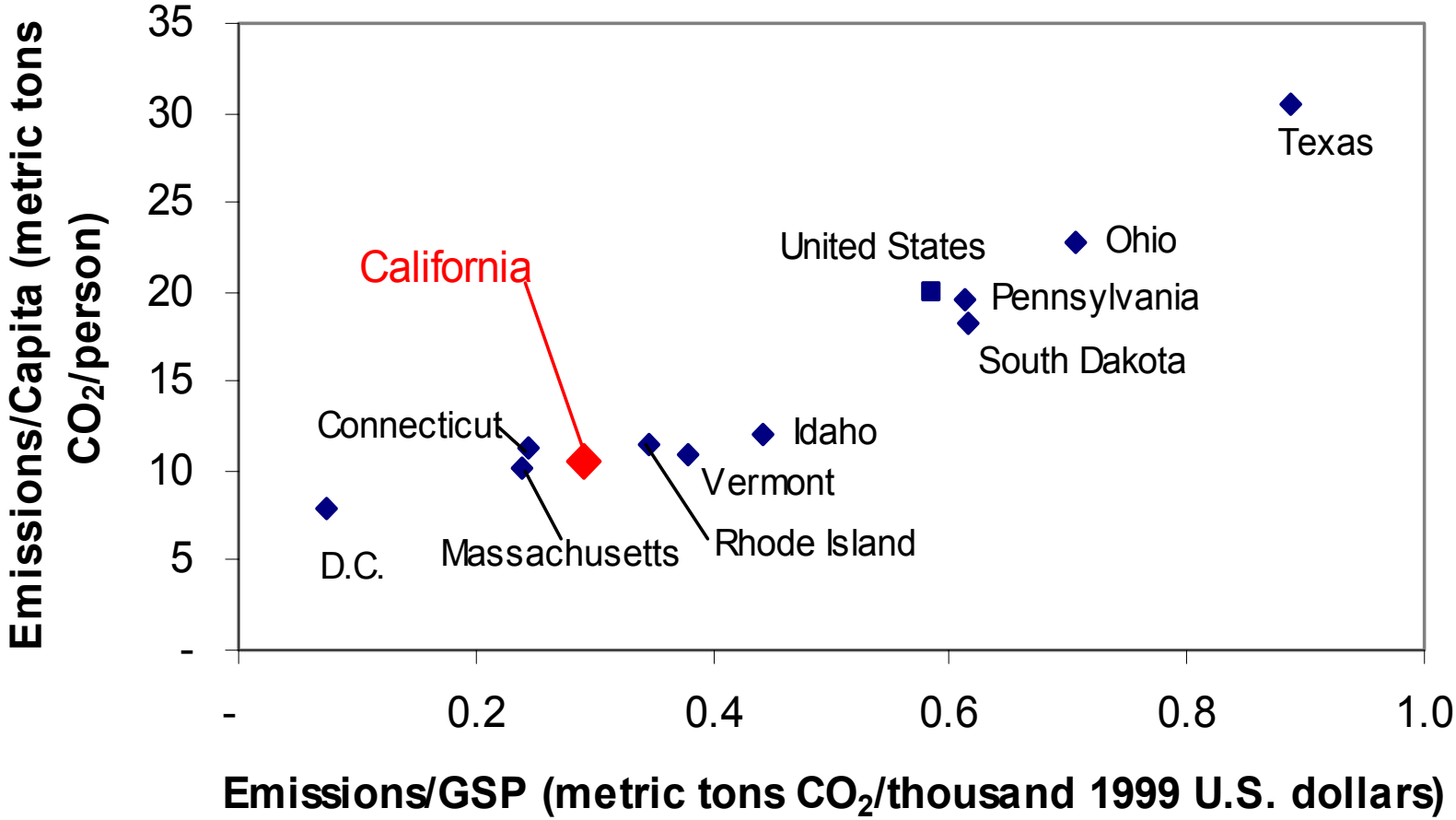


Cool Colored Cars could have smaller a/c units and save ~2% in fuel economy or $ 6 Billion/year

