

EXTREME EFFICIENCY

Lessons from California

AAAS

February 21, 2005

Washington, D.C.

Arthur H. Rosenfeld, Commissioner

California Energy Commission

(916) 654-4930

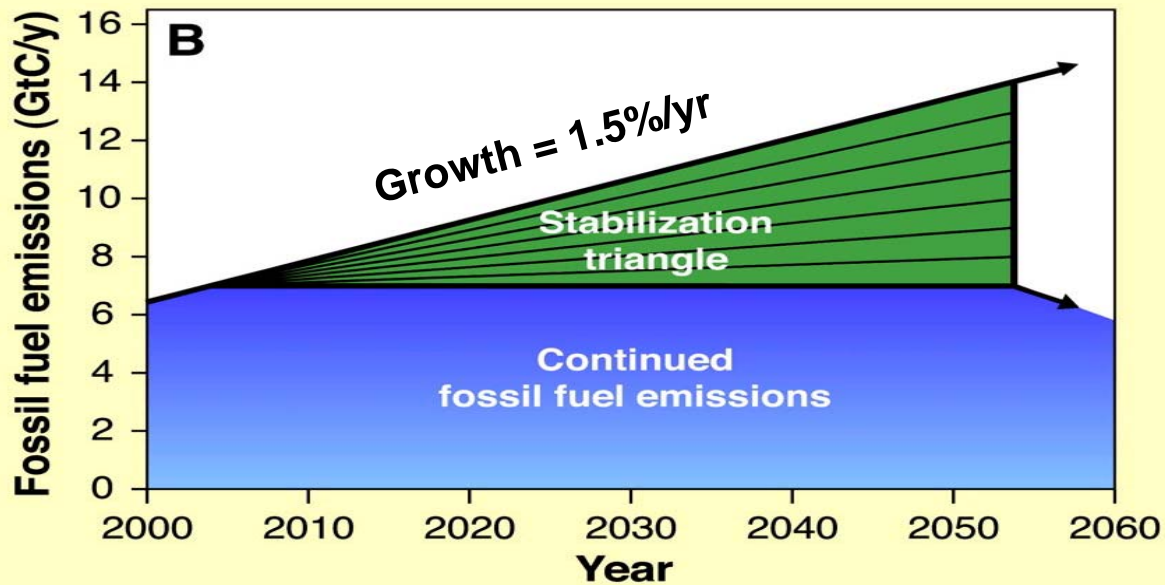
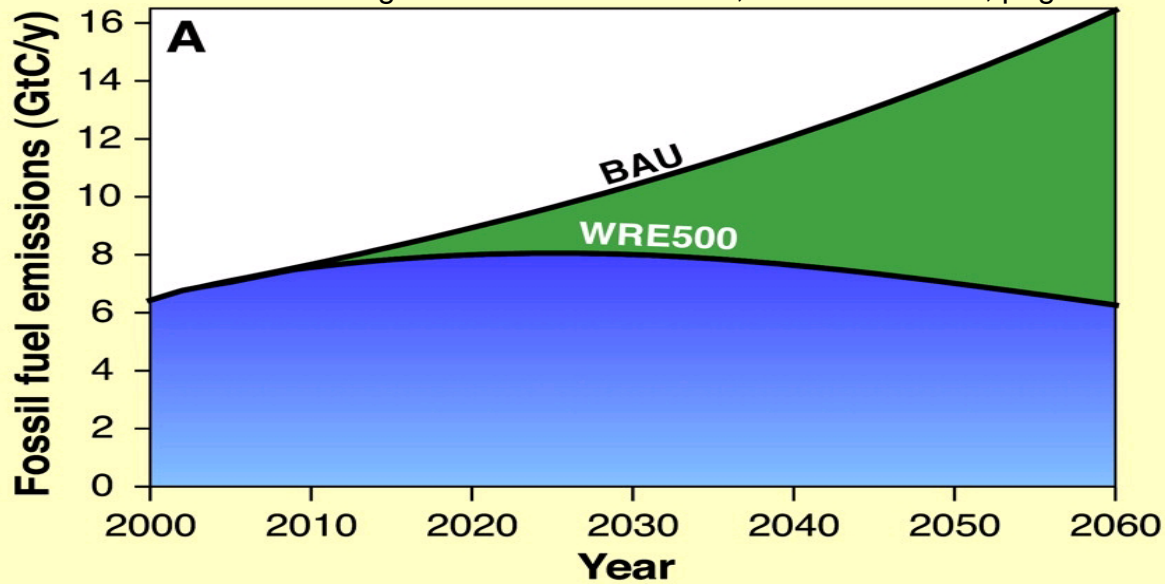
ARosenfe@Energy.State.CA.US



<http://www.energy.ca.gov/commission/commissioners/rosenfeld.html>

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

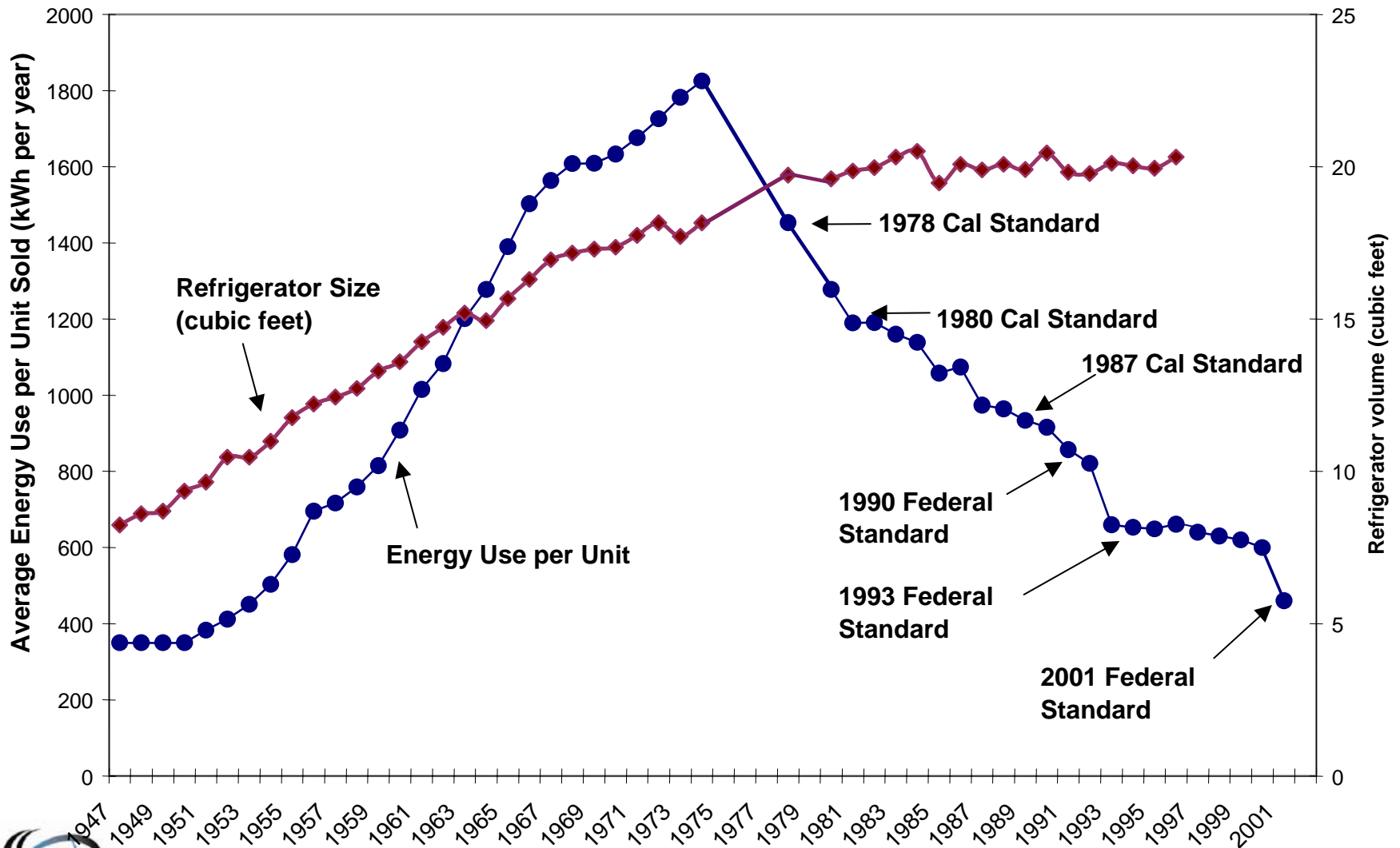


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United States Refrigerator Use v. Time

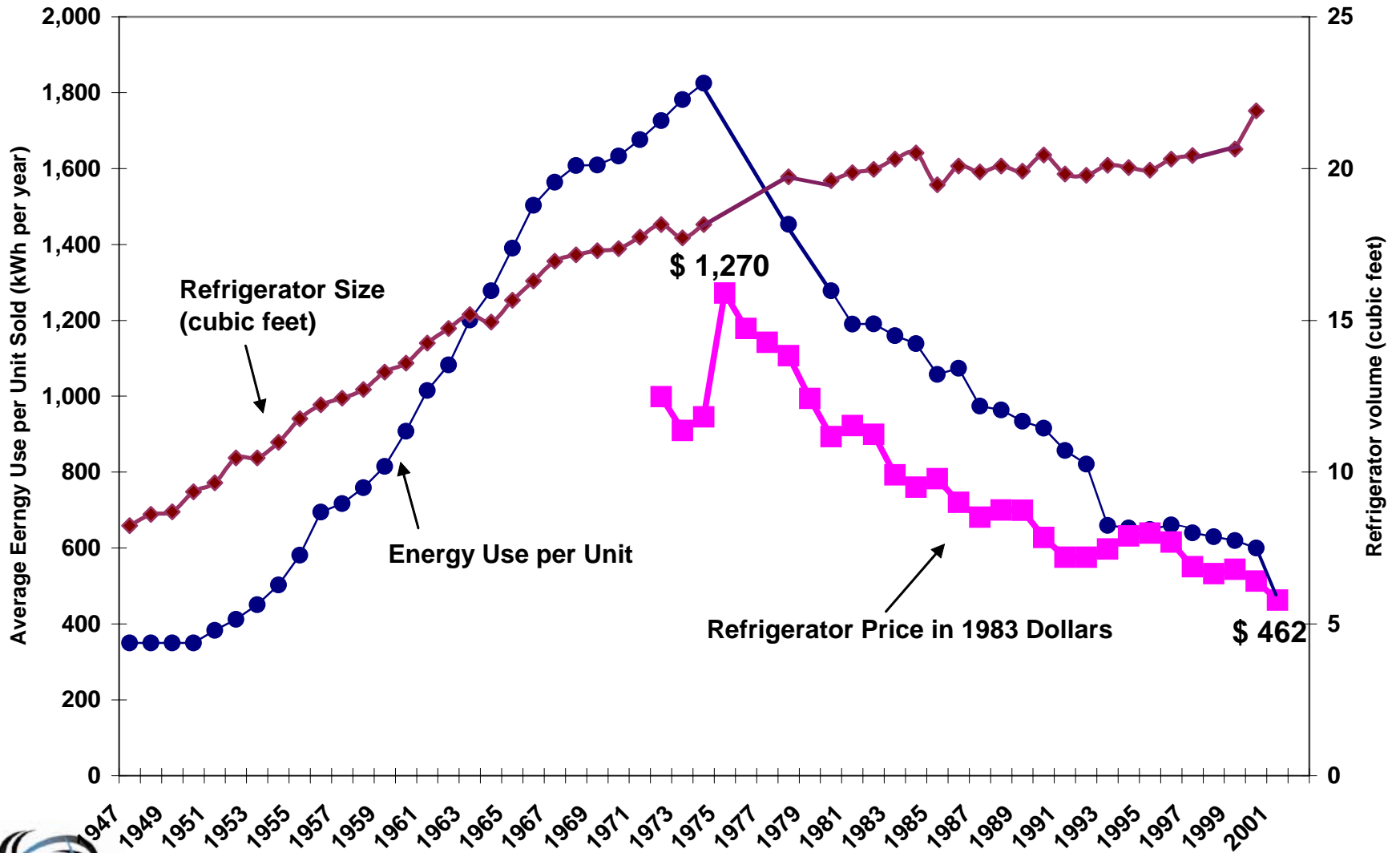
Annual drop from 1974 to 2001 = 5% per year



