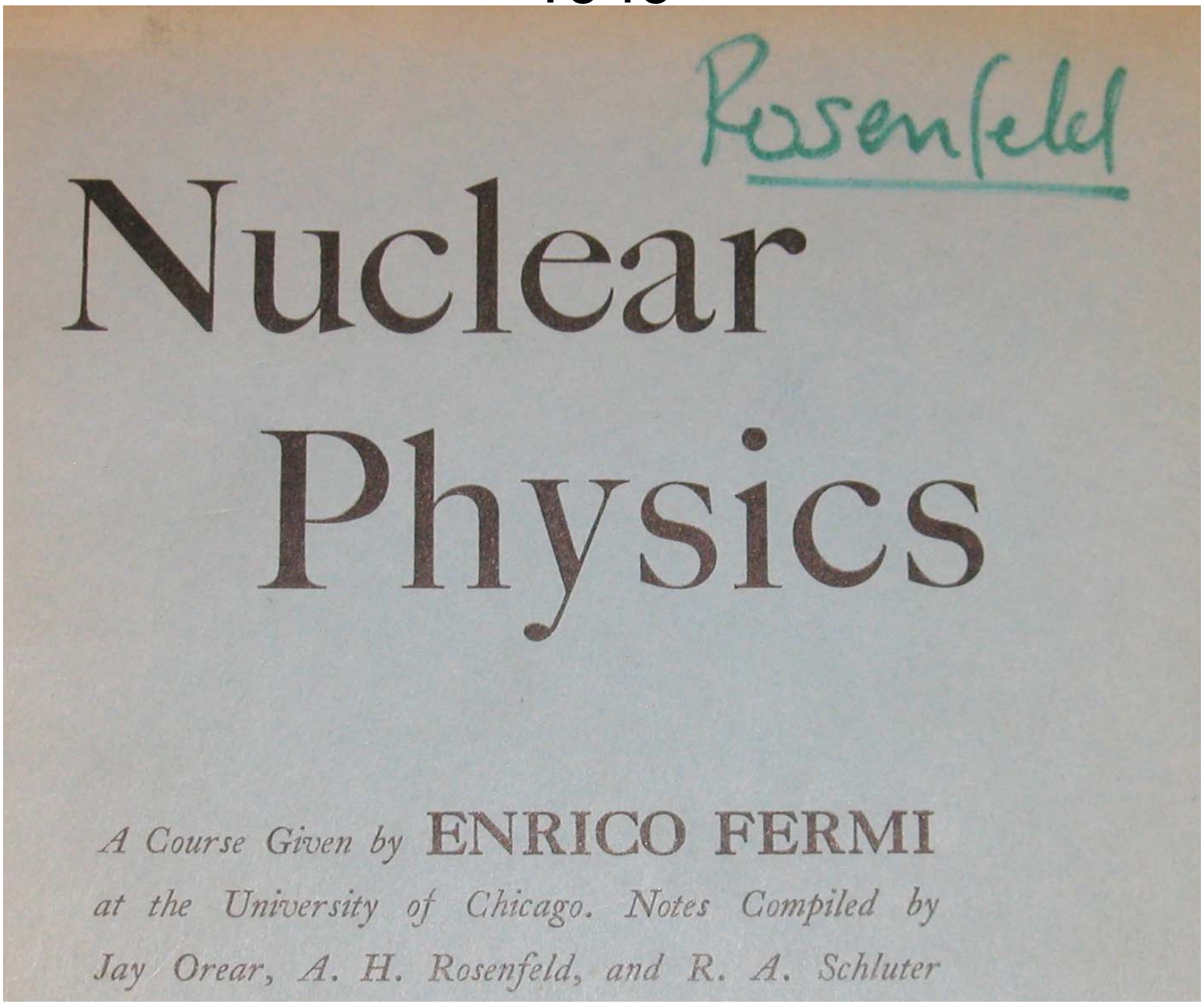
California's Success in Energy Efficiency and Climate Change: Past and Future

Electricite de France, 24 May 2007

Arthur H. Rosenfeld, Commissioner
California Energy Commission
(916) 654-4930
ARosenfe@Energy.State.CA.US

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

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

California Energy Commission Responsibilities

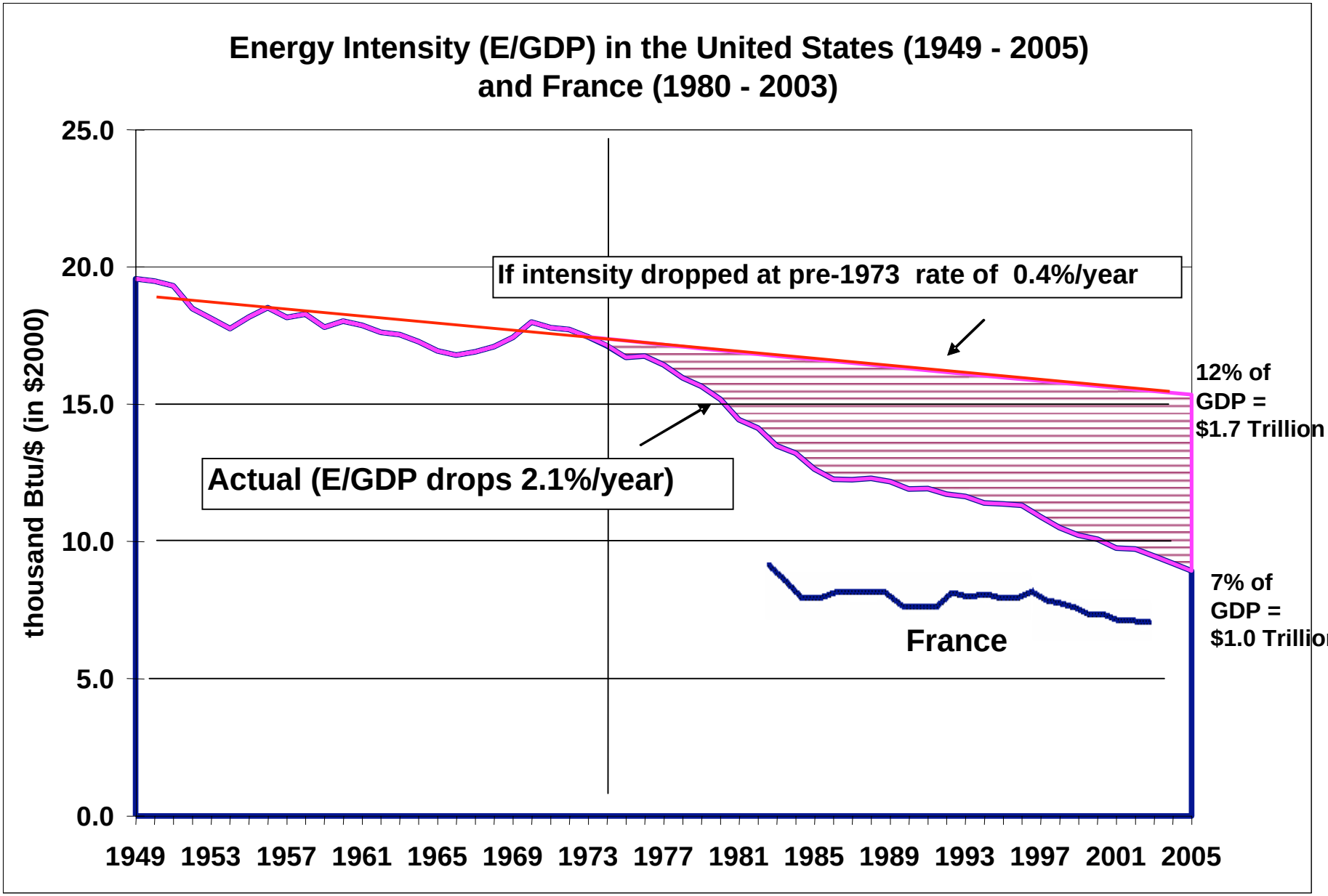
Both Regulation and R&D

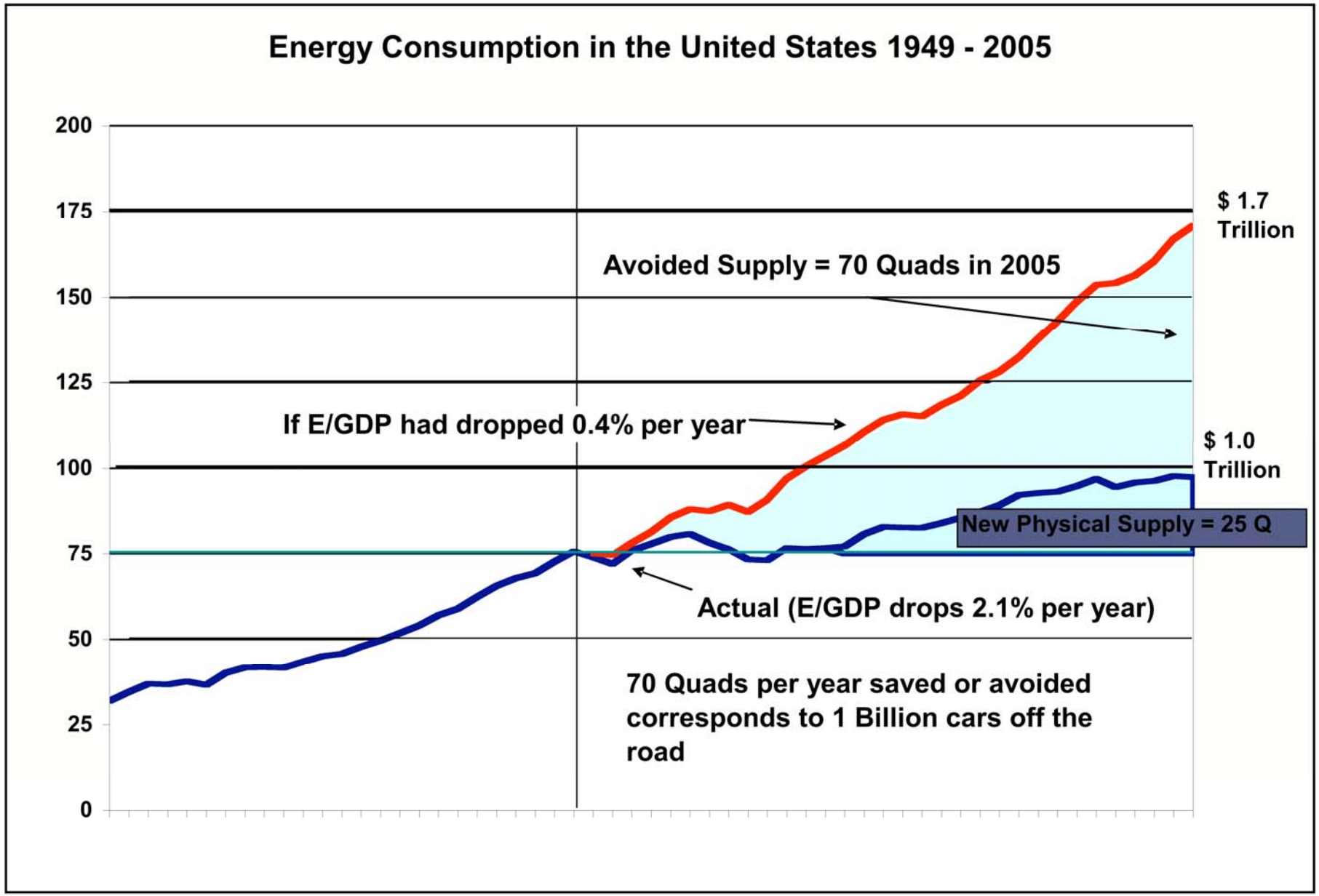
- California Building and Appliance Standards
  - Since the late 1970s
  - Updated every few years
- Siting Thermal Power Plants Larger than 50 MW
- Forecasting Supply and Demand (electricity and fuels)
- Research and Development
  - ~ $80 million per year
  - Including collaborative effort with EDF R&D

California Successes...