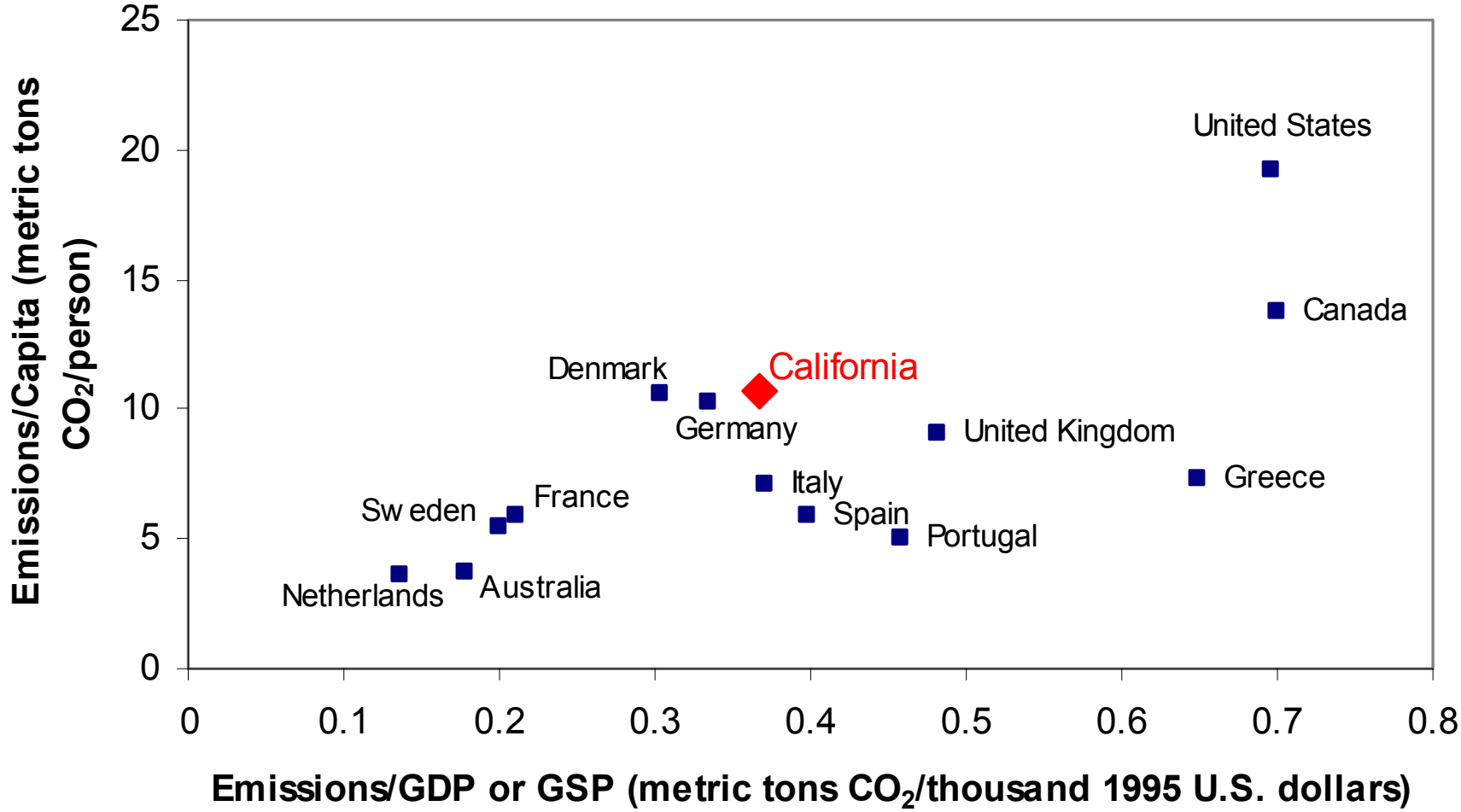

green metal panel
COURTESY BASF CORPORATION
cool
solar reflectance = 0.36
thermal emittance = 0.85
roof temp – air temp = 31°C (56°F)
standard
solar reflectance = 0.24
thermal emittance = 0.85
roof temp – air temp = 38°C (68°F)