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United States Refrigerator Use v. Time



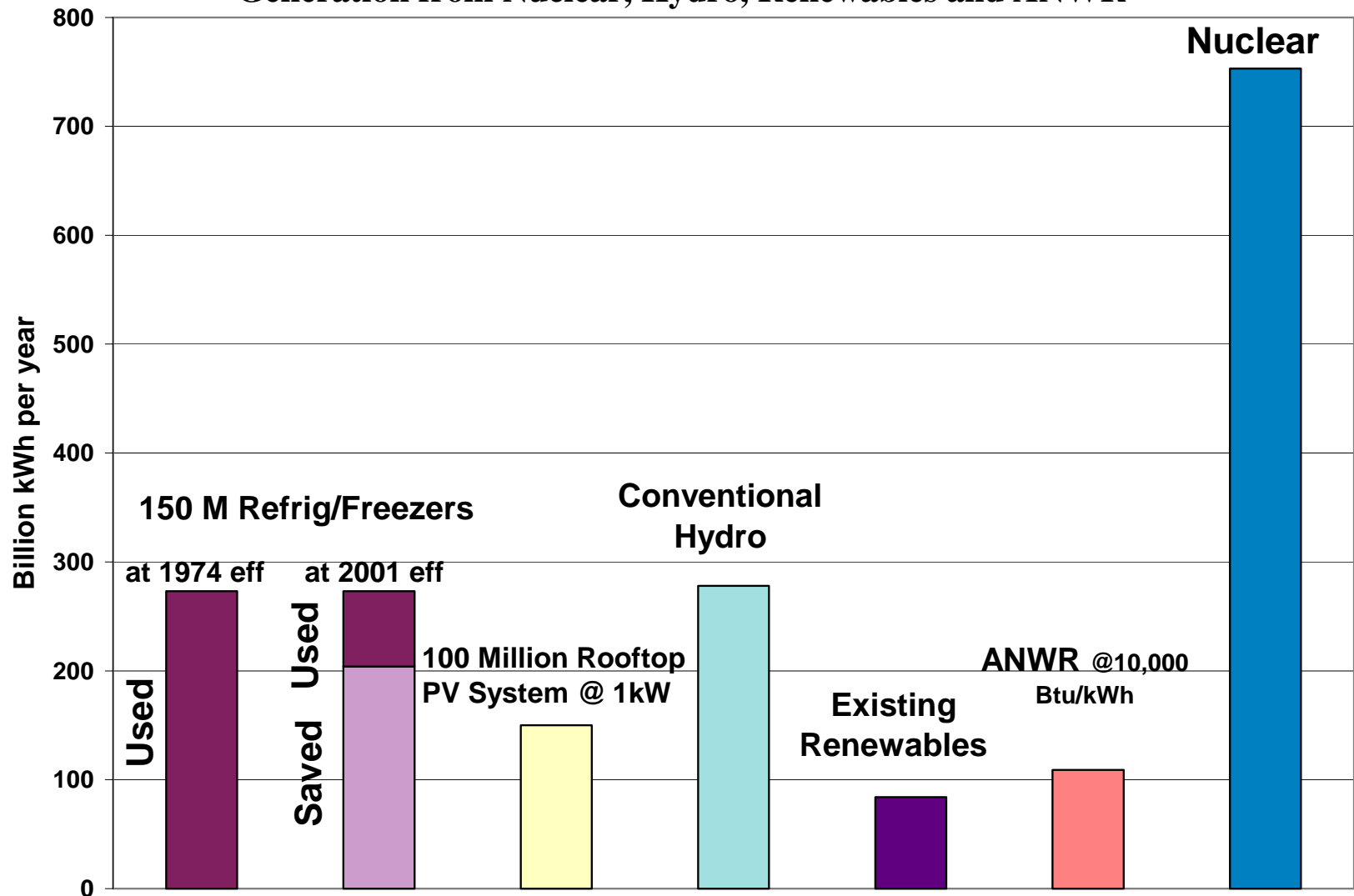
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Source: David Goldstein

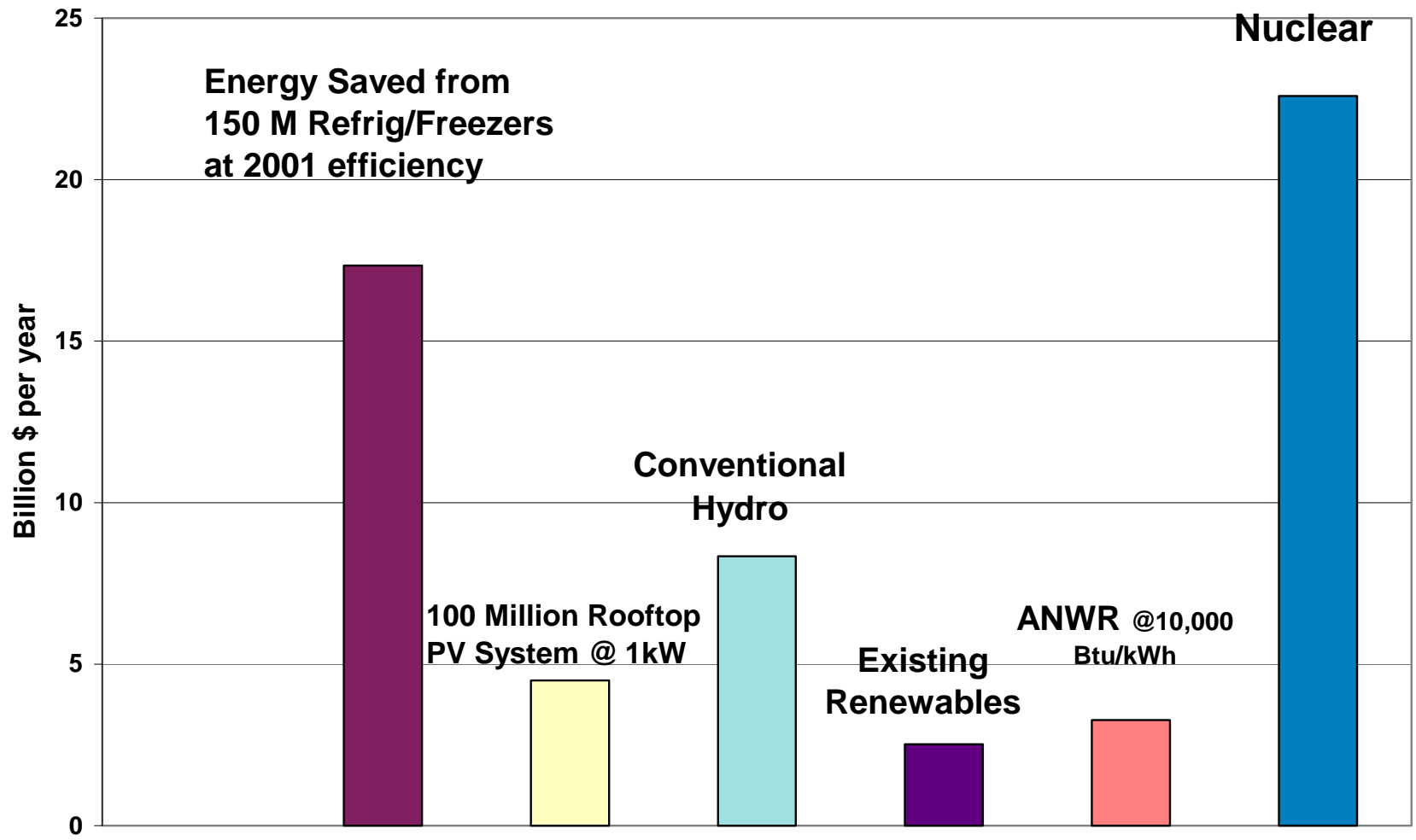
Arthur Rosenfeld, page 4

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

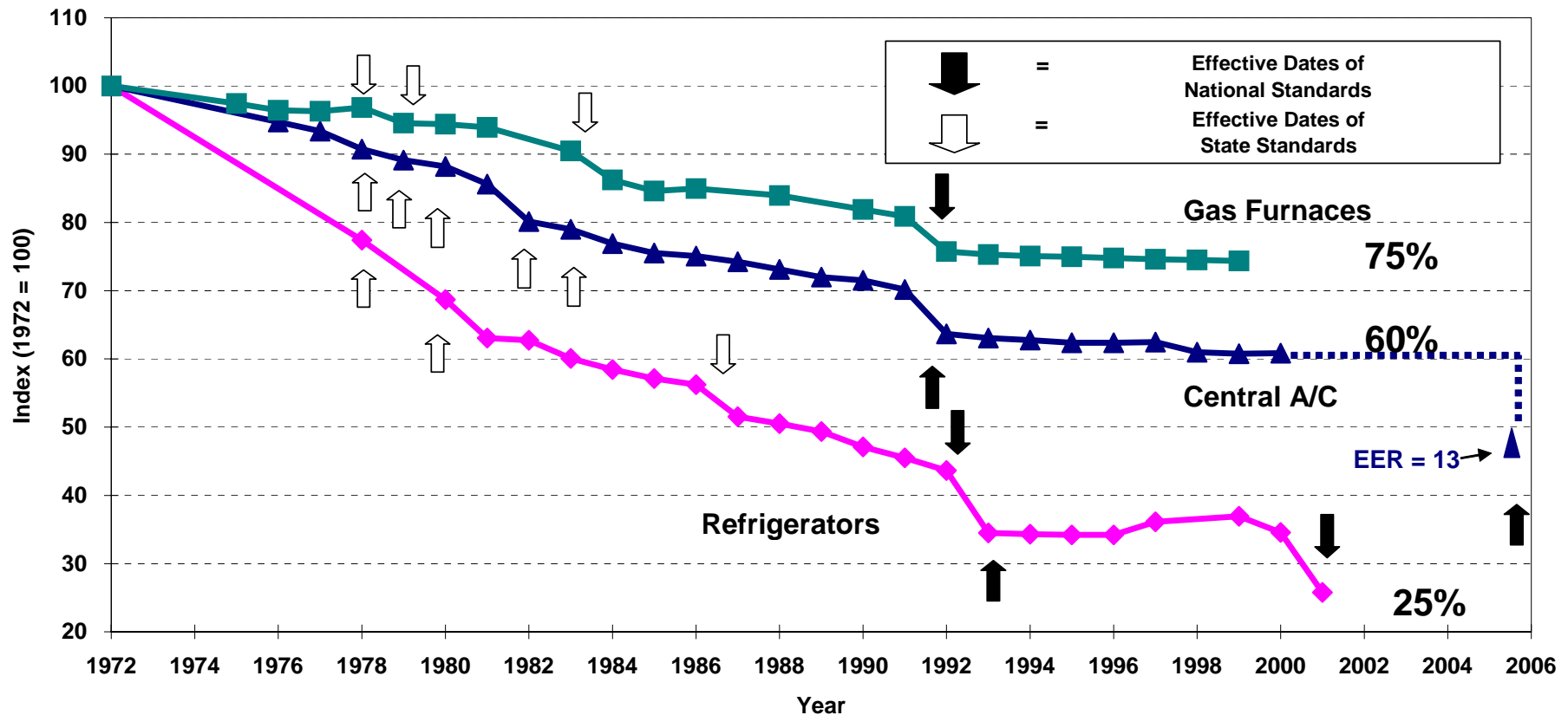
(production @ .03 and savings @ .085 \$/kWh)



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Impact of Standards on Efficiency of 3 Appliances