- Part 1 – Past Success
- Part 2 – Underway (this year and next)
- Part 3 – States Attempt To Take Charge: Global Warming and Cool Communities

Part 1 – Past Success


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
7% of
GDP =
$1.0 Trillion

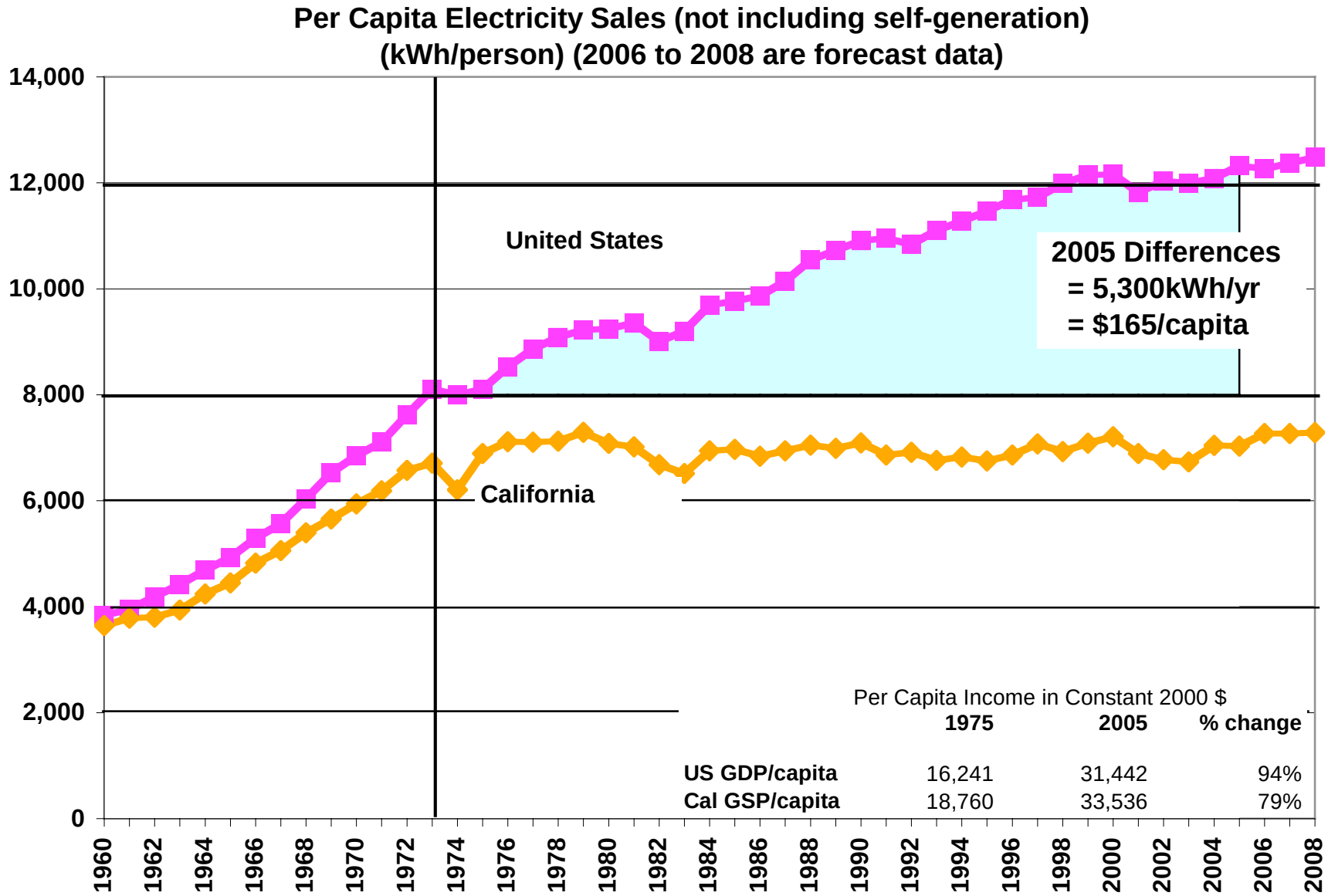

Energy Consumption in the United States 1949 - 2005
200
175
150
125
100
75
50
25
0
$ 1.7 Trillion
Avoided Supply = 70 Quads in 2005
If E/GDP had dropped 0.4% per year
$ 1.0 Trillion
New Physical Supply = 25 Q
Actual (E/GDP drops 2.1% per year)
70 Quads per year saved or avoided corresponds to 1 Billion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

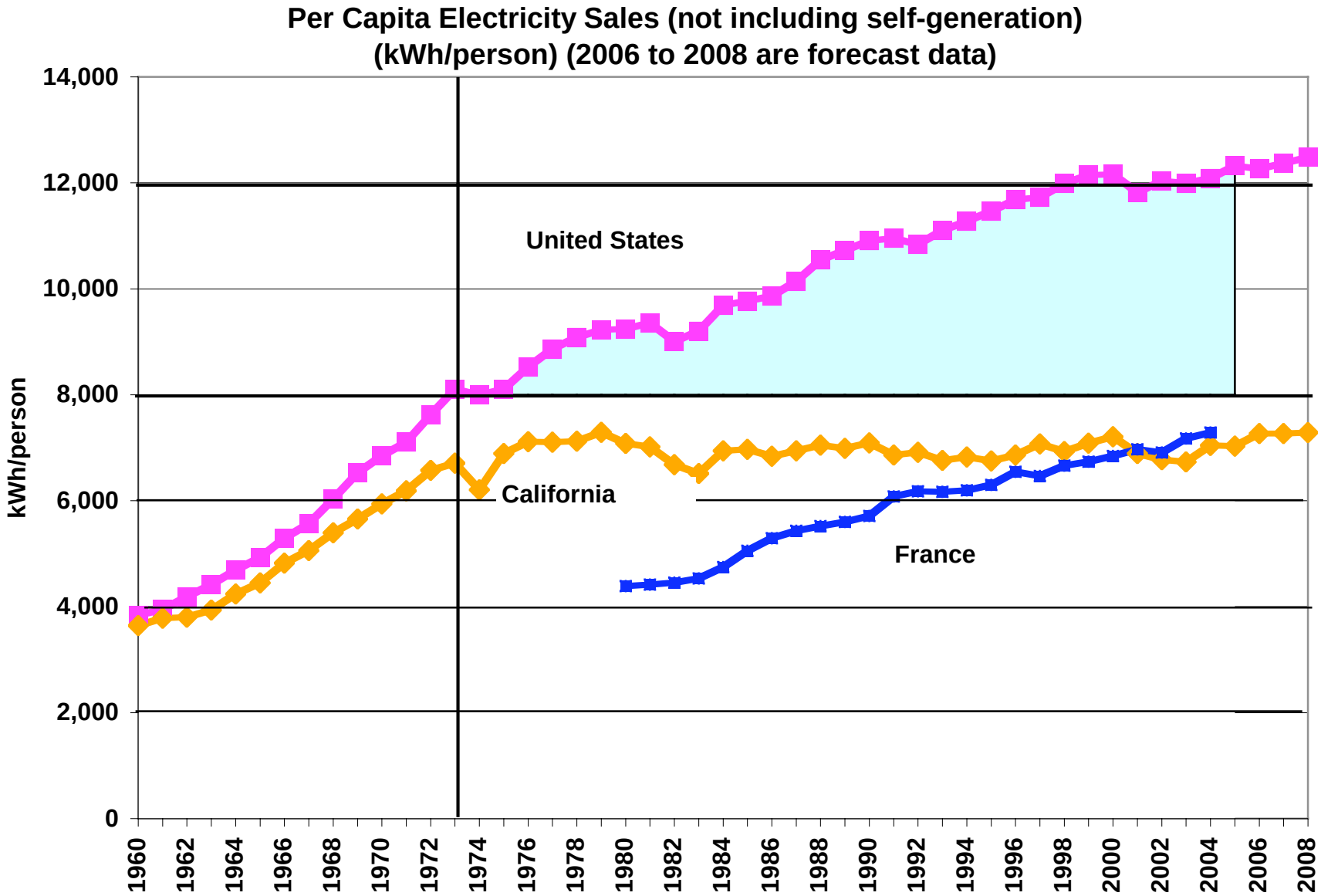
How Much of The Savings Come from Efficiency

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

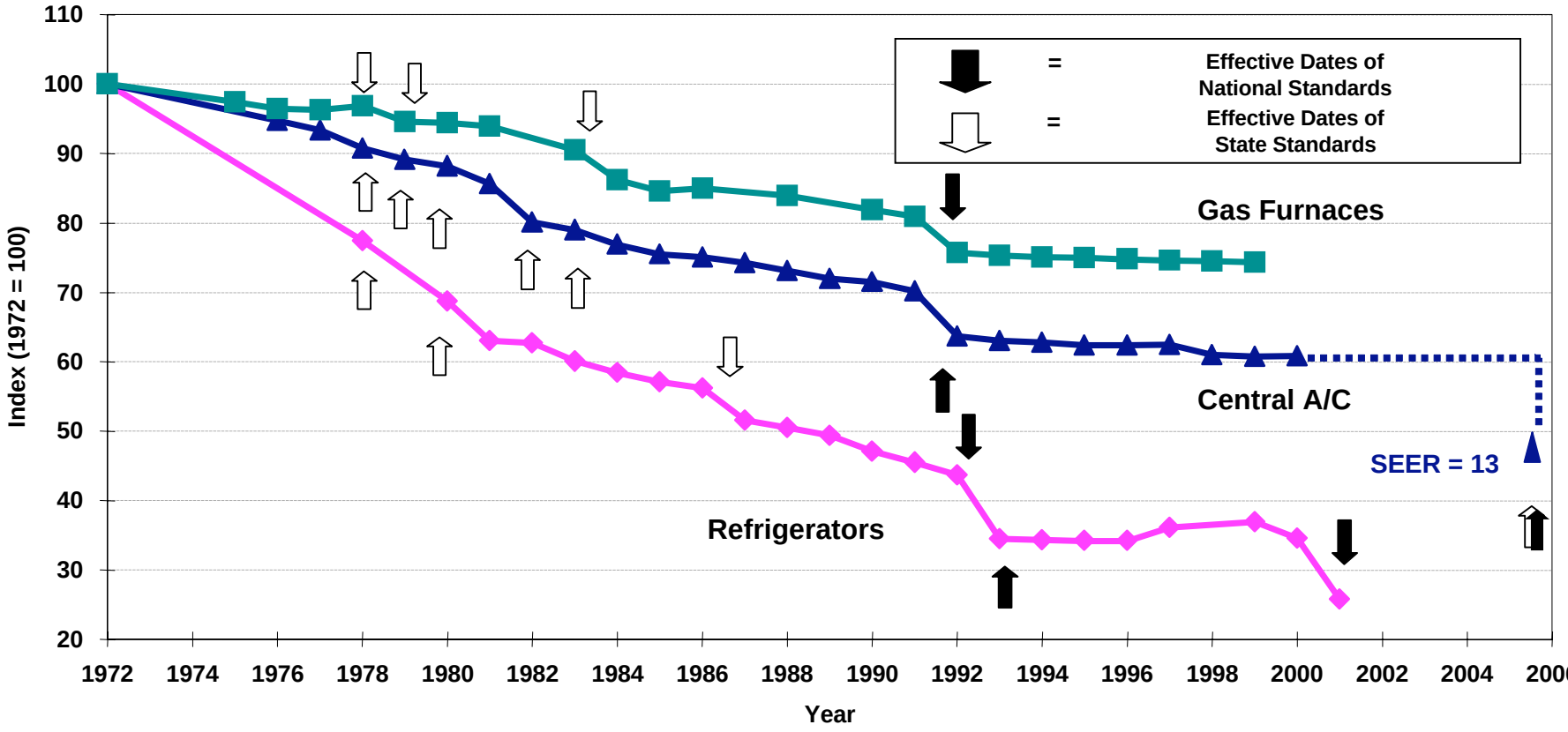
	Billion $
Space Heating	**40**
Air Conditioning	**30**
Refrigerators	**15**
Fluorescent Tube Lamps	**5**
Compact Floursecent Lamps	**5**
Total	**95**

- 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.