UV visible near-infrared
cool green
solar reflectance = 0.36
standard green
solar reflectance = 0.24
Reflectance
1.0
0.8
0.6
0.4
0.2
0.0
250 500 750 1000 1250 1500 1750 2000 2250 2500
Wavelength (nanometers)

Carbon Intensity for California and Selected States - 1999



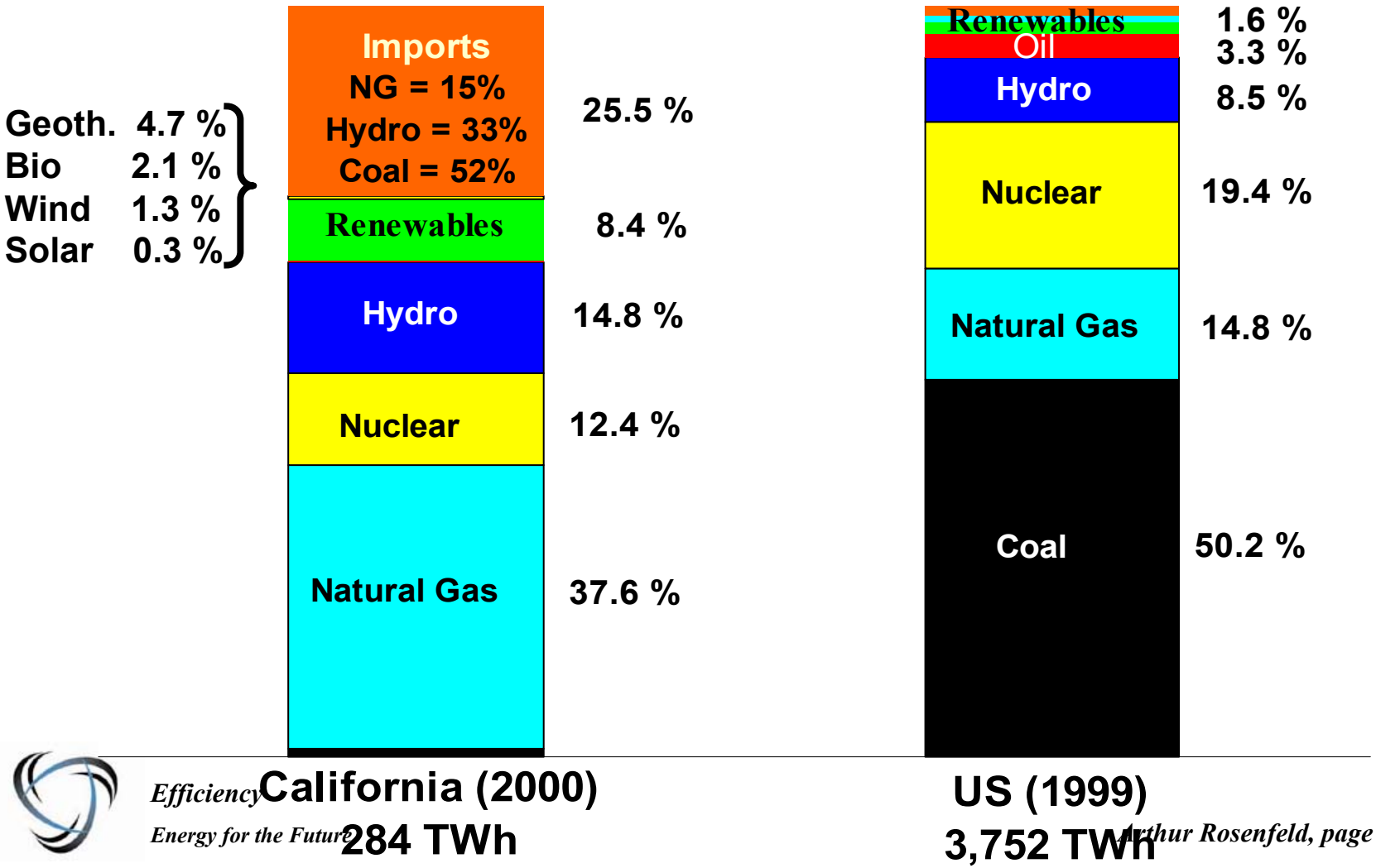
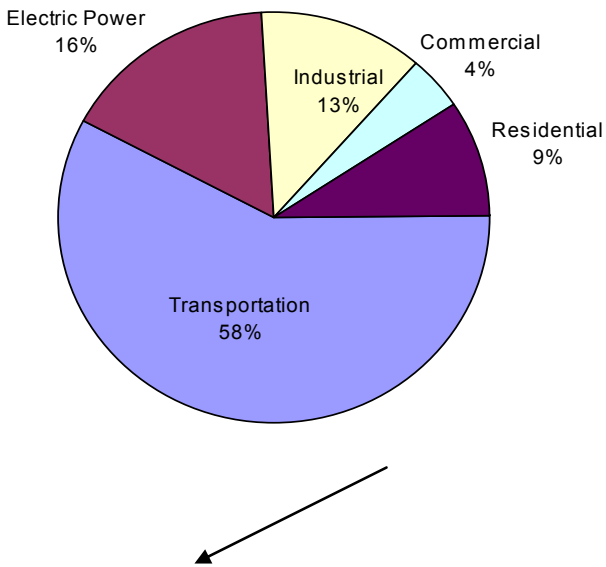
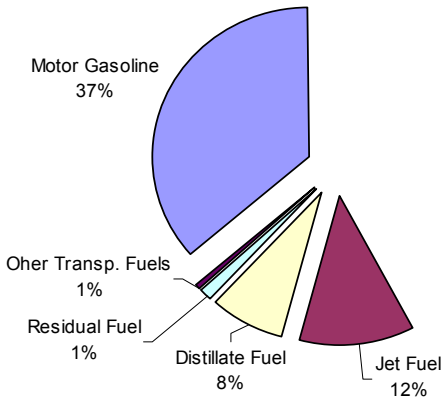
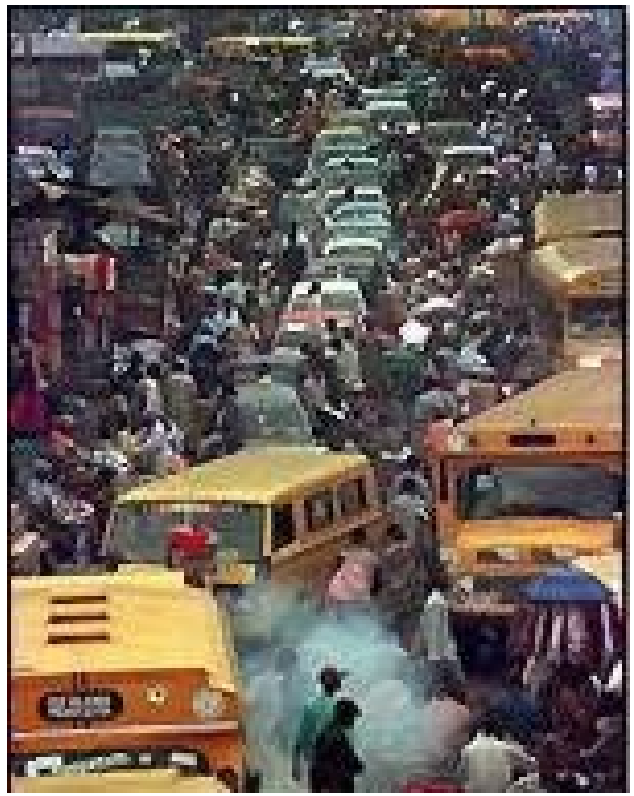
Carbon Intensity for California and Selected Countries - 1995



Climate Change Activities

- GHG inventories in 1997, 2002 – next update in 2005
- California Climate Change Registry
- Forest Sequestration of CO2
- Joint Agency Climate Team
- Renewable Portfolio Standard
- West Coast Global Warming Initiative
- Energy Commission's Virtual Research Center
- Geologic Carbon Sequestration - Western States Partnership
- Reducing Vehicle GHG Emissions

California versus US Electricity Supply



In-State CO_2 Emissions by Sector