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

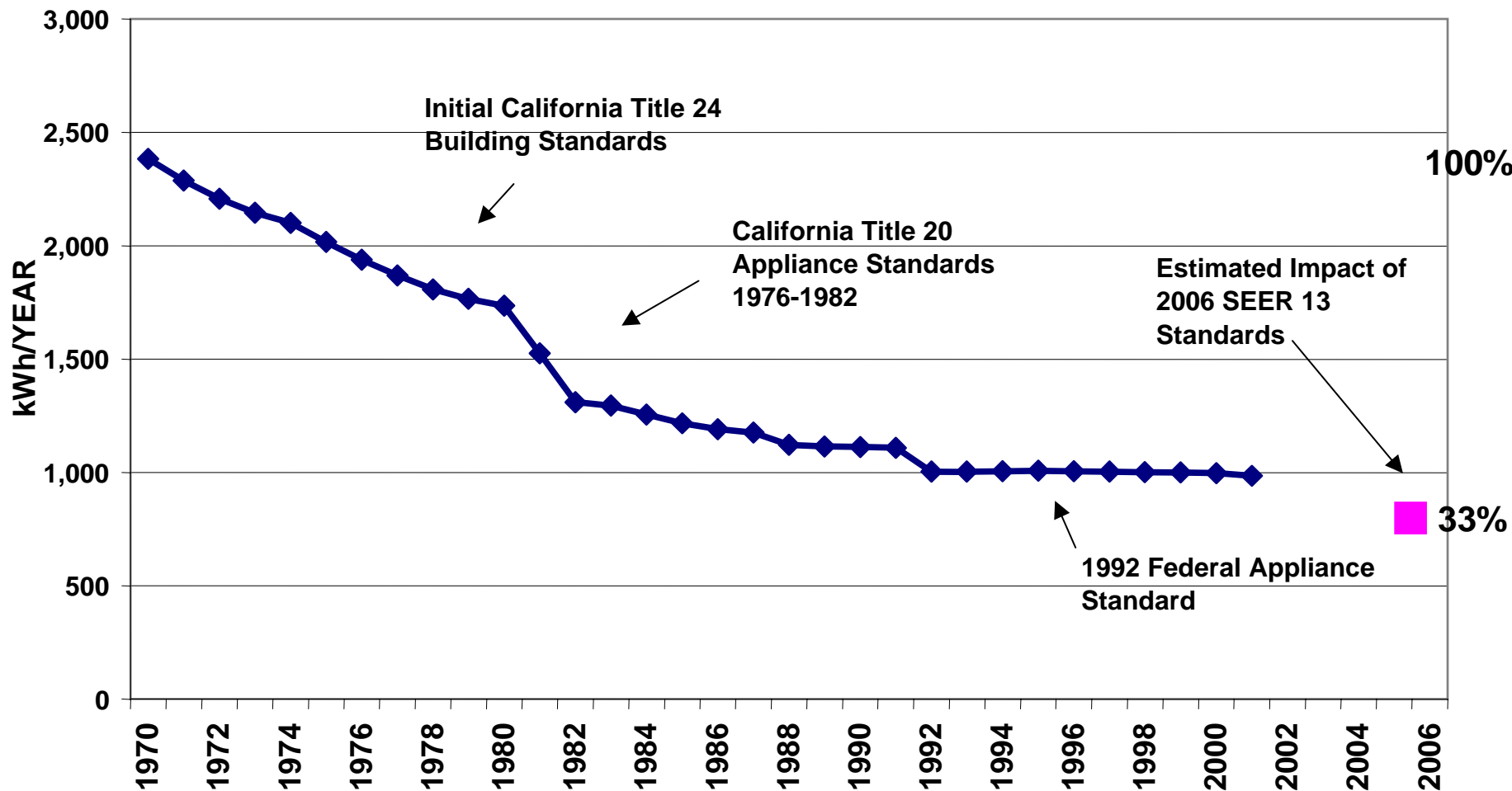


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Arthur Rosenfeld, page 7

Annual Usage of Air Conditioning in New Homes in California

Annual drop averages 4% per year

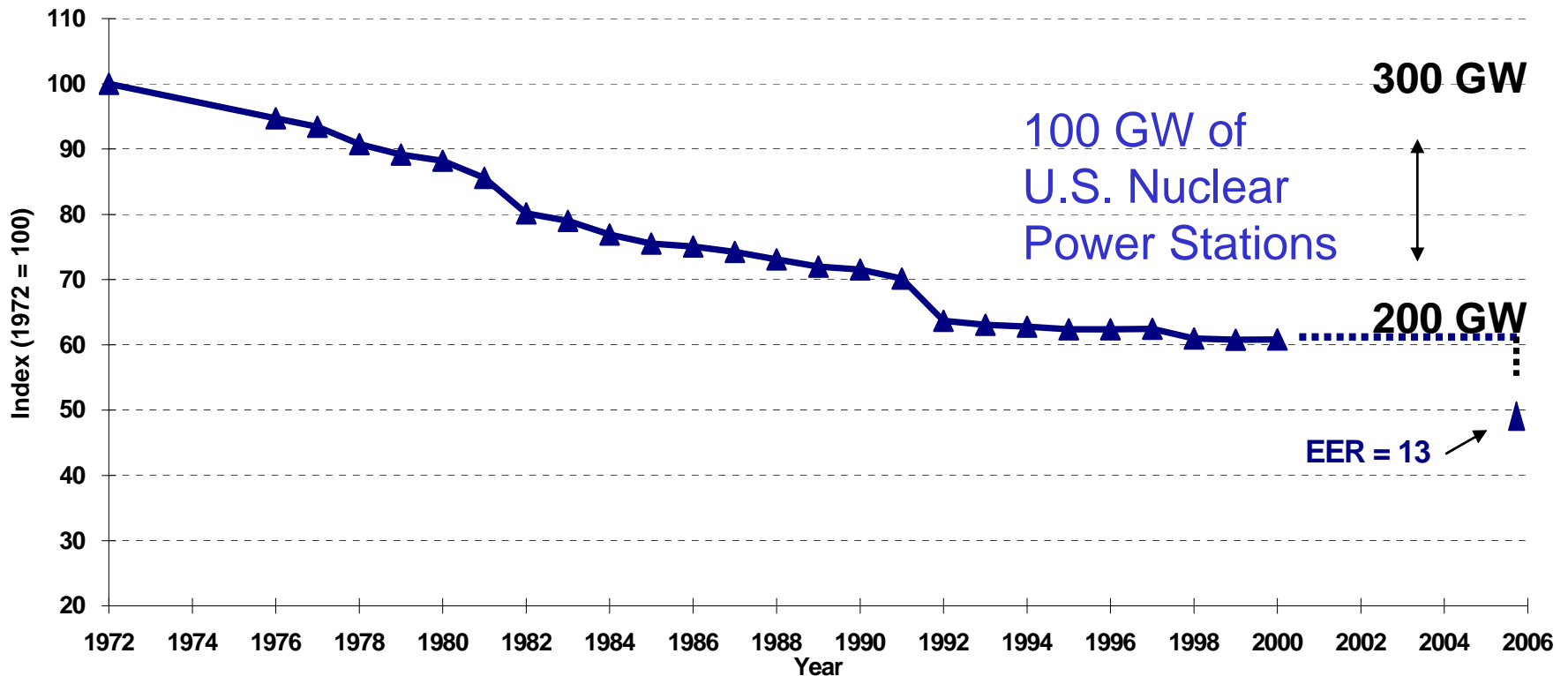


Source: CEC Demand Analysis Office



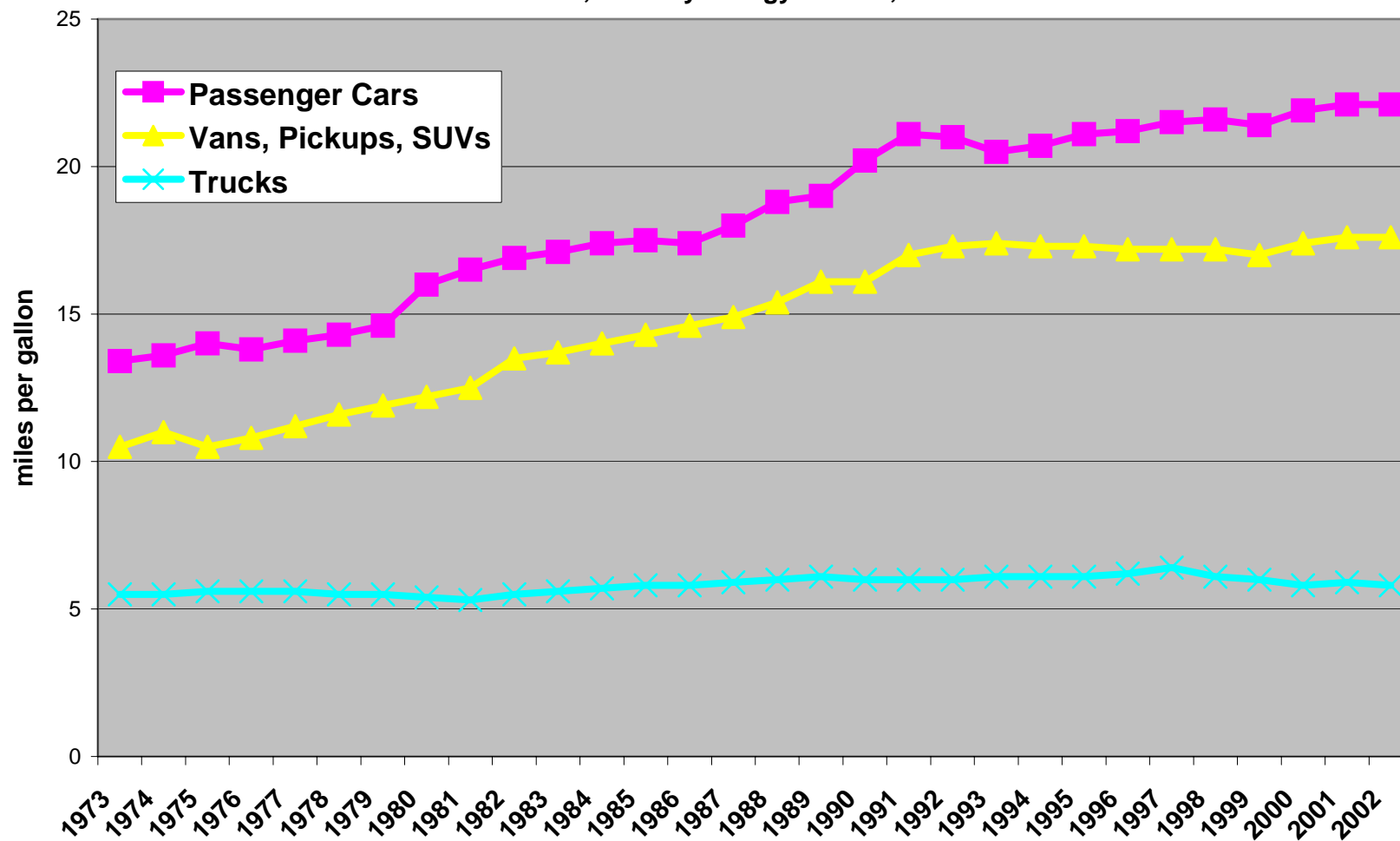
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After Saturation (16 years) Impact of Standards on Residential Central A/C and Roof Top A/C Units in the United States