Per Capita Electricity Sales (not including self-generation)
(kWh/person) (2006 to 2008 are forecast data)
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
United States
California
2005 Differences
= 5,300kWh/yr
= $165/capita
Per Capita Income in Constant 2000 $
1975
2005
% change
US GDP/capita 16,241 31,442 94%
Cal GSP/capita 18,760 33,536 79%


Per Capita Electricity Sales (not including self-generation)
(kWh/person) (2006 to 2008 are forecast data)
kWh/person
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
United States
California
France
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008

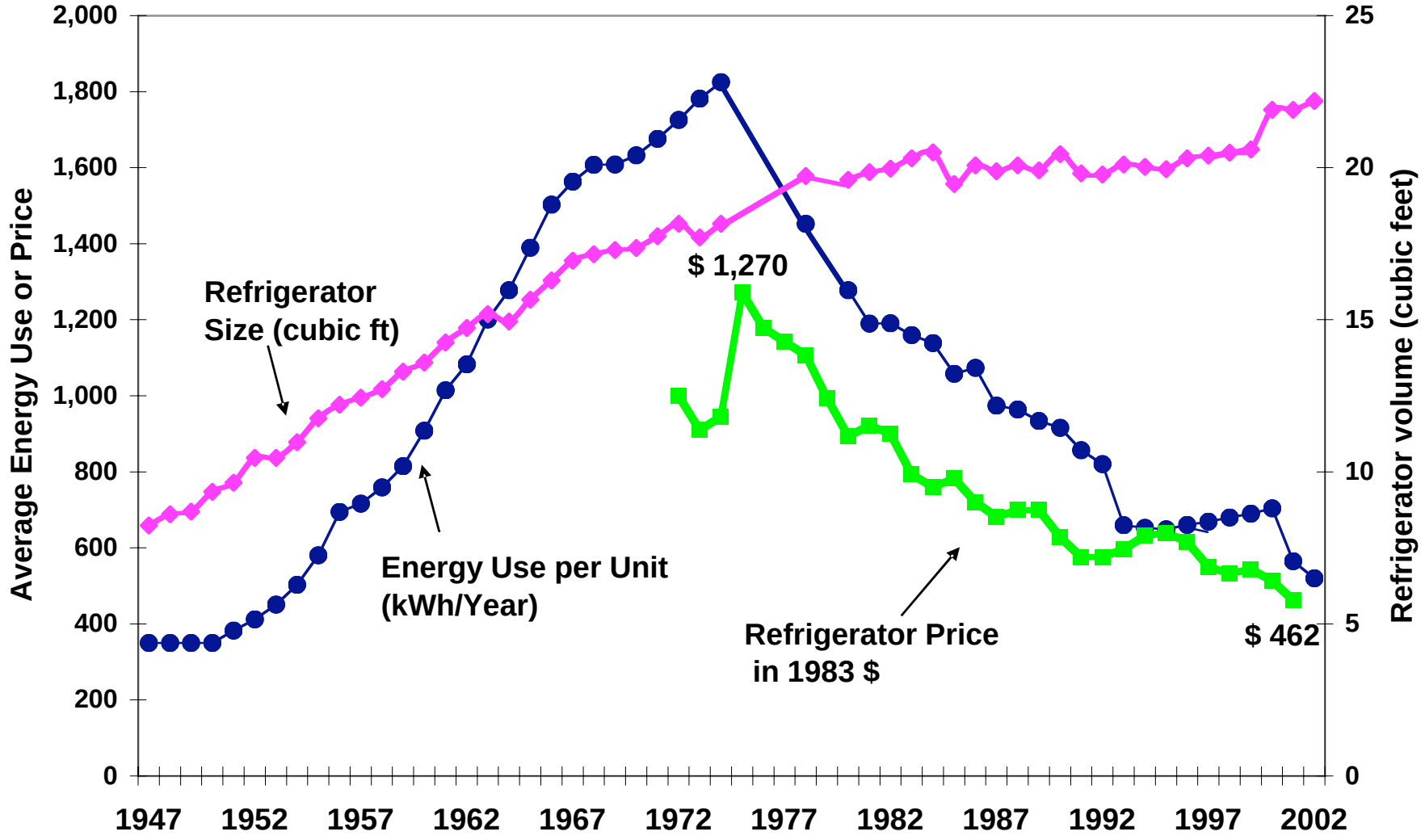
Impact of Standards on Efficiency of 3 Appliances



Source: S. Nadel, ACEEE,

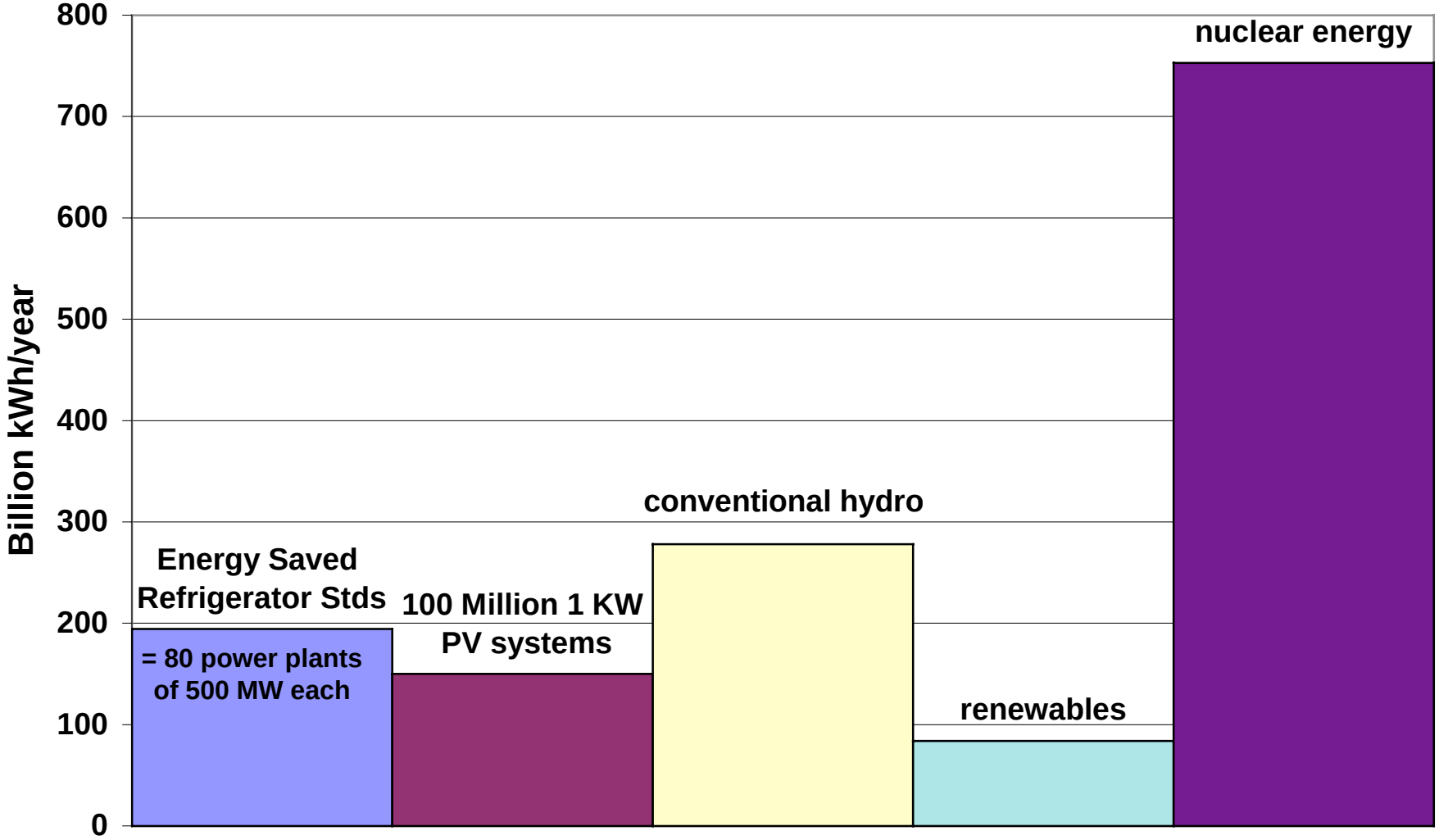
in ECEEE 2003 Summer Study, www.eceee.org