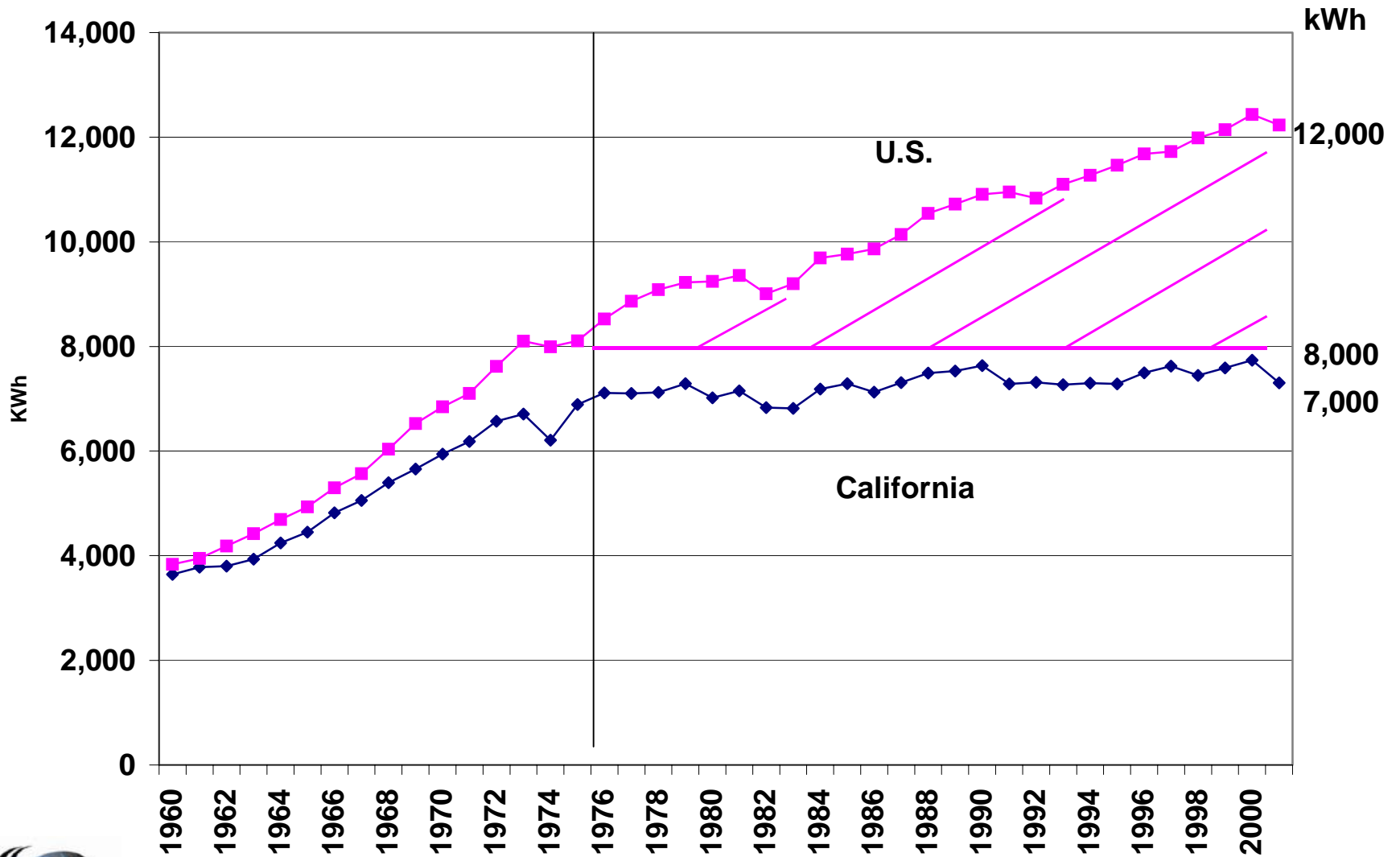


Motor Vehicle Efficiency -- United States Totals

Source: EIA, Monthly Energy Review, Table 1.9

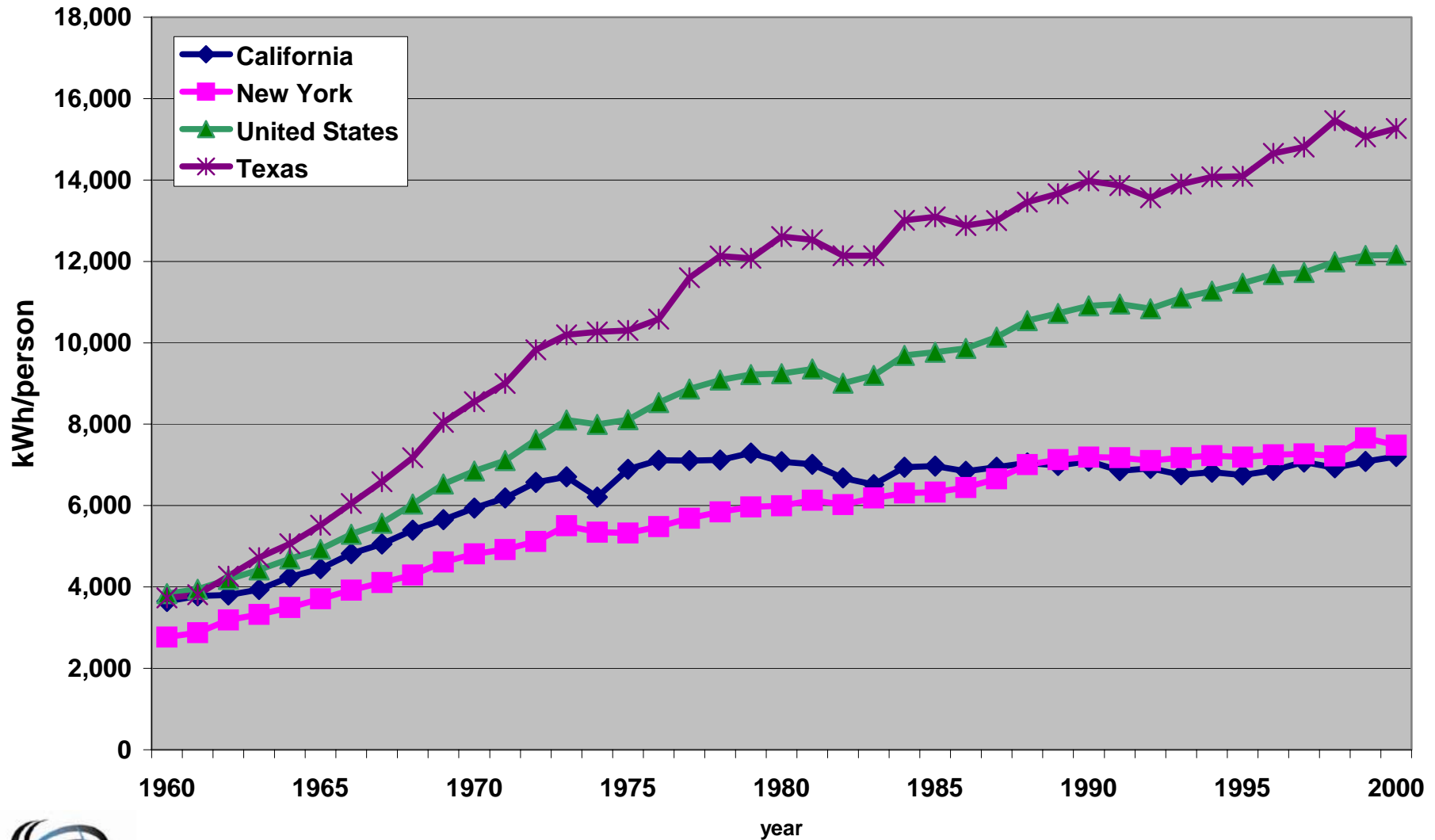


Total Electricity Use, per capita, 1960 - 2001



Per Capita Electricity Consumption

Source: http://www.eia.doe.gov/emeu/states/sep_use/total/csv/use_csv

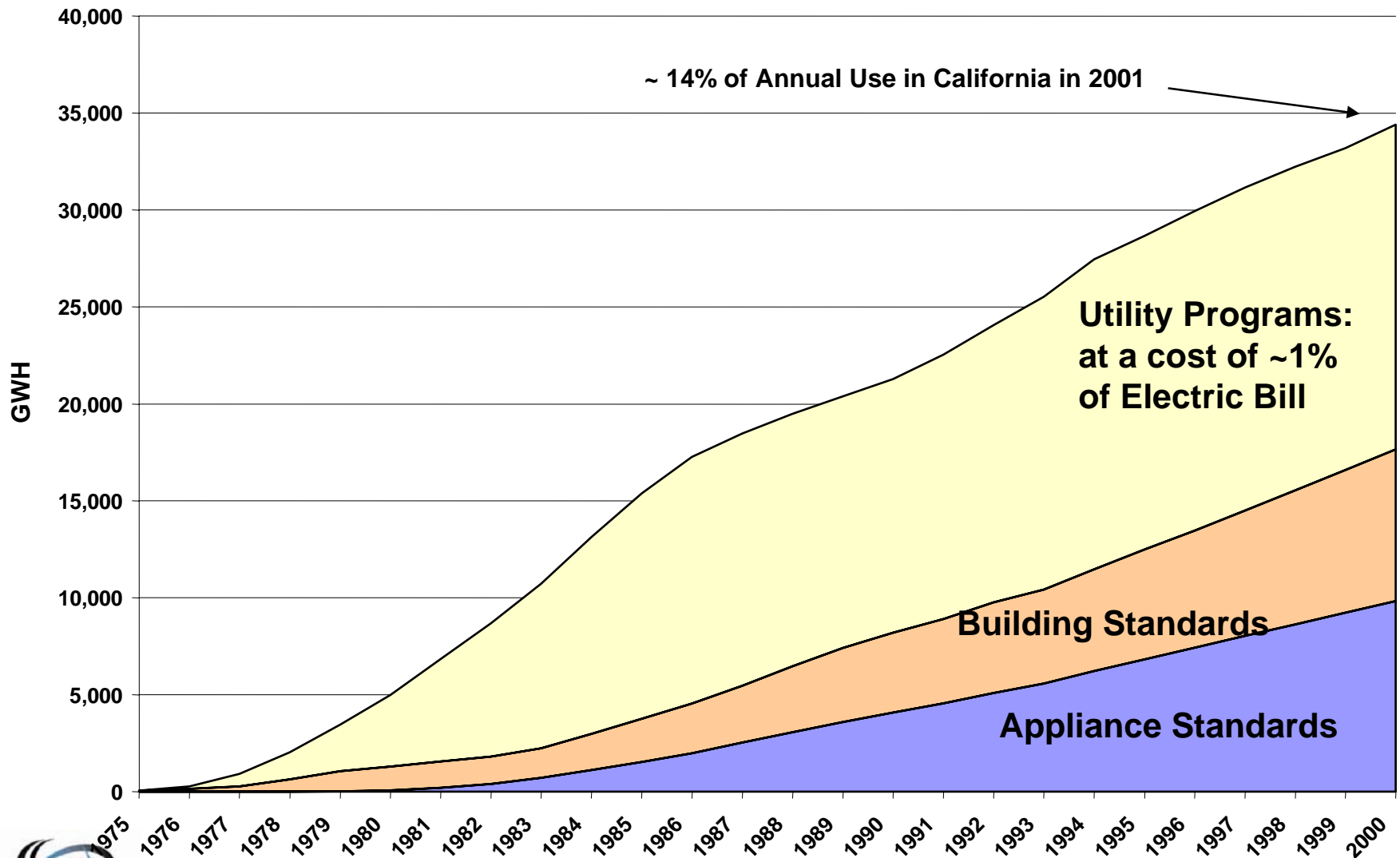


Costs and Pollution saved by avoiding a 50% expansion of Calif. Electric system.

- ◆ Avoiding half of Calif electricity avoids 18 M tons/year of Carbon, equivalent the getting 12 million cars off the road, along with their NO_x, CO, and particulate emissions. But Calif has only ~25 M motor vehicles, so we've avoided 50% more equivalent pollution. The Pavley bill, starting in model year '09, should start to reduce another 30%.
- ◆ Calif annual electric bill in 2004 ~ \$32 B, so we've avoided ~\$16 B of bills, but net saving is only ~\$12B/year, i.e. **\$1000/family**. Compare this with the \$15B Mar.2004 multi-year bond issue to cover the deficit.



GWH Impacts from Programs Begun Prior to 2001



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The 2% Public Goods Charge (PGC) has grown to 2½% of our electricity bill.

◆ Current PGC	\$M/yr
– Energy Efficiency (yellow wedge, previous slide) includes rebates, technical assistance, standards support (training code officials), ...	250
– Renewable Portfolio Standard (RPS) for wind, geothermal, PV <ul style="list-style-type: none">• Renewables currently 12% of CA. electricity• Will increase 1% per year to 20%	150
– R&D: 50% spent to improve end-use efficiency and 50% for air quality and environmental issues	80
– Low Income Assistance	<u>180</u>
2003 Total	660
◆ New Energy Efficiency acquisition thru Integrated Resource Planning (whenever efficiency is cheaper than supply)	<u>140</u>
2004 Total	800

Note: California retail electric bill is ~ \$30 billion/year. PGC adds 2% to retail bills. With new \$ 140 million, this increases to 2.5% per year



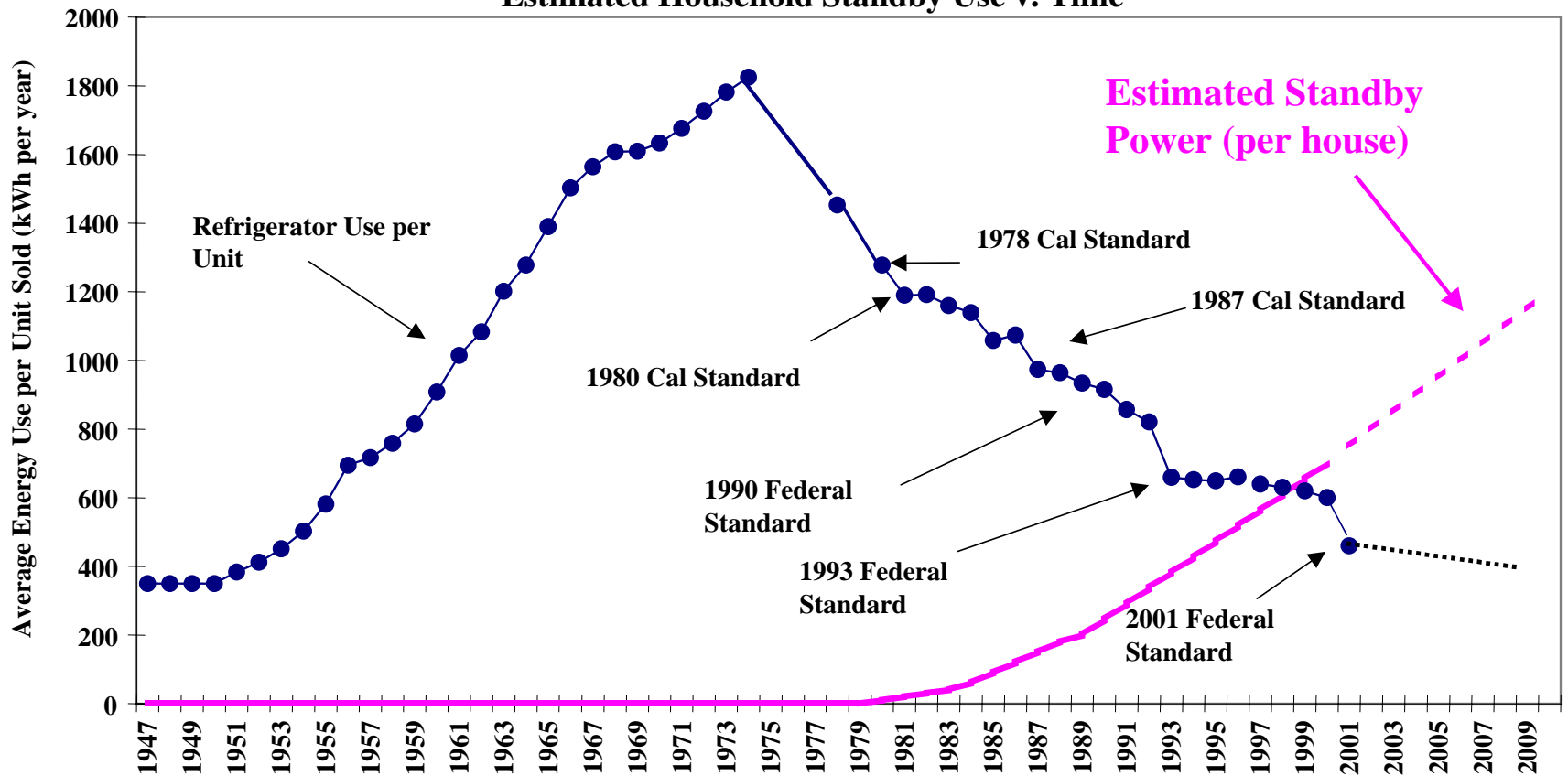
Electricity Efficiency and Renewables in California

Goals of California Energy Action Plan 2003

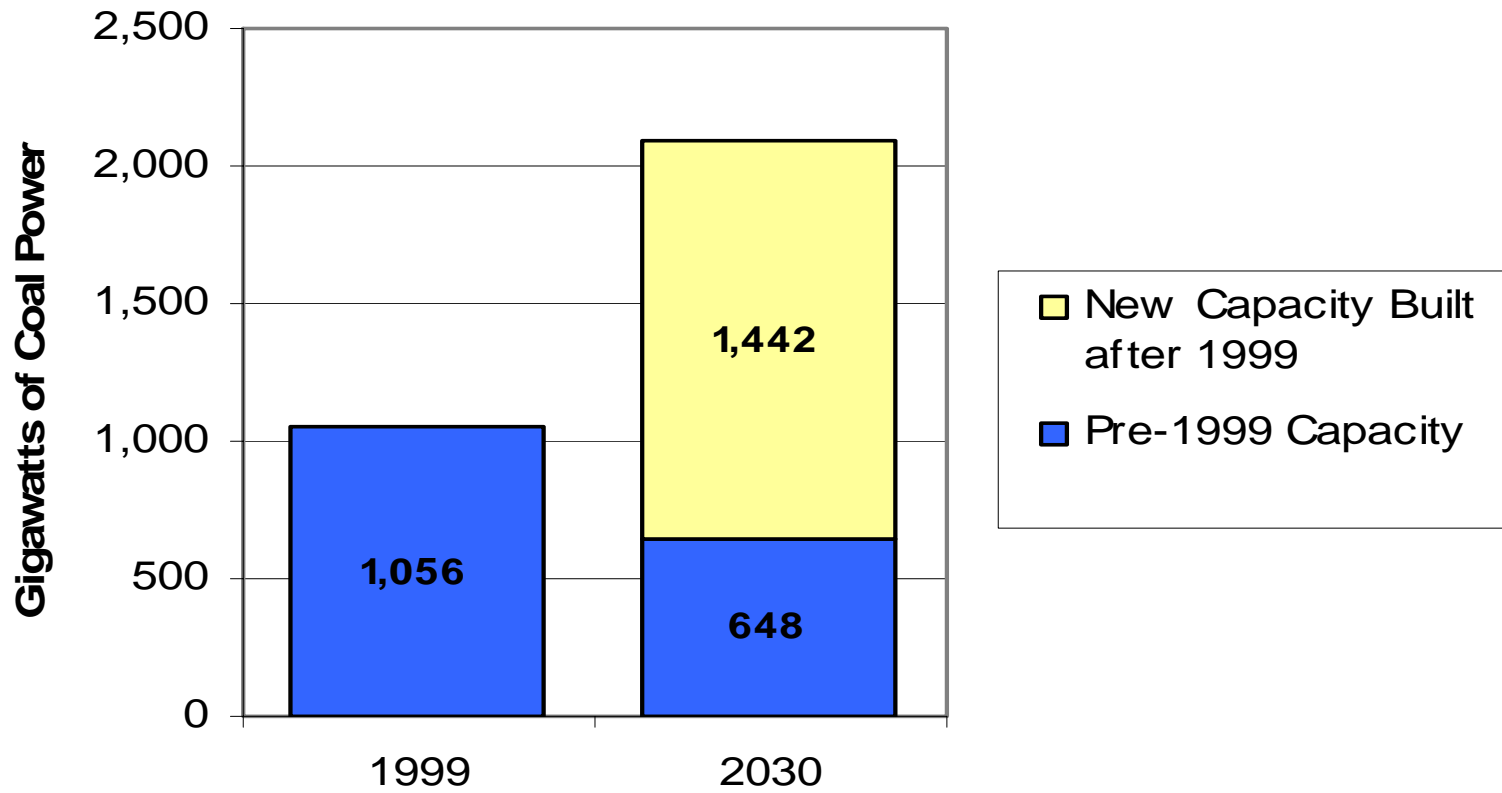
- ◆ California kWh per capita is already flat compared to U.S. climbing 2%/yr.
- ◆ New California goal is to **reduce** kWh per capita by 1/2% to 1% each year
- ◆ Renewable Portfolio Standard: add 1% of renewables per year
- ◆ Additional *peak* reduction of 1% per year by Demand Response when power is expensive or reliability is a problem
- ◆ Some recent initiatives:
 - Green (commercial) Buildings Initiative: to accelerate building efficiency gain by 1% per year
 - Million Solar Homes Initiative (mainly for new homes): to couple super-efficient homes with photovoltaics (PVs)
- ◆ **In total, goals aim to reduce electricity growth, increase renewables, and grow demand response**



United States Refrigerator Use (Actual) and Estimated Household Standby Use v. Time



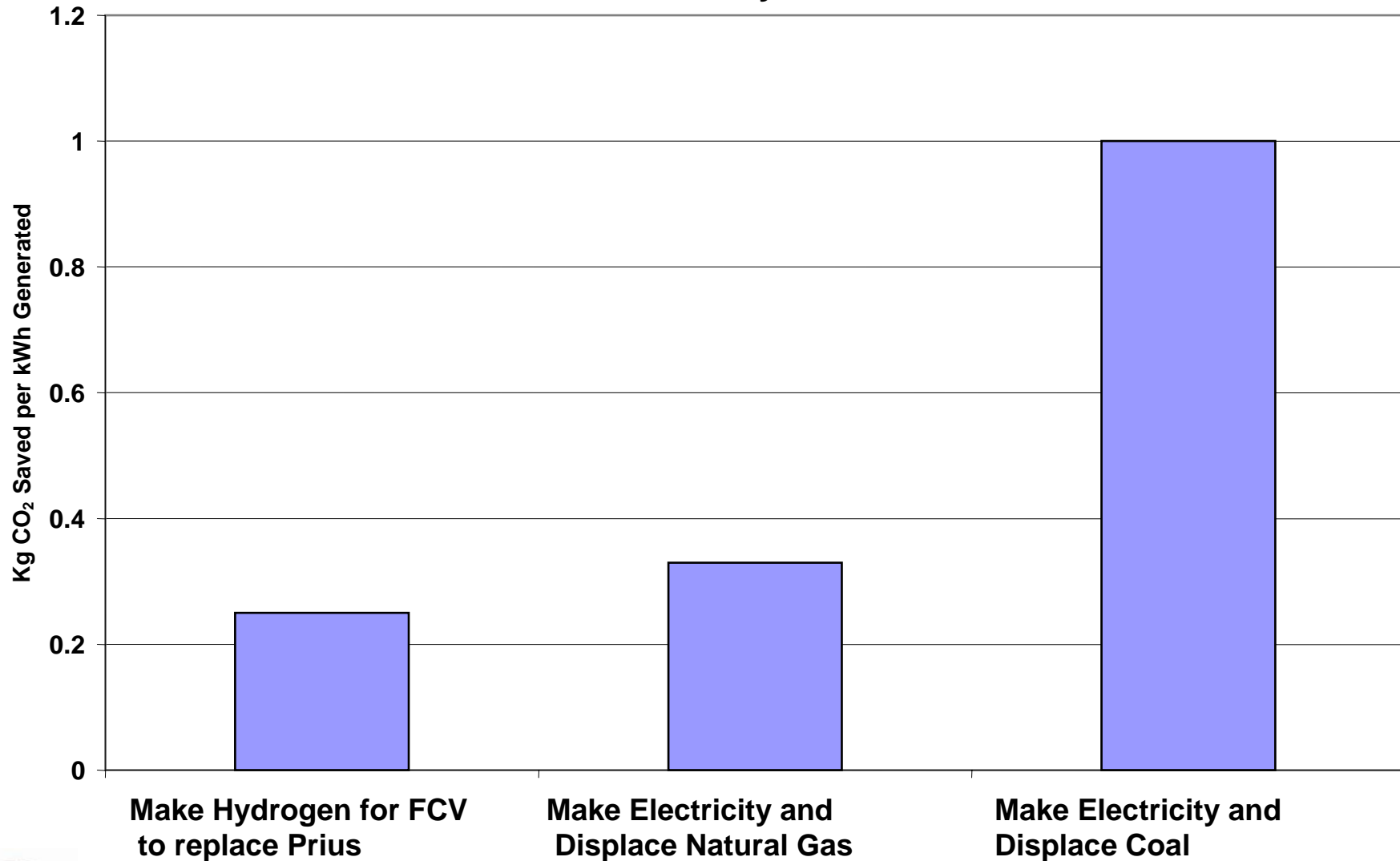
2/3 of 2030 Coal Plants not yet Built



Source: IEA and NRDC



Renewable Electricity Used To



Source : *The Hype About Hydrogen: Fact and Fiction in the Race to Save the Climate*, Joseph Romm, 2004



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Arthur Rosenfeld, page 19

When can Hydrogen Cars Help Fight Global Warming?