New United States Refrigerator Use v. Time and Retail Prices



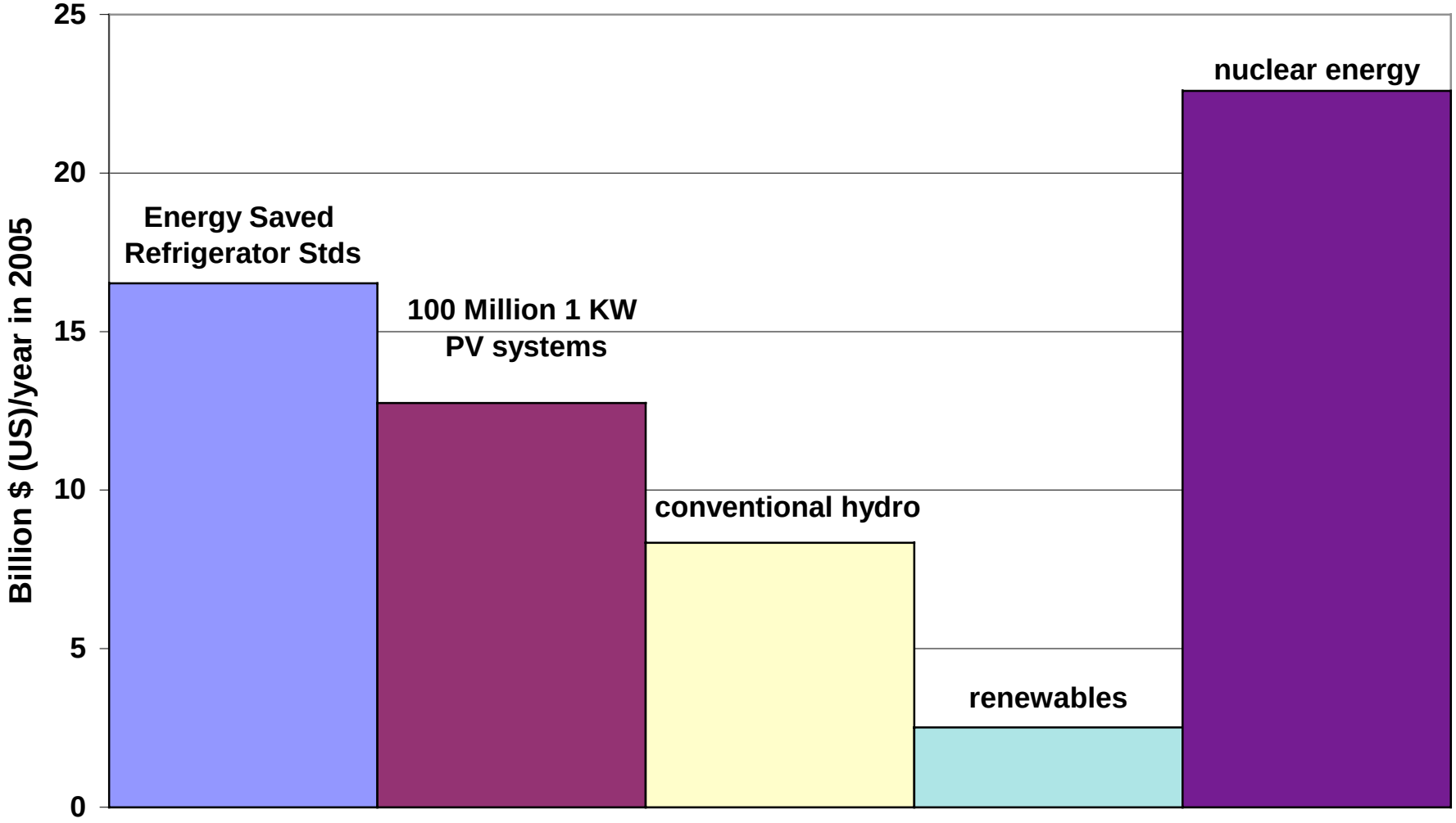
Source: David Goldstein

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



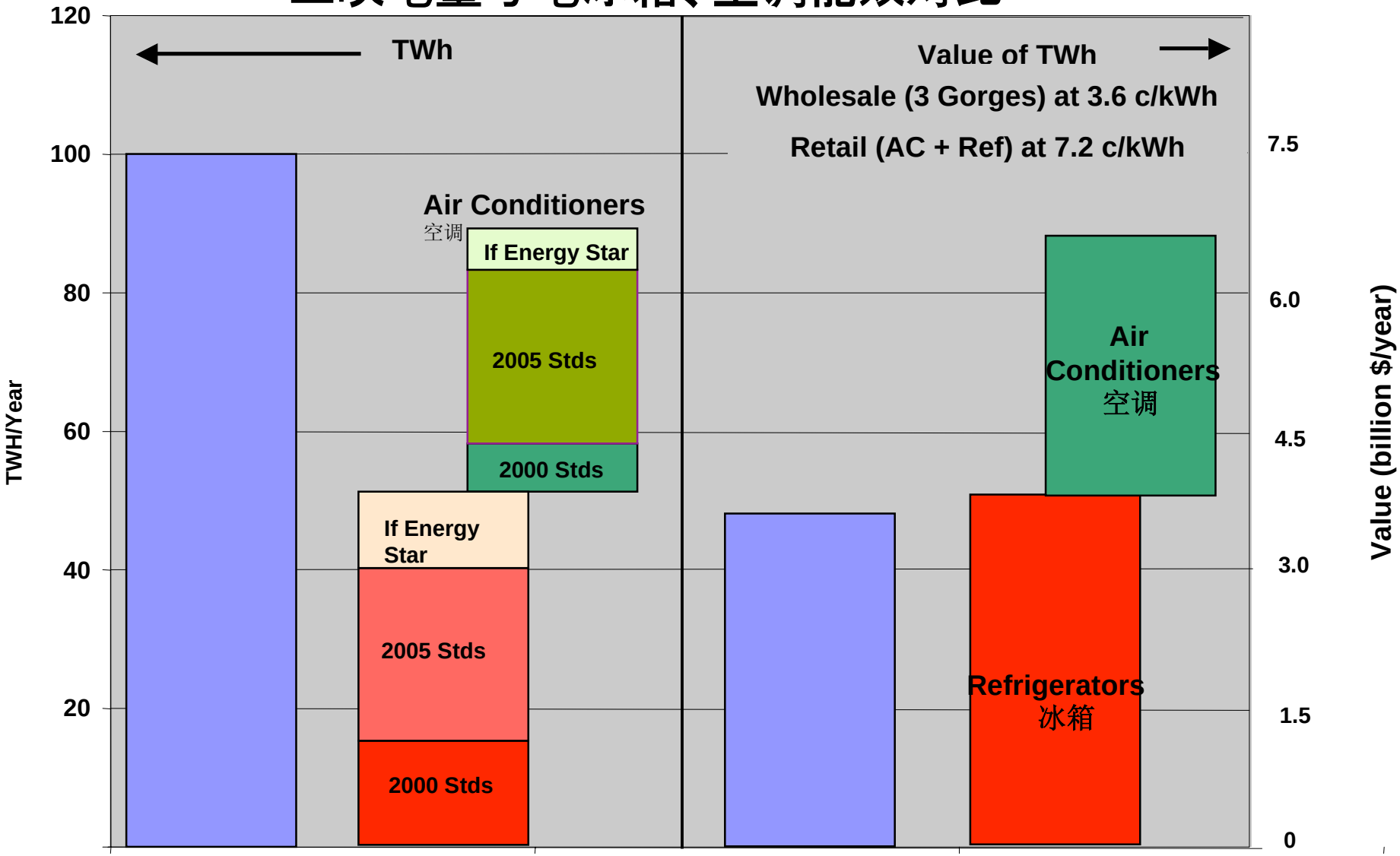
In the United States

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)



Comparison of 3 Gorges to Refrigerator and AC Efficiency Improvements

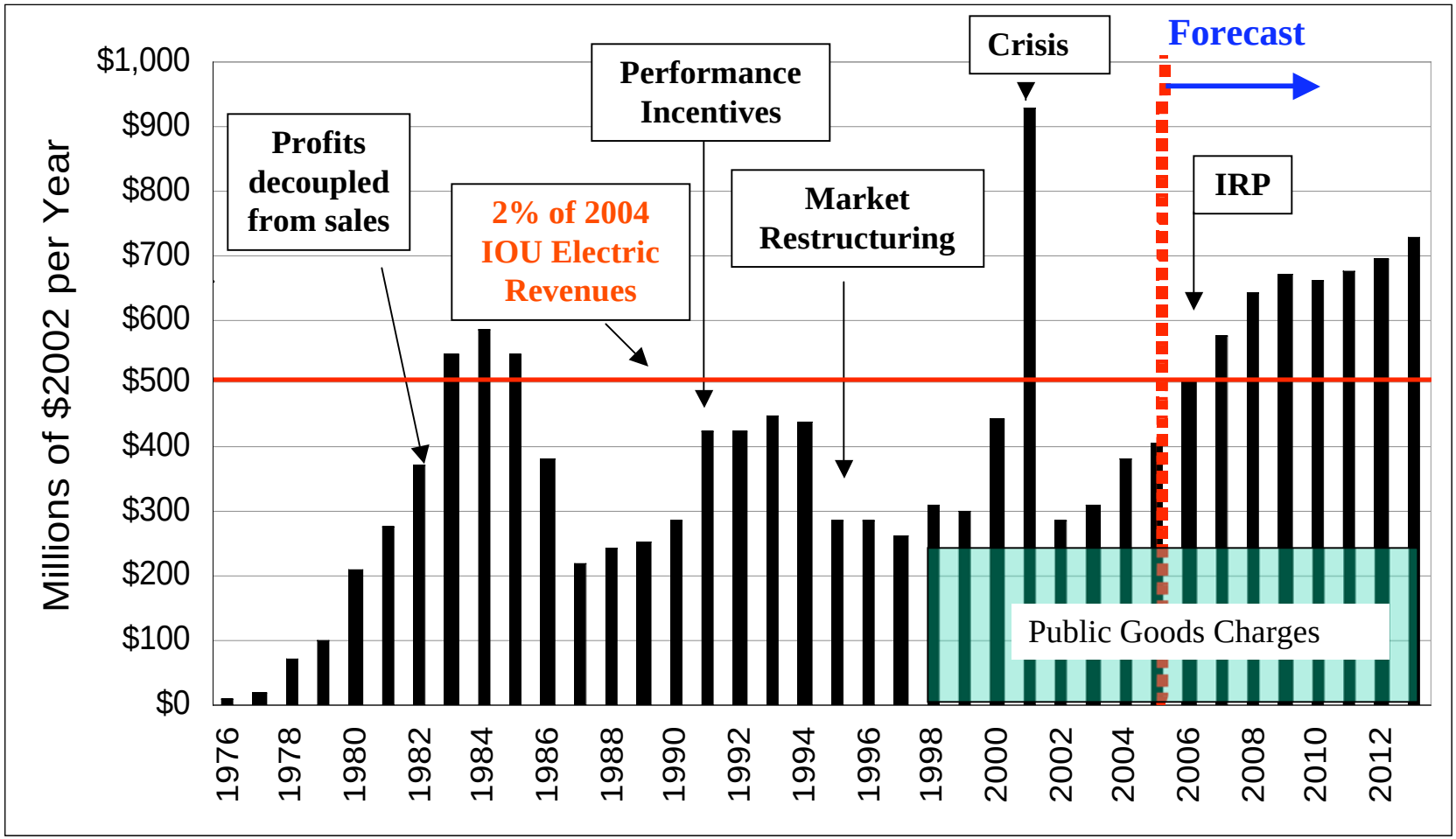
三峡电量与电冰箱、空调能效对比



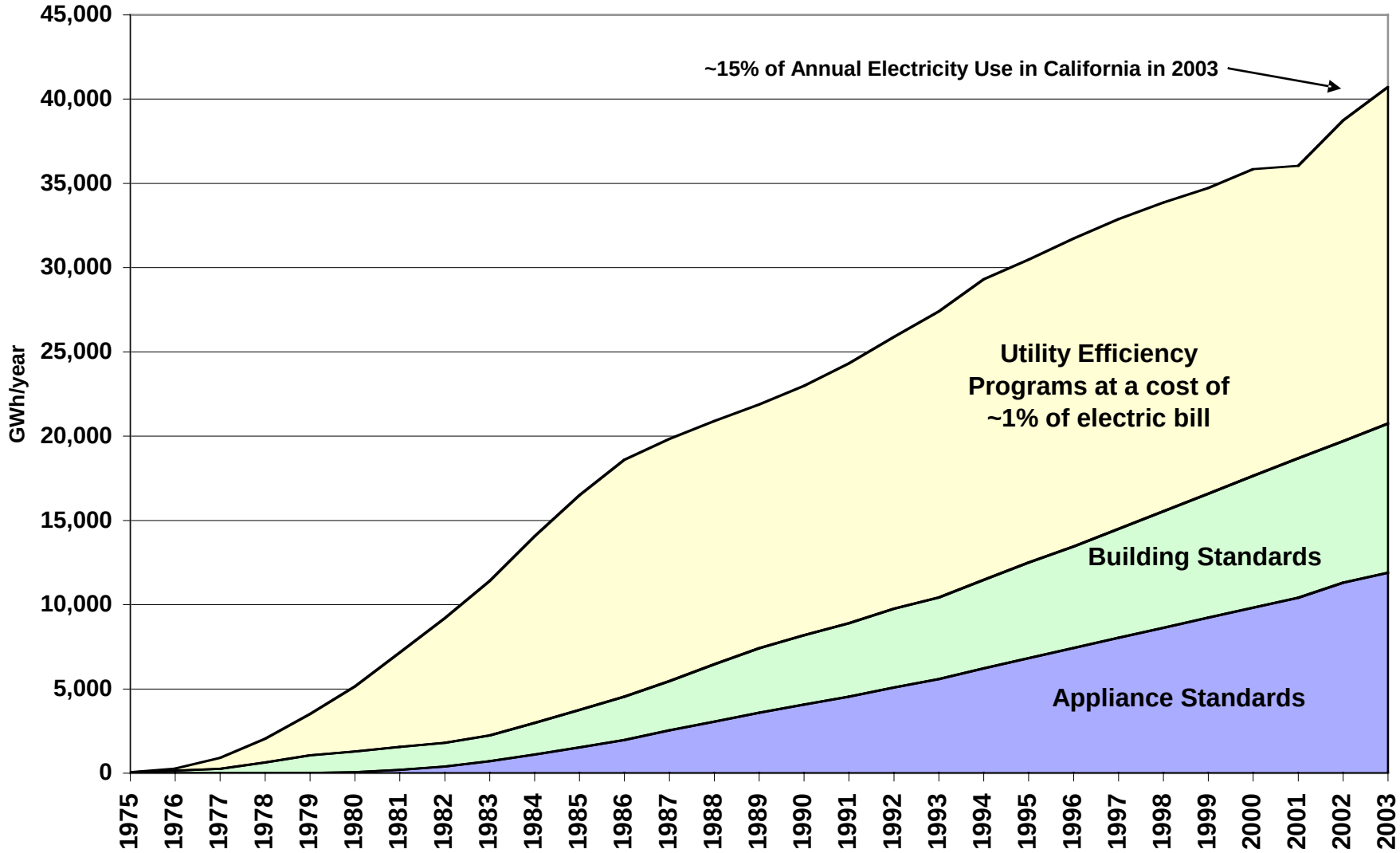
Savings calculated 10 years after standard takes effect. Calculations provided by David Fridley, LBNL