- ◆ After “CO₂ emissions from electricity generation are virtually eliminated....” (*Science*, 7/03)
- ◆ After “there is a surplus of renewable electricity.”
(UK Study, 1/03)
- ◆ Science Special Issue on H₂, 13 Aug 2004. “Not so simple” (p. 957),
The Hydrogen Backlash (p.958)
- ◆ Specifically, Hybrid Cars Now, Fuel Cells Later by Nurettin Demirdoven & John Deutsch,
“...fuel cell vehicles using hydrogen from fossil fuels offer no significant advantage over hybrids operating in an urban drive cycle. We conclude that priority should be placed on hybrids by industry and governments.”

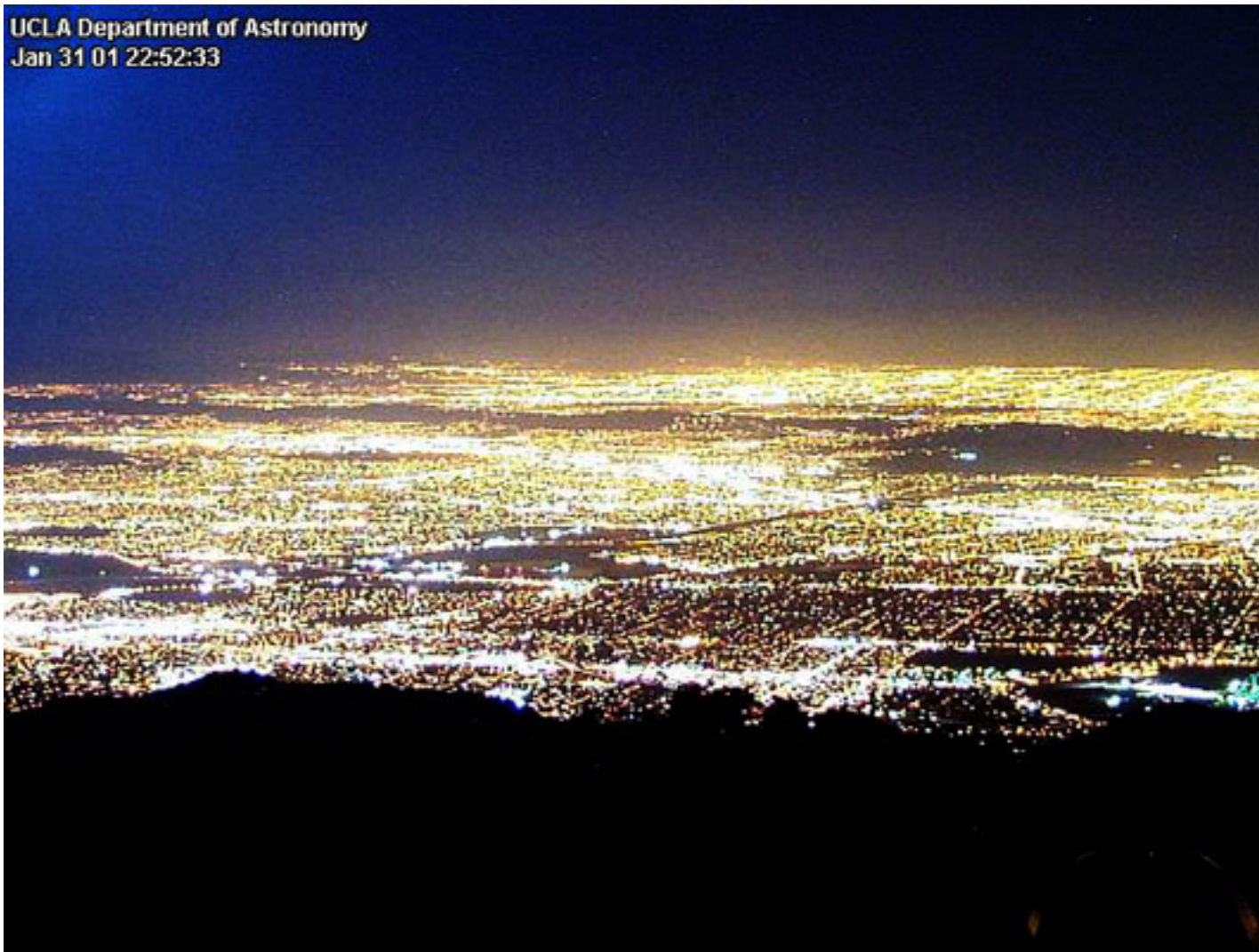


Petroleum Dependence -- Transportation

- ◆ The Pavley Report recommends reducing **emissions** by 30% starting in 2009, thus achieving a 17% overall reduction by 2020
- ◆ Reducing rolling resistance of replacement tires
 - Require tires to be of same quality as new tires
 - Savings ~ 3% in fuel economy
- ◆ Pay-as-you-drive auto insurance
 - Insurance and gasoline each cost ~ \$1,000/year but gasoline is perceived as variable cost; insurance as sunk cost
 - Savings not yet estimated
 - Favored by low income and environmental groups
- ◆ White roofs on state auto fleets



UCLA Department of Astronomy
Jan 31 01 22:52:33



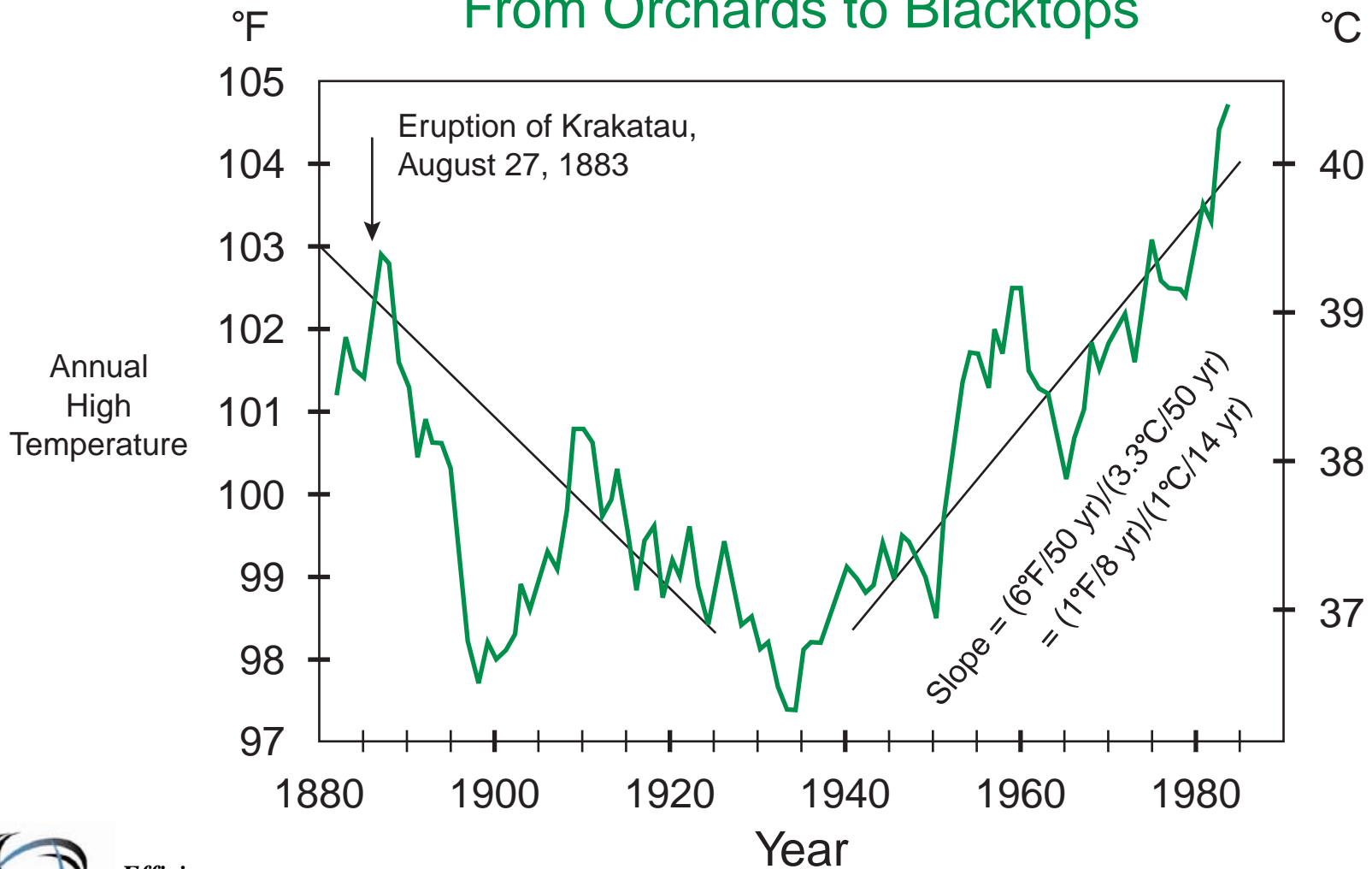
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Illuminating Space vs. the Street



Temperature Trends in Downtown Los Angeles

From Orchards to Blacktops



Cool Communities

- ◆ The most lucrative way to:
 - Save air conditioning
 - Cool cities
 - Reduce Urban Ozone
- ◆ Involves 3 strategies:
 - White roofs (5,000 yr old idea) and cool **colored** roofs (a new idea)
 - Cooler pavements (concrete colored to avoid glare)
 - Shade trees (shade buildings and cool by evapo-transpiration)
- ◆ CEC spent \$10 Million for white “re-roofs” and offers credits for cool roofs in meeting new building standards
- ◆ Benefits can be substantial:
 - In LA Basin, 3 strategies can save 1,500 MW and \$ 200 million per year in A/C; Cool LA by 3-4 degrees Celsius; and reduce ozone by 4 – 8 %, worth another \$ 250 million per year in reduced sickness and sick leave