标准生效后，10年节约电量

California IOU's Investment in Energy Efficiency



Annual Energy Savings from Efficiency Programs and Standards

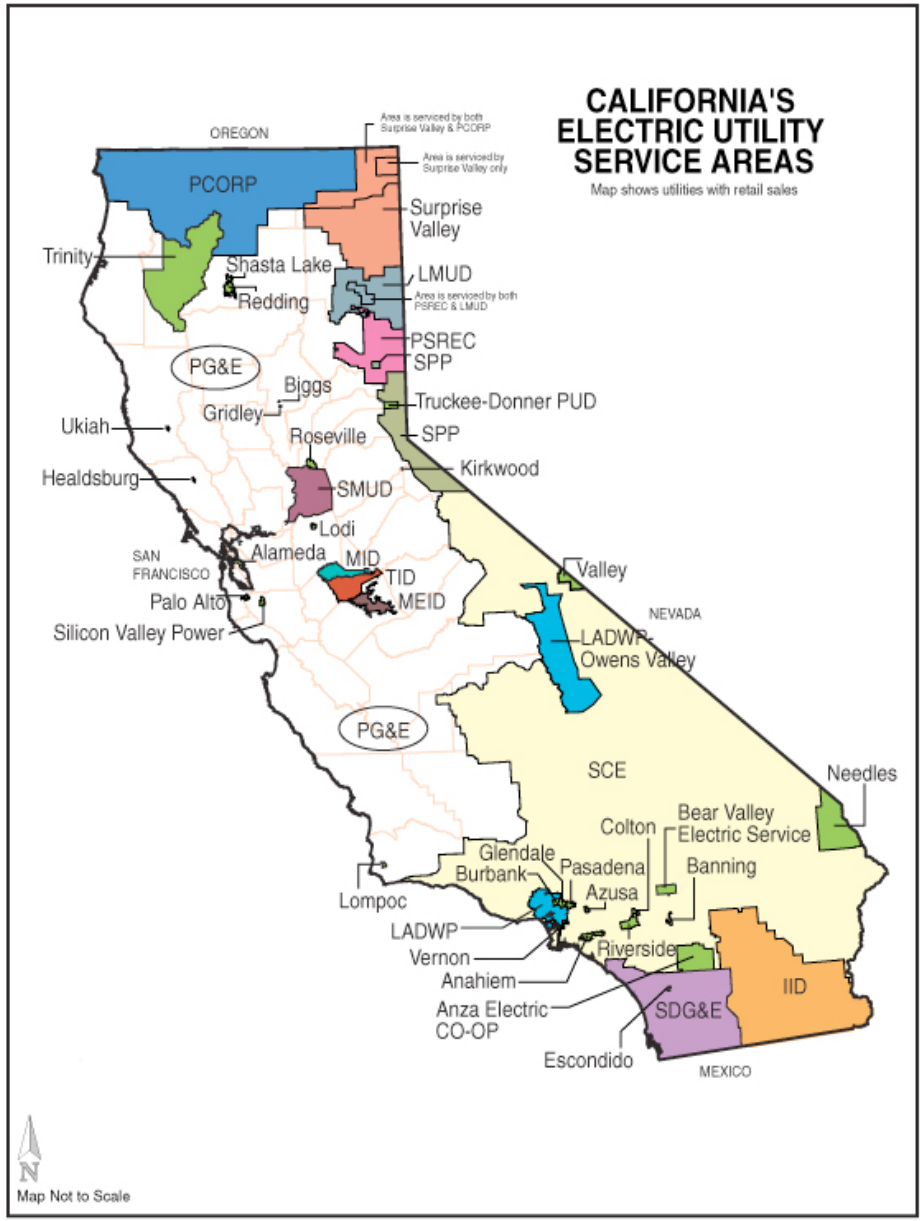


Conclusions Part 1

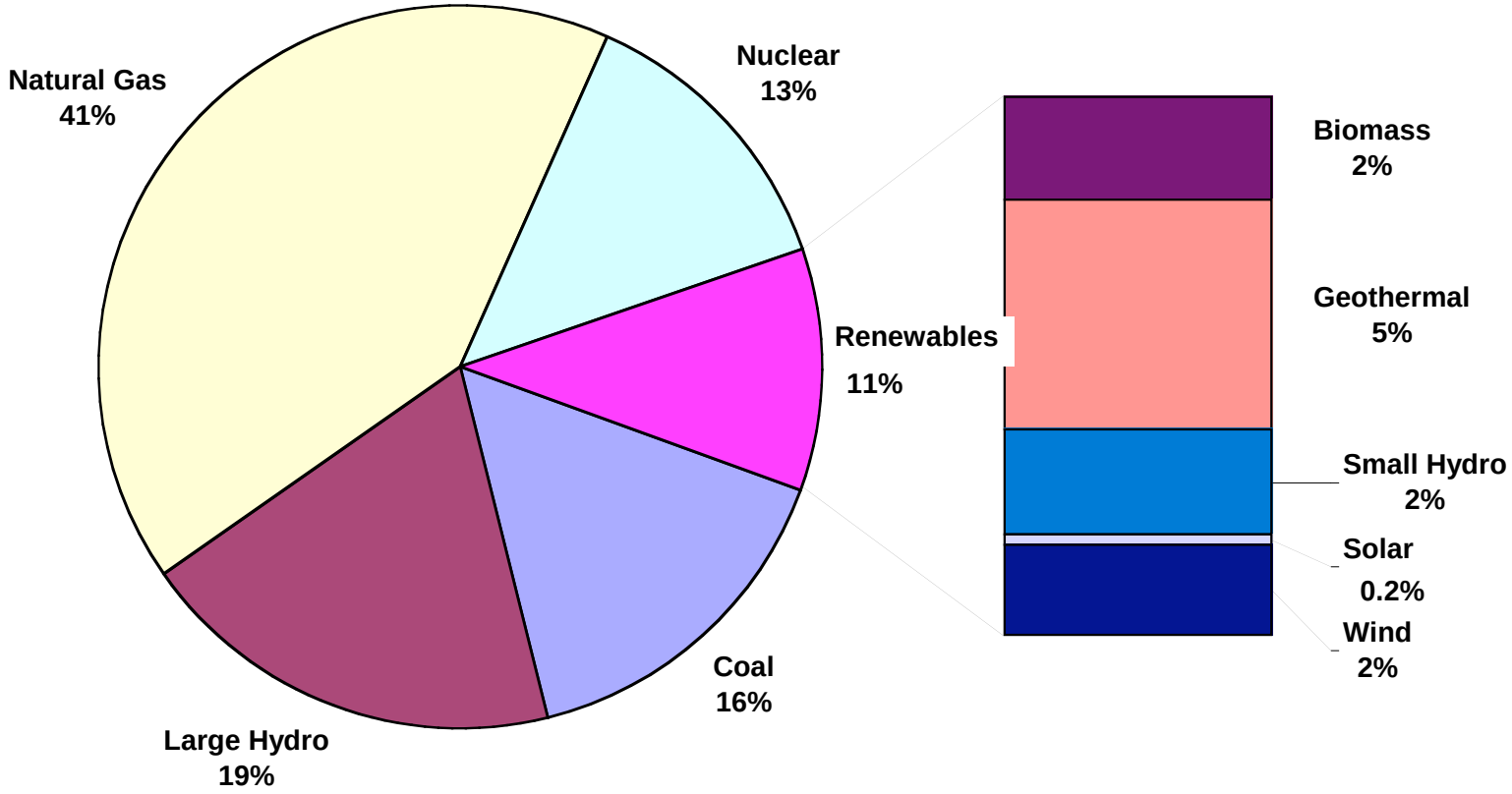
- Efficiency improvements were the cornerstone of our previous efforts
- These improvements were achieved in a number of ways:
  - Some simply in response to the increasing cost of energy
  - Much in response to specific policies and programs
- Consistent leadership and funding were important components of these efforts
  - For example, California decided early to focus on customer **bills** and not necessarily on the price per kWh.

Part 2 – What's Underway

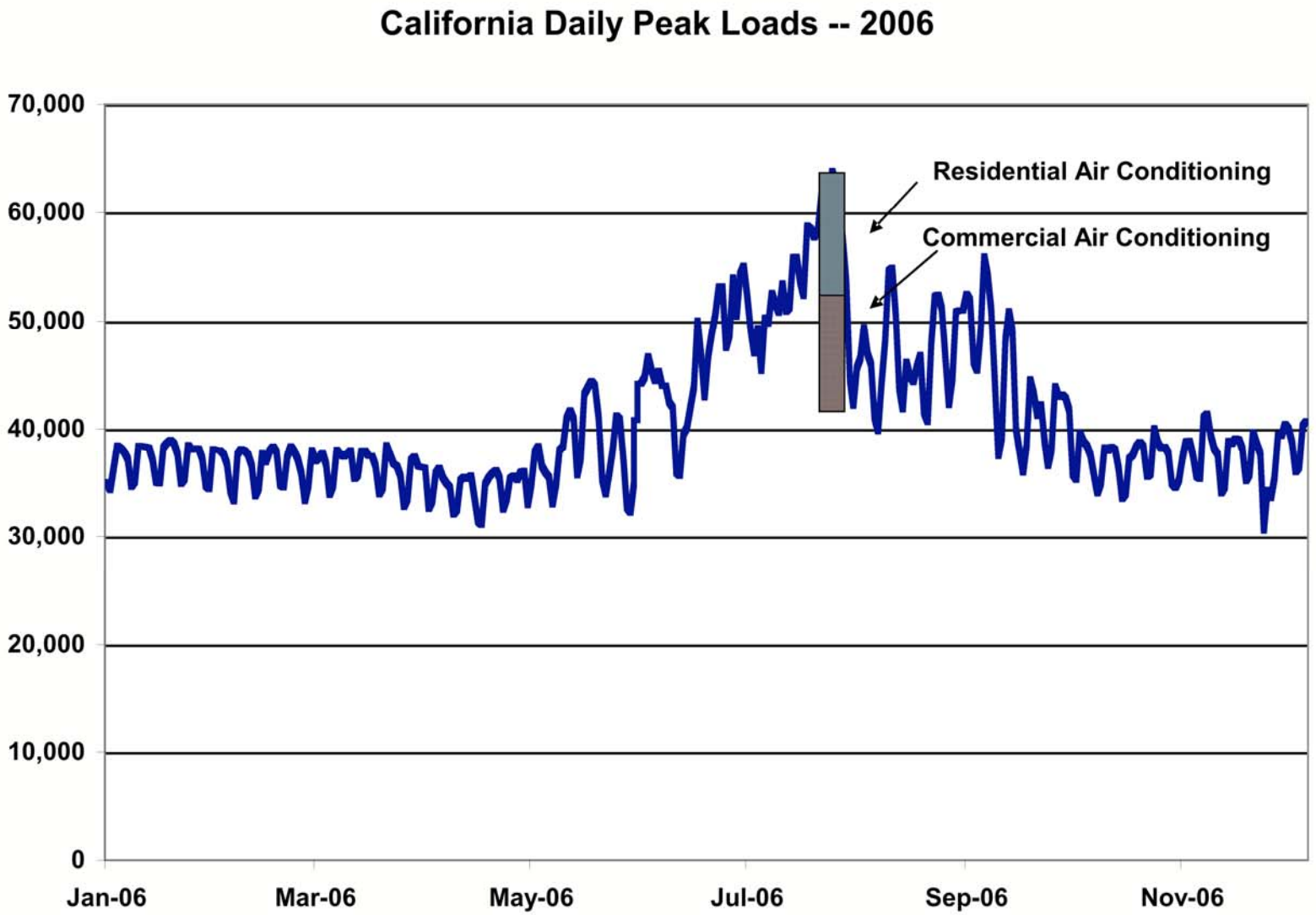
- Multiple Utility Service Territories:
  75% Investor Owned (regulated by CPUC
  25% Municipal
- 2006 Peak Demand:
  64,000 MW
- 2006 Electricity Use:
  275,000 GWH
- Population: *35 million,*
  1.5% per year growth
- Electricity growth for
  last decade:
  1.6% per year



California Generation Mix 2006 -- Total Generation of 295,000 GWH
(includes imports from outside California that account for 28% of total)



California is VERY MUCH a Summer Peaking Area



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, including renewable Distributed Generation (smaller resources generally located closer to load centers)
- 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