Relationship: Heat Islands and Global Warming

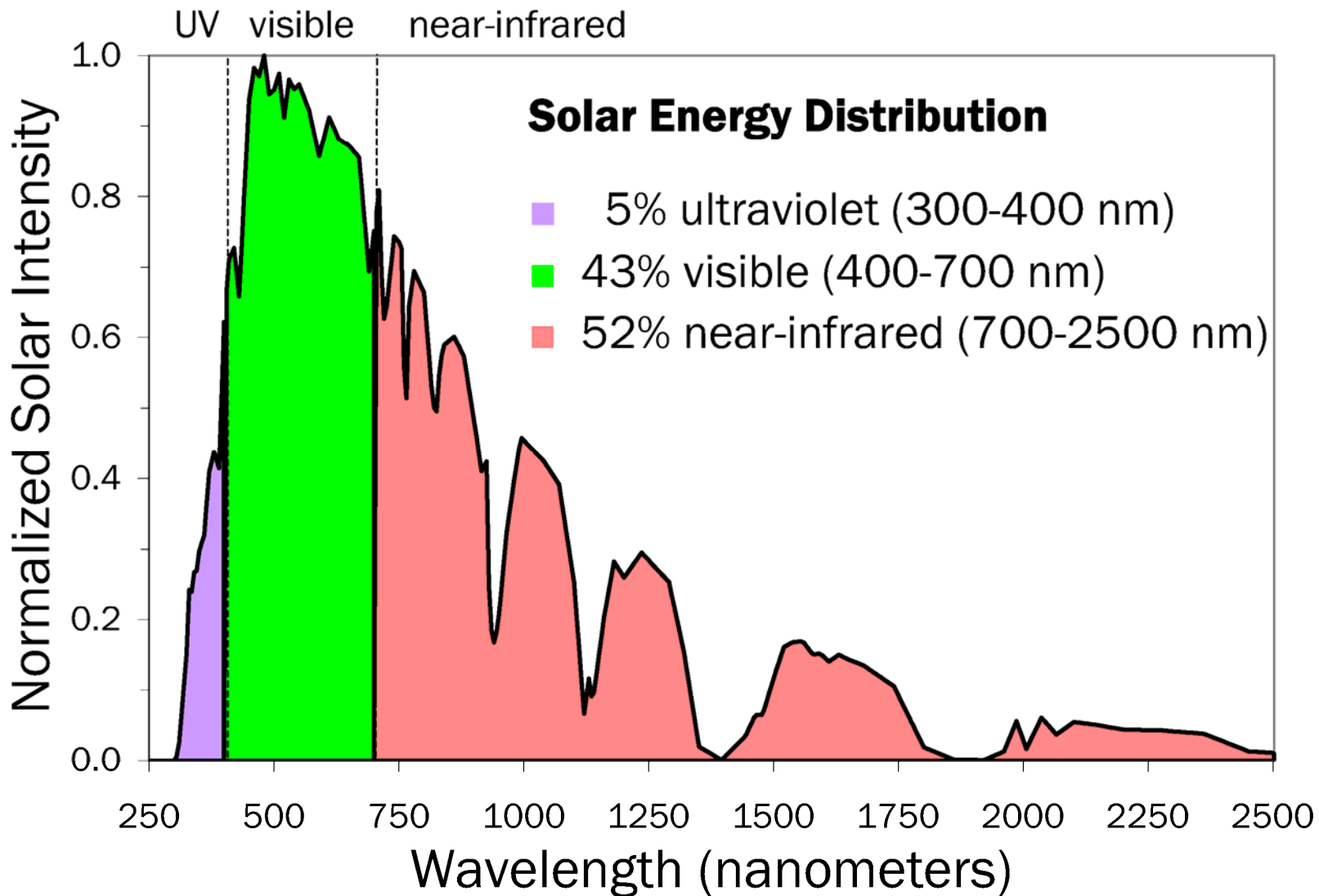
- ◆ The Los Angeles heat island is growing 1 deg. F every 8 years. Global Warming at temperate latitudes, IF WE LEVEL OFF AT 550 PPM CO₂, might be 1 F/14 years, but could be 1 F/decade.
- ◆ Heat storms add to urban heat islands.
15,000 deaths in France in summer 2003.
- ◆ White roofs on buildings and cars directly cool Earth, as contrasted w/ removing CO₂.

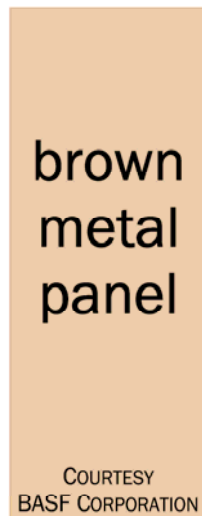


California Cool Roof Policies

- ◆ Annual Public Goods-funded Utility programs of \$2 to \$3 M/year, offer rebates of ~10 cents/sqft.
- ◆ 2005 Building Standards for flat roofs: White is required.
- ◆ 2008 Building Standards for sloped roofs: Cool required (any color).
- ◆ Most buses have white roofs
- ◆ White cars should be bought for public and private fleets
- ◆ R&D
 - Cool Colored Roofs, including cars (recommended in Pavley Report) to reduce emissions by 30%
 - Service Life of Cooler Roofs
- ◆ Adding Cool communities to State Implementation Plans is frustratingly slow







cool

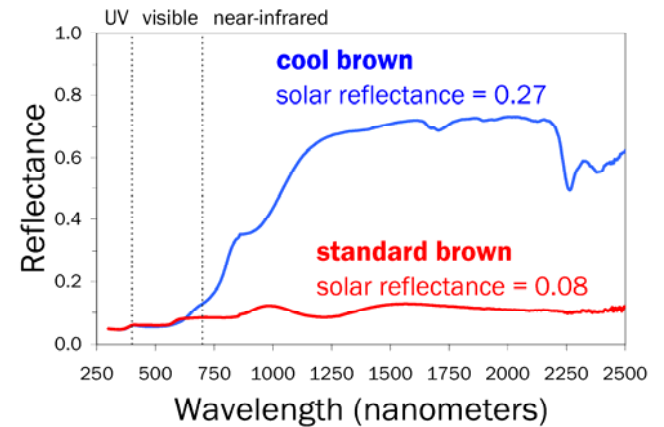


solar reflectance = 0.27
thermal emittance = 0.85
roof temp - air temp = 36°C (65°F)

standard



solar reflectance = 0.08
thermal emittance = 0.85
roof temp - air temp = 45°C (81°F)



Source: Hashem Akbari, LBNL

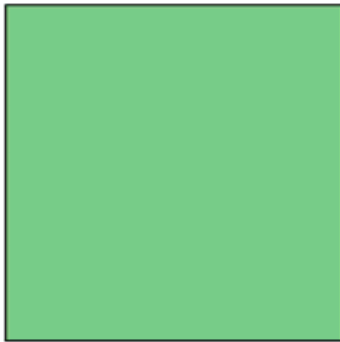


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green
metal
panel

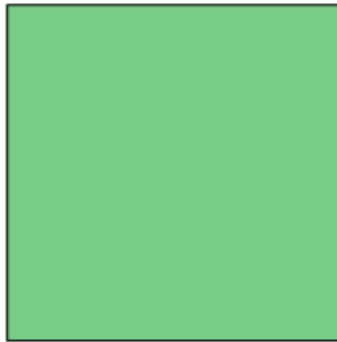
COURTESY
BASF CORPORATION

cool

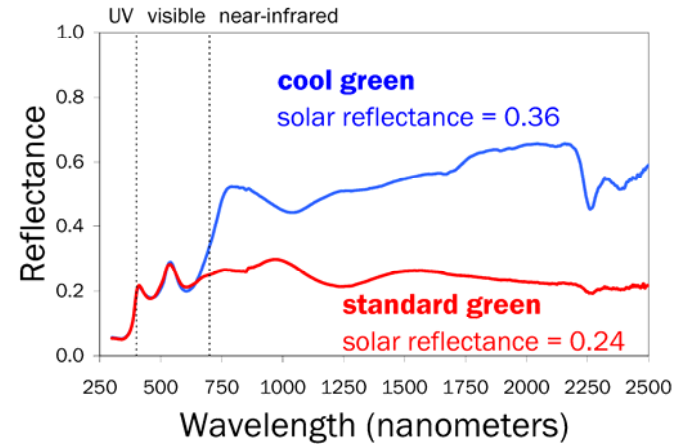


solar reflectance = 0.36
thermal emittance = 0.85
roof temp - air temp = 31°C (56°F)

standard



solar reflectance = 0.24
thermal emittance = 0.85
roof temp - air temp = 38°C (68°F)



Source: Hashem Akbari, LBNL

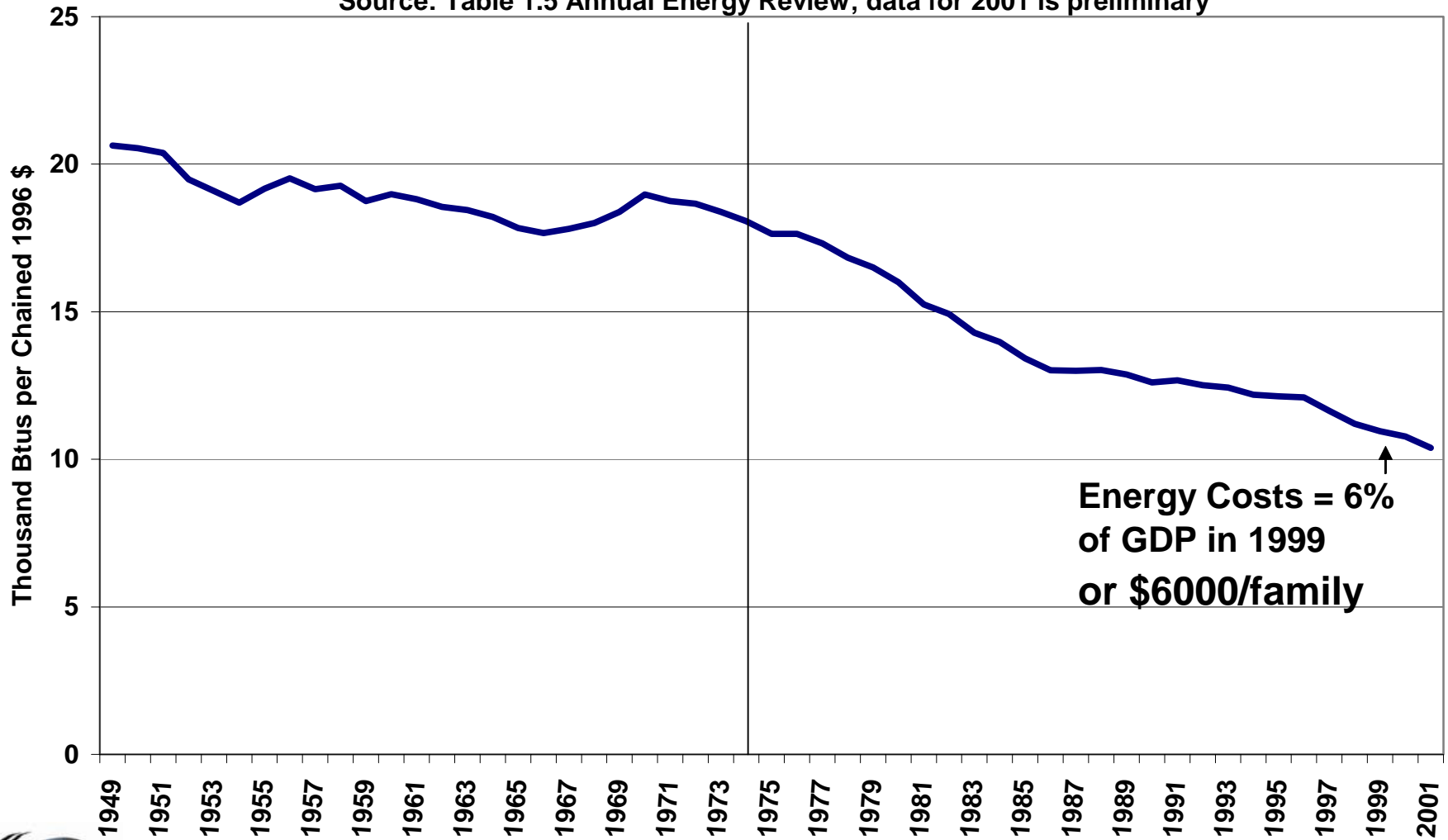


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Energy Intensity in the United States

Energy Consumption Per \$ of Gross Domestic Product 1949-2001

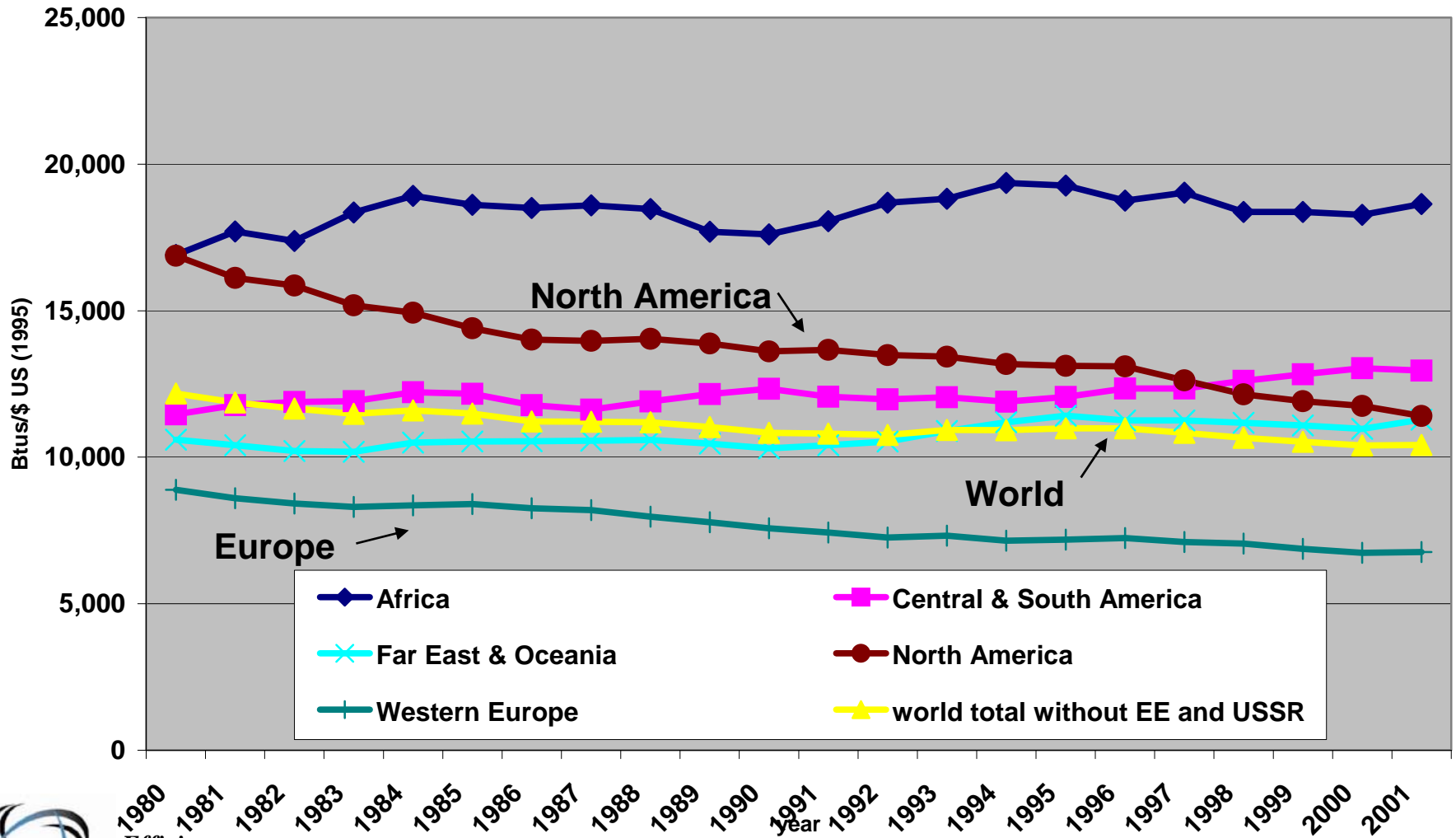
Source: Table 1.5 Annual Energy Review; data for 2001 is preliminary



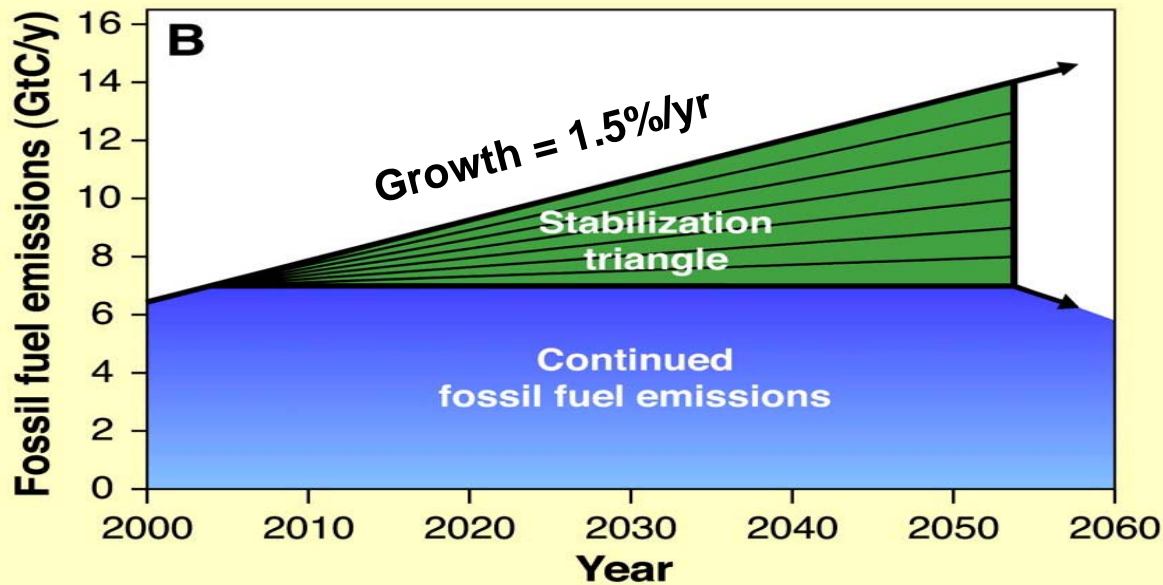
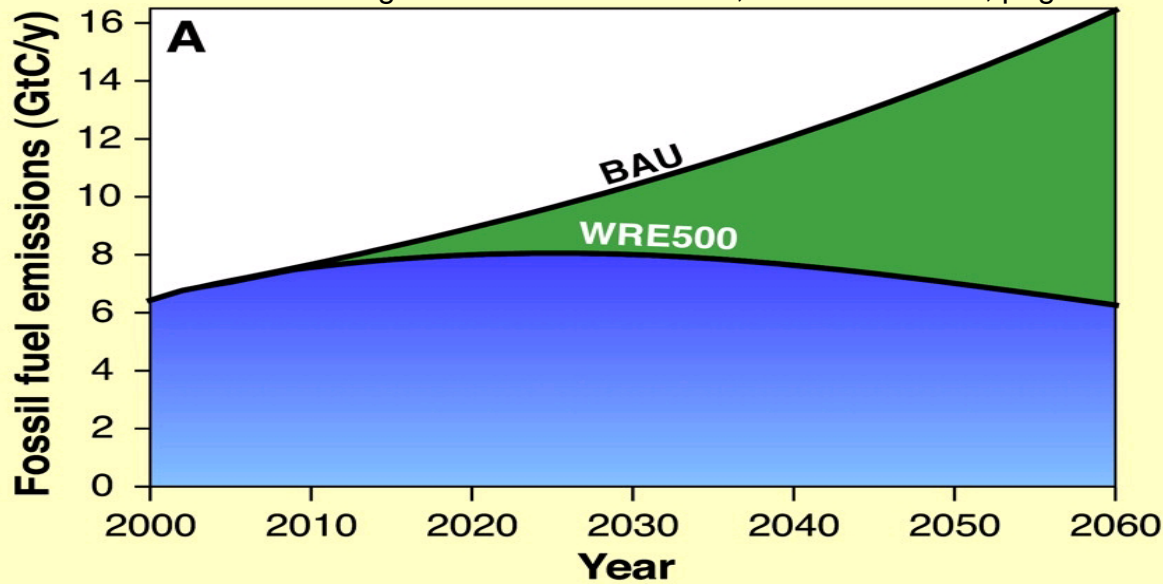
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Energy Intensity By Geographic Region 1980 to 2001
(Btus/\$US 1995) from EIA data



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



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Stabilization Wedges: Pacala and Socolow

Science Vol 305, page 968

◆ **Efficiency and Conservation**

- Efficient Vehicles
- Reduced Use of Vehicles
- Efficient Buildings
- Efficient Coal Power Plants

◆ **Fuel Shifting**

- Natural Gas for Coal
- Nuclear Power for Coal

◆ **CO₂ Capture and Storage (CCS)**

- At Power Plants
- At Hydrogen Plants
- At Coal to Synfuel Plants

◆ **Renewable Electricity and Fuels**

- Wind Power for Coal
- Photovoltaics for Coal
- Wind Power for H₂
- Biomass for fossil fuel

◆ **Forests and Agriculture**

- Reduce Deforestation and Reforest
- Conservation tillage



Table 1. Potential wedges: Strategies available to reduce the carbon emission rate in 2054 by 1 GtC/year or to reduce carbon emissions from 2004 to 2054 by 25 GtC.

Option	Effort by 2054 for one wedge, relative to 14 GtC/year BAU	Comments, issues
<i>Energy efficiency and conservation</i>		
Economy-wide carbon-intensity reduction (emissions/\$GDP)	Increase reduction by additional 0.15% per year (e.g., increase U.S. goal of 1.96% reduction per year to 2.11% per year)	Can be tuned by carbon policy
1. Efficient vehicles	Increase fuel economy for 2 billion cars from 30 to 60 mpg	Car size, power
2. Reduced use of vehicles	Decrease car travel for 2 billion 30-mpg cars from 10,000 to 5000 miles per year	Urban design, mass transit, telecommuting
3. Efficient buildings	Cut carbon emissions by one-fourth in buildings and appliances projected for 2054	Weak incentives
4. Efficient baseload coal plants	Produce twice today's coal power output at 60% instead of 40% efficiency (compared with 32% today)	Advanced high-temperature materials
<i>Fuel shift</i>		
5. Gas baseload power for coal baseload power	Replace 1400 GW 50%-efficient coal plants with gas plants (four times the current production of gas-based power)	Competing demands for natural gas
<i>CO₂ Capture and Storage (CCS)</i>		
6. Capture CO ₂ at baseload power plant	Introduce CCS at 800 GW coal or 1600 GW natural gas (compared with 1060 GW coal in 1999)	Technology already in use for H ₂ production
7. Capture CO ₂ at H ₂ plant	Introduce CCS at plants producing 250 MtH ₂ /year from coal or 500 MtH ₂ /year from natural gas (compared with 40 MtH ₂ /year today from all sources)	H ₂ safety, infrastructure



8. Capture CO ₂ at coal-to-synfuels plant	Introduce CCS at synfuels plants producing 30 million barrels a day from coal (200 times Sasol), if half of feedstock carbon is available for capture	Increased CO ₂ emissions, if synfuels are produced without CCS
Geological storage	Create 3500 Sleipners	Durable storage, successful permitting
9. Nuclear power for coal power	<i>Nuclear fission</i> Add 700 GW (twice the current capacity)	Nuclear proliferation, terrorism, waste
10. Wind power for coal power	<i>Renewable electricity and fuels</i> Add 2 million 1-MW-peak windmills (50 times the current capacity) "occupying" 30×10^6 ha, on land or offshore	Multiple uses of land because windmills are widely spaced
11. PV power for coal power	Add 2000 GW-peak PV (700 times the current capacity) on 2×10^6 ha	PV production cost
12. Wind H ₂ in fuel-cell car for gasoline in hybrid car	Add 4 million 1-MW-peak windmills (100 times the current capacity)	H ₂ safety, infrastructure
13. Biomass fuel for fossil fuel	Add 100 times the current Brazil or U.S. ethanol production, with the use of 250×10^6 ha (one-sixth of world cropland)	Biodiversity, competing land use
14. Reduced deforestation, plus reforestation, afforestation, and new plantations.	<i>Forests and agricultural soils</i> Decrease tropical deforestation to zero instead of 0.5 GtC/year, and establish 300 Mha of new tree plantations (twice the current rate)	Land demands of agriculture, benefits to biodiversity from reduced deforestation
15. Conservation tillage	Apply to all cropland (10 times the current usage)	Reversibility, verification

13 AUGUST 2004 VOL 305 SCIENCE www.sciencemag.org



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Arthur Rosenfeld, page 36

Available Reports/Program Details

- ◆ **Electric Industry – CPUC Information and Programs**
<http://www.cpuc.ca.gov/static/industry/electric>
- ◆ **CEC's Integrated Energy Policy Report**
<http://www.energy.ca.gov/energypolicy/index.html>
- ◆ **State of California Energy Action Plan**
http://www.energy.ca.gov/2003_energy_action_plan/index.html
- ◆ **CEC's Renewables Program**
<http://www.energy.ca.gov/renewables/index.html>
- ◆ **CEC's Public Interest Energy Research**
<http://www.energy.ca.gov/research/index.html>
- ◆ **CEC's Energy Efficiency Rebates and Demand Reduction**
<http://www.consumerenergycenter.org/rebate/index.php>