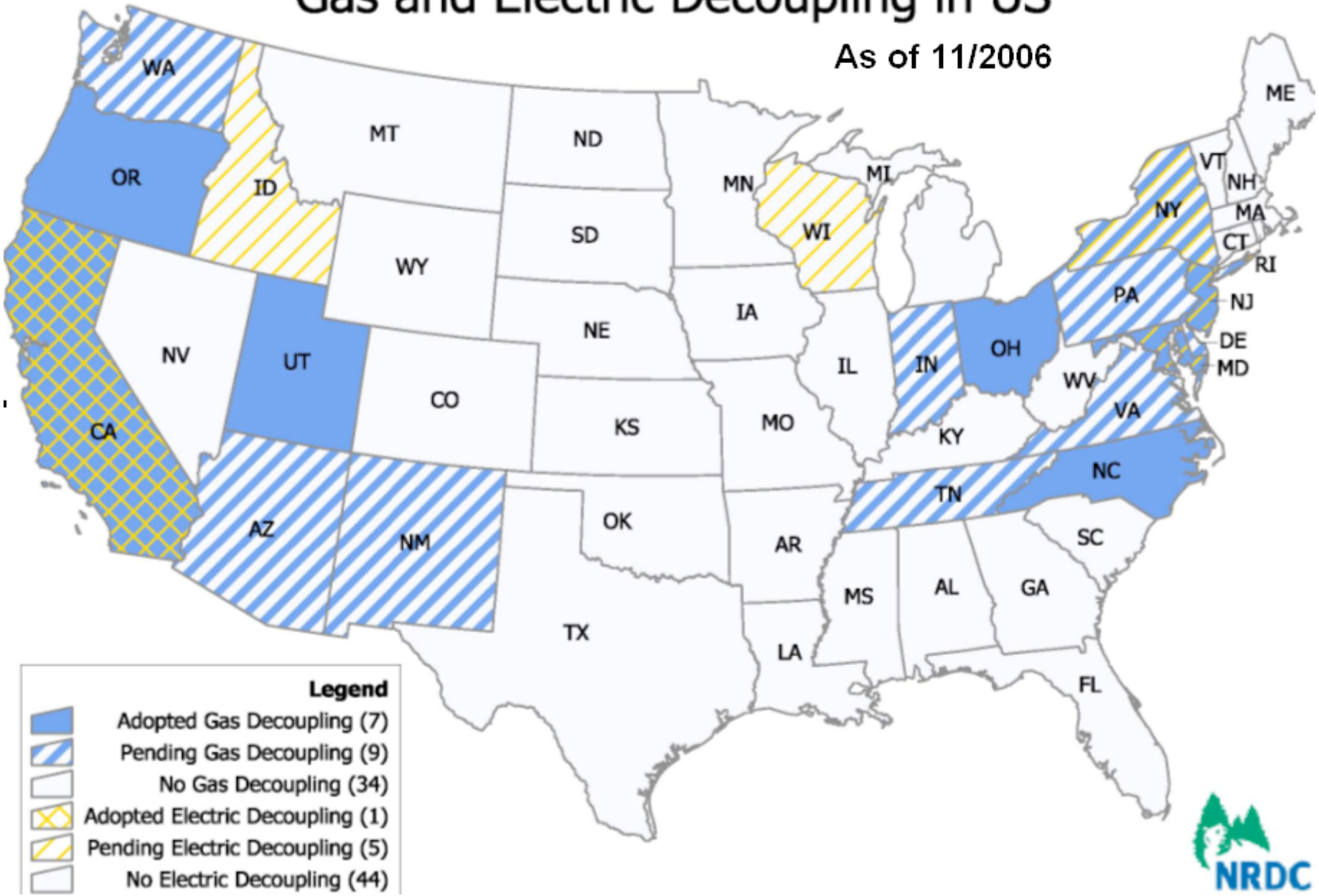
General Picture of Funding for Energy Efficiency and Renewables

- PIER (Public Interest Energy Research) at **$80** Million per year
  - 50% on efficiency and 50% for renewables and clean generation
- Public Goods Charge (Investor Owned Utilities)
  - **$250** Million for energy efficiency
  - Another **$500** Million from utility procurement budgets
  - Goal of 2,500 GWH per year (~ 1% of sales)
  - Or about $.03 US per kwh saved (assuming 10 year life of savings)
- Total Annual Budget for Efficiency = **~$800 Million per year**
- Renewable Portfolio Standard Expenses currently are small
  - Wind, Geothermal, and Biomass are competitive with current natural gas prices
  - "Million Solar Roof" (California Solar Initiative) will cost

  ~$300 million per year (more on this later in talk)
- Consistent with the State's Energy Action Plan: Efficiency First.

Gas and Electric Decoupling in US

As of 11/2006



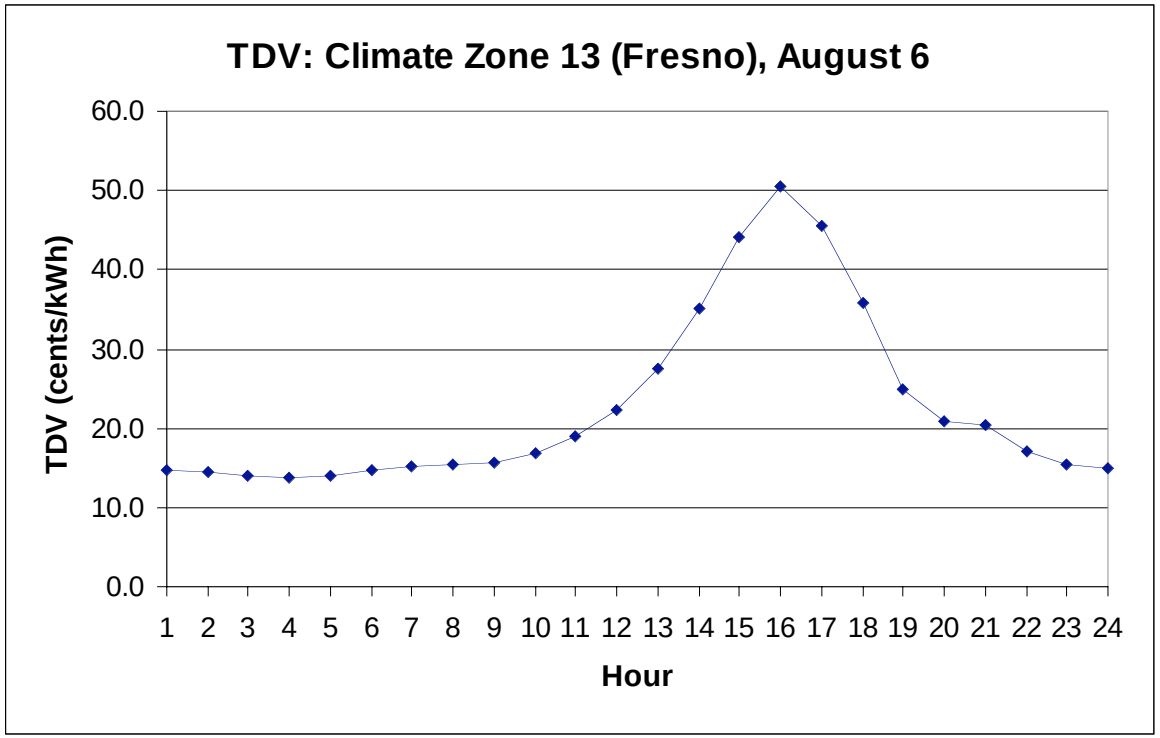
NRDC

Decoupling of profits from sales, and Decoupling Plus

- Decoupling of profits from sales was the first step, 1982.
- Now, the California Public Utilities Commission is adding financial incentives for energy efficiency savings. **“Decoupling Plus”**
  - Details are still being discussed
  - Generally, if savings goals are met or exceeded utilities will earn additional money for their shareholders
  - We are attempting to provide additional motivation for energy efficient investments and savings

Time dependent valuation (TDV) prices are also used to calculate bills

- TDV prices are incorporated into California appliance standards (Title 20) and building standards (Title 24)
- TDV prices, or avoided costs, are independent of the idiosyncrasies of utility tariffs
- TDV prices incent efficient air conditioners



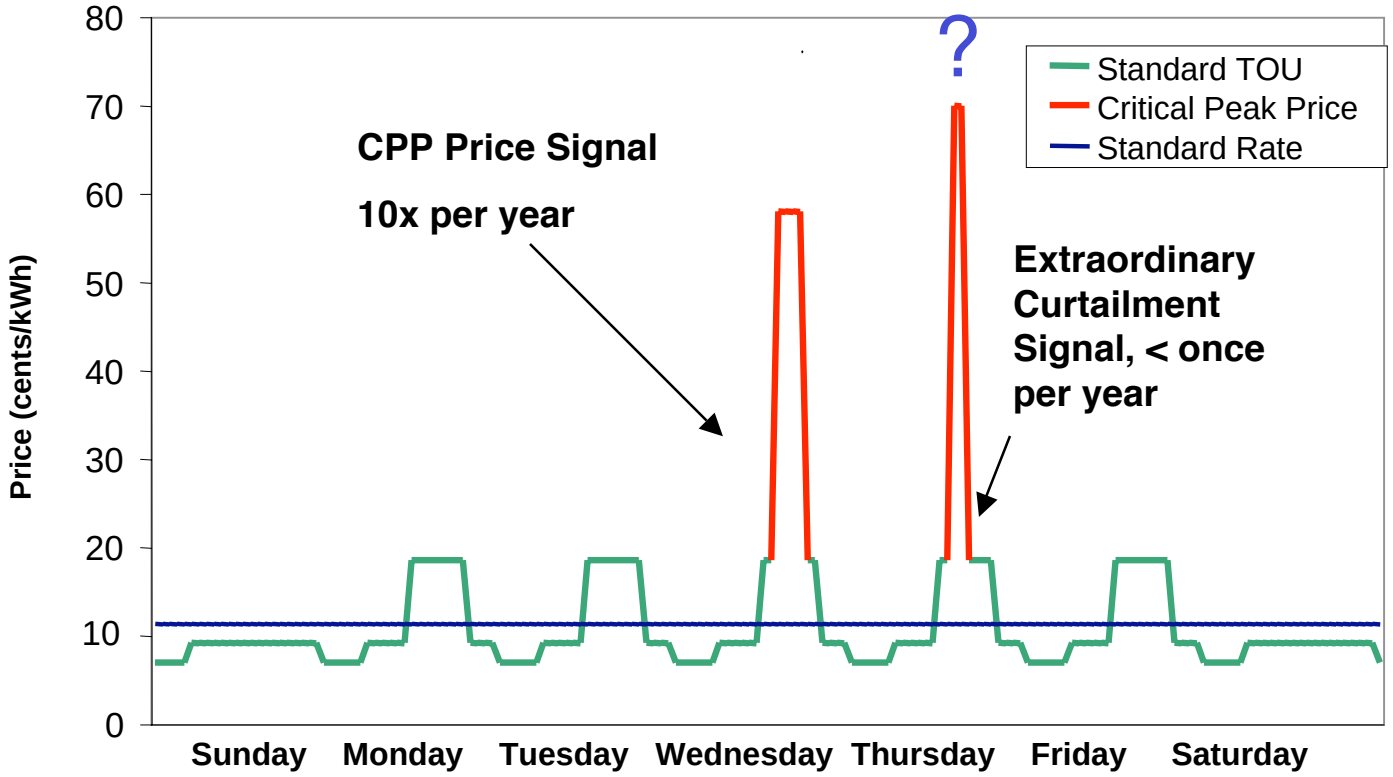
Demand Response and Advanced Metering Infrastructure

- Began 6 years ago during California electricity crisis
  - All large customers (>200kW) received digital meters and were required to move to Time-of-Use rates
- In 2003, we established a Goal of 5% price responsive demand by 2007
- We have been testing the demand response of "CPP" (Critical Peak Pricing, which is the California version of French "Tempo")
- Results for residential customers
  - 12% reduction when faced with critical peak prices and no technology
  - 30% to 40% reduction for customers with air conditioning, technology, and a critical peak price.
- For larger customers, the Demand Response Research Center at Lawrence Berkeley National Lab has been testing Automated Demand Response with the same type of "CPP" tariff
  - Customer Response in the range of 12% during events
  - And response is "pre-programmed" and can be automatic
    - Highly customer specific (process load, lighting, HVAC)

Critical Peak Pricing (CPP)
with additional curtailment option

Potential Annual Customer Savings:

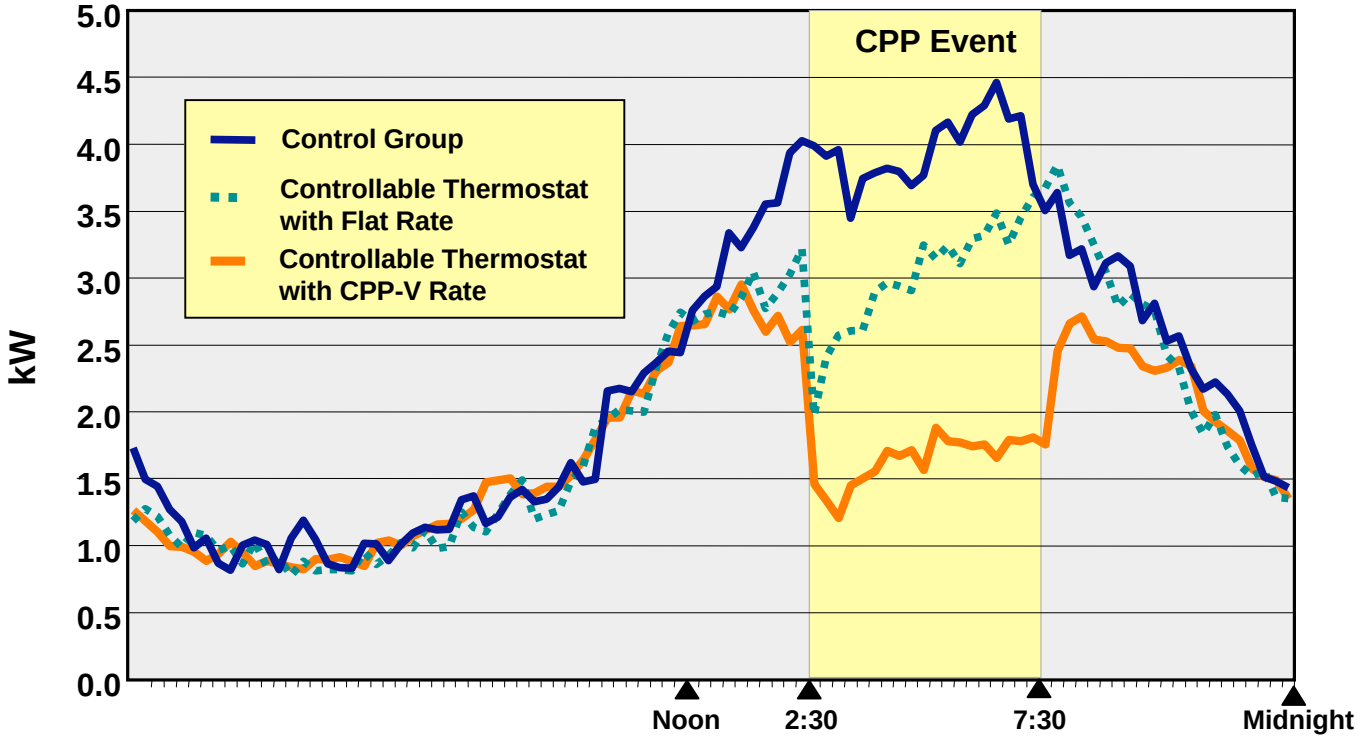
10 afternoons x 4 hours x 1kw = 40 kWh at 70 cents/kWh = ~$30/year



CPP rates – Load Impacts

Residential Response on a typical hot day
Control vs. Flat rate vs. CPP-V Rate

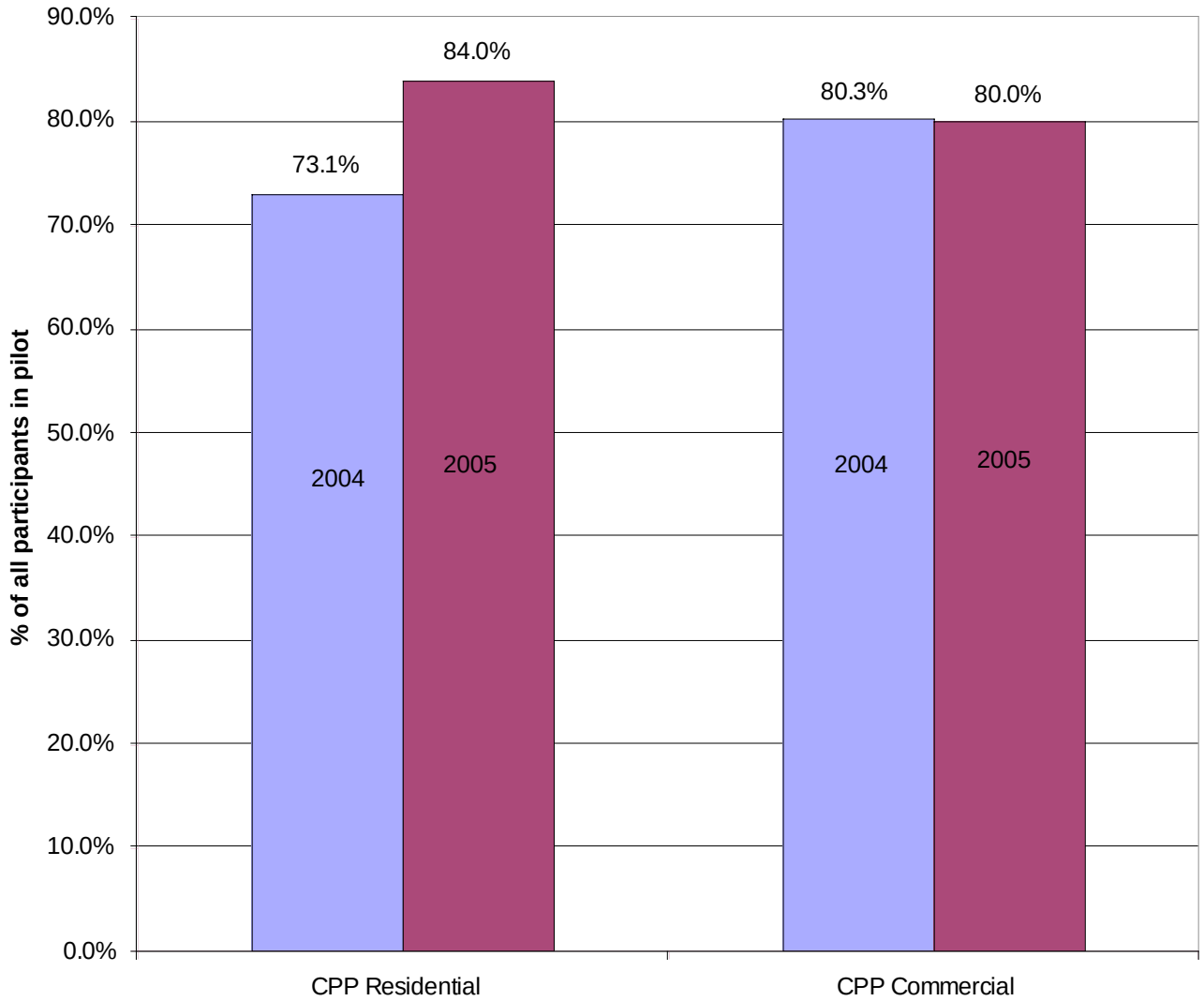
(Hot Day, August 15, 2003, Average Peak Temperature 88.5^0)



Most customers (~ 80%) Saved Money and Most (~60%) thought all customers should be offered this type of rate.

Source: Response of Residential Customers to Critical Peak Pricing and Time-of-Use Rates during the Summer of 2003, September 13, 2004, CEC Report.

Fraction of Customers on CPP Rates with Lower bills in 2004 and 2005- Residential and Small Commercial



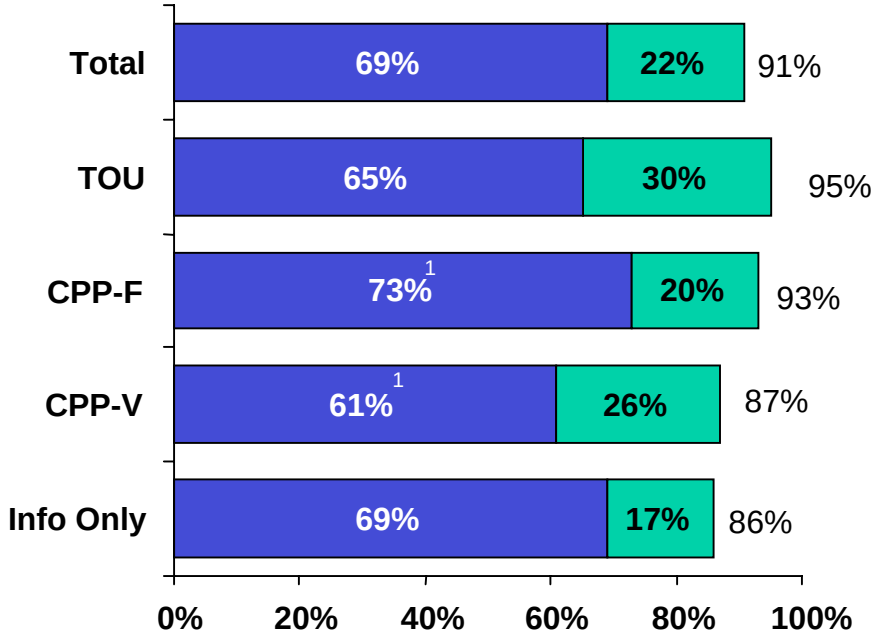
Average residential savings= $38/year

Average small commercial savings-$1300/yr

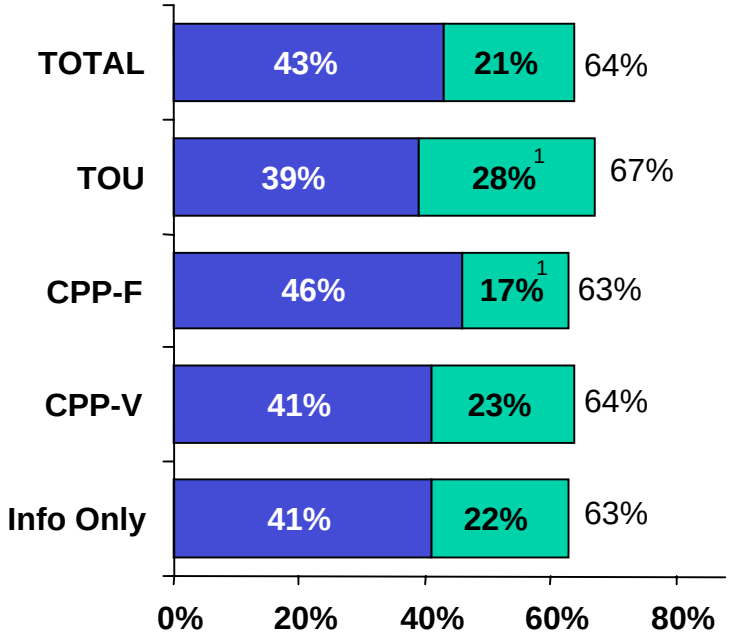
Customer Acceptance of CPP rates

Residential participants express a strong interest in having dynamic rates offered to all customers.

Should dynamic rates be offered to all customers?



Should all customers be placed on a dynamic rate and given an option to switch to another rate?

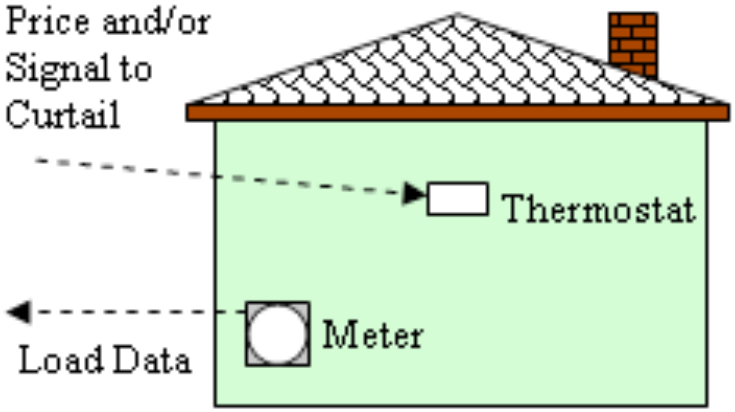


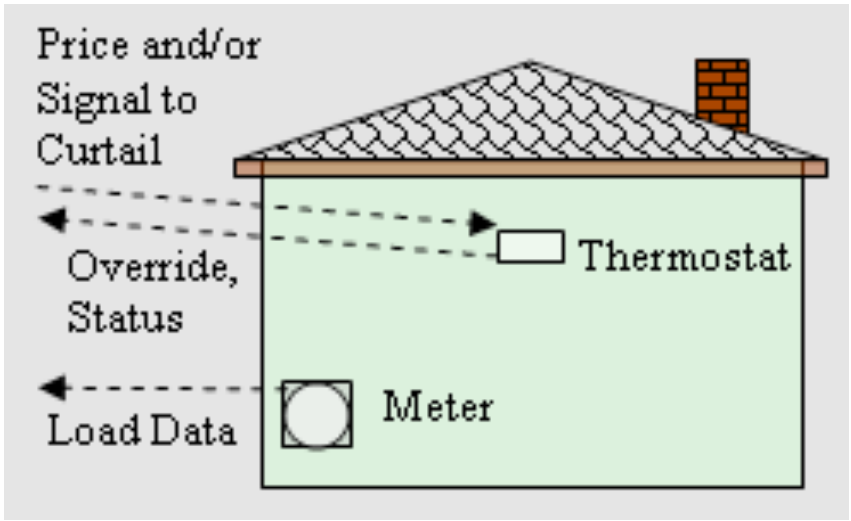
Source: Statewide Pricing Pilot: End-of-Pilot Customer Assessment, December 2004, Momentum Market Intelligence.

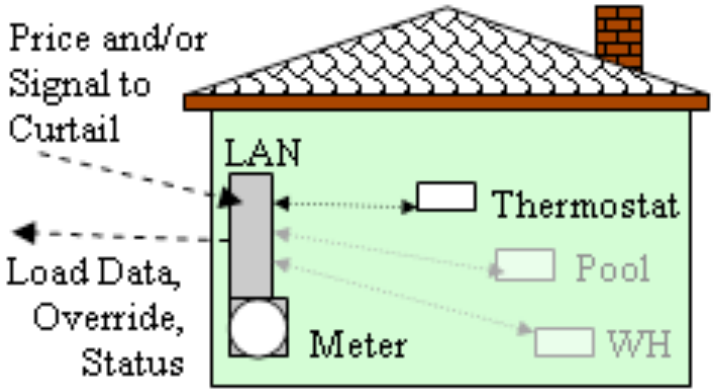
Three Necessary Components for Demand Response and Utility Modernization

- Advanced Metering Infrastructure
  - Digital meters with communication
- Dynamic Tariffs
  - Enable customers to be able to respond to hourly prices
  - The structure of these tariffs is critically important as customers are hoping to reduce total energy costs
- Automated Response Technology at customer locations
  - Programmable Communicating Thermostats (PCTs)
    - Enable residential and small commercial customers to respond to price automatically
    - Larger customers with energy management systems linked to pricing signals over the internet or through other communication channels
- And, when coupled with energy efficiency programs and policies the result can be reduction in total consumption as well as peak period consumption
- However, there has been considerable discussion and many meetings to design a statewide PCT and get PCTs adopted into the CEC building standards (see next slide)

Just some of the proposed systems for PCTs and demand response in the residential and small commercial/industrial sectors.







Current Status

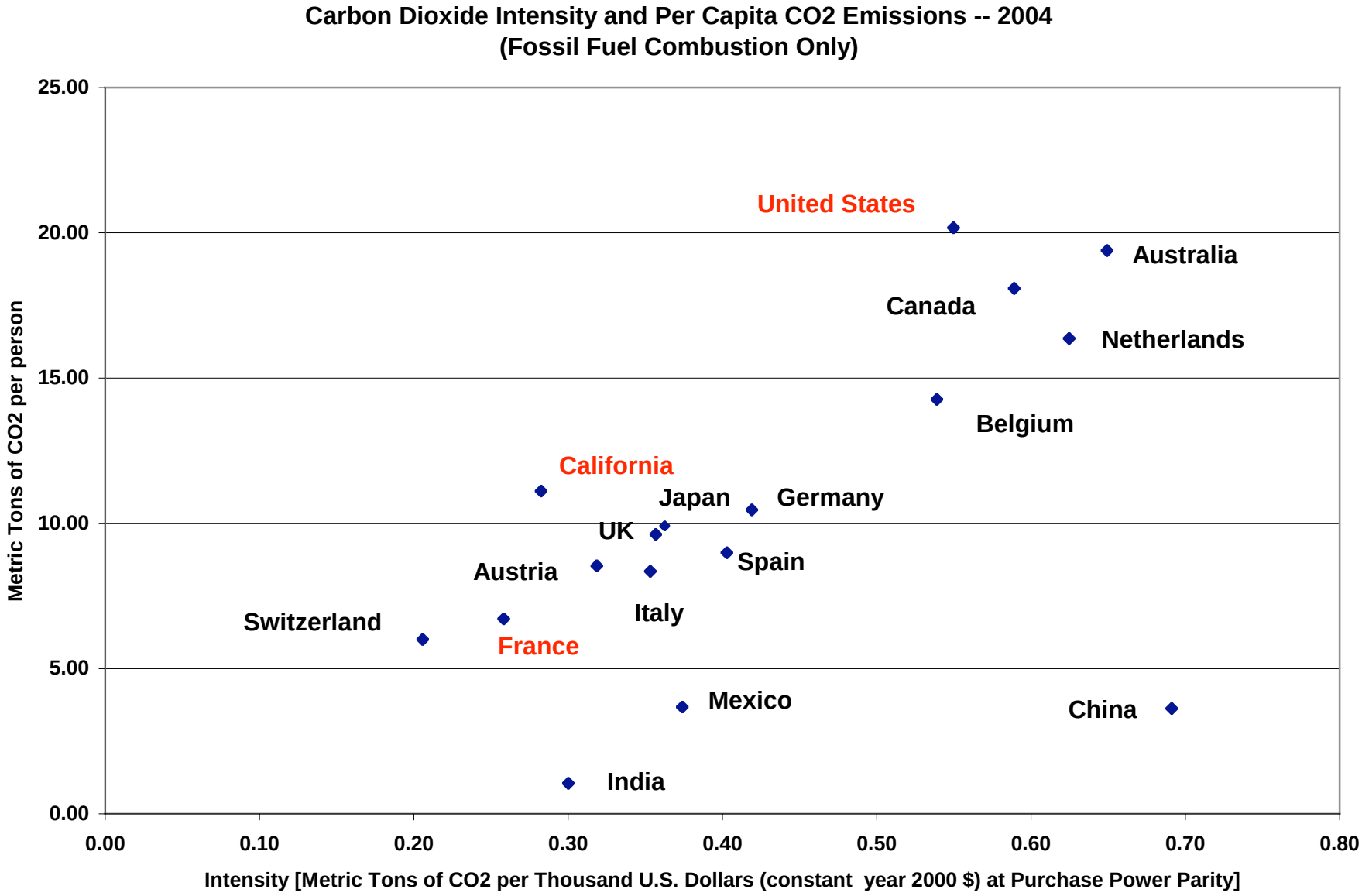
- PG&E is installing advanced meters and SDG&E begins soon; SCE will apply soon.
  - Digital with minimum 1 hour time recording of consumption
  - Communications to utility companies
  - Most of the economic benefits expected to be due to reductions in utility costs and improvements in service
  - Also benefits from Demand Response – both economic response to dynamic prices and emergency response if needed
- Incorporating Programmable Communicating Thermostats “PCTs” into California’s Building Standards
  - Many issues dealing with design and communications have taken considerable effort to resolve
- Considerable effort underway to establish protocols and systems for communications between utility and customers to enable home gateways

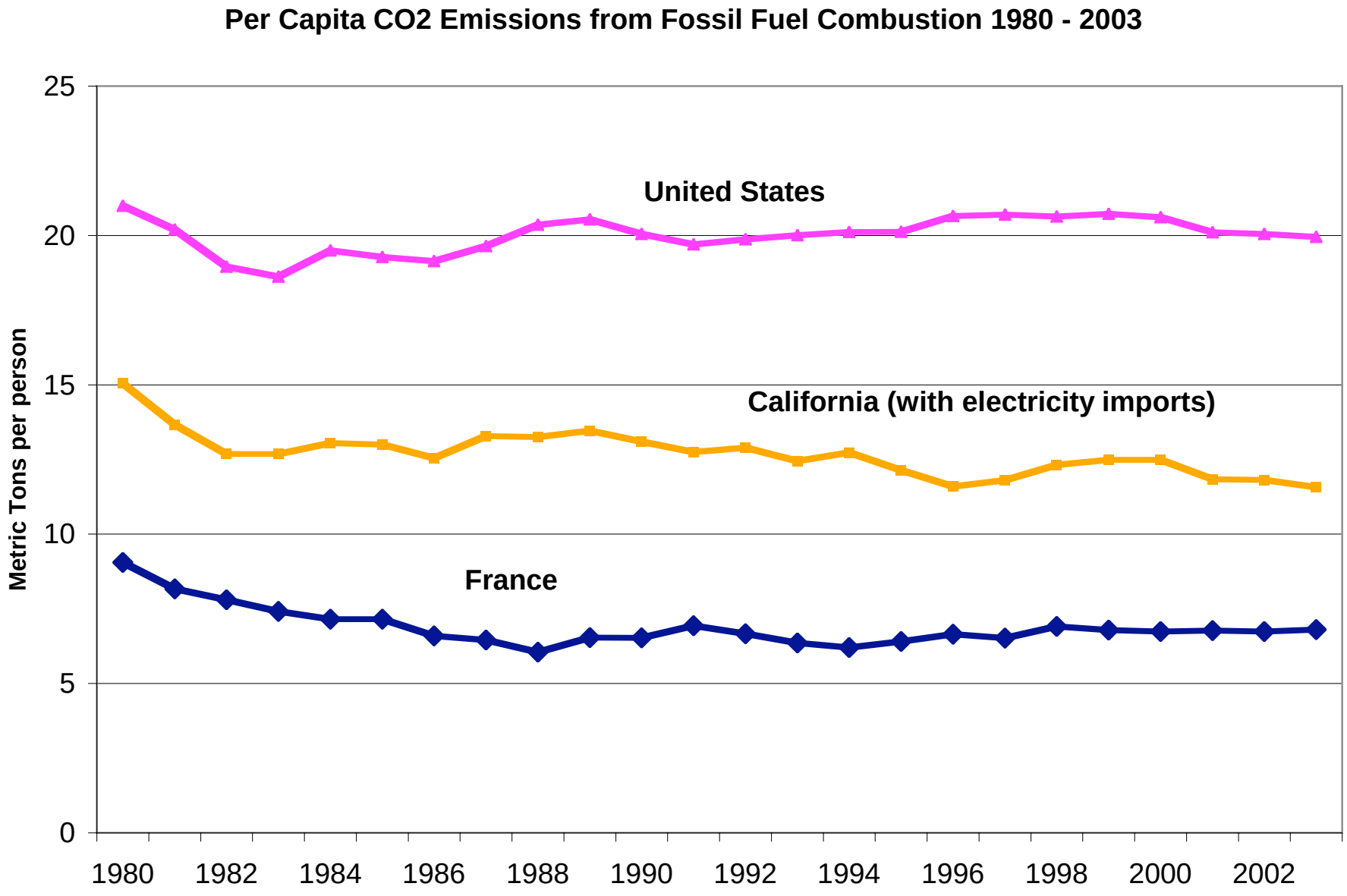
Conclusions Part 2

- California has established specific policies on its resource preferences
  - This provides direction to all its energy agencies
- We are increasing energy efficiency funding and setting specific goals
- And trying to put in place the necessary components for price-sensitive demand response
  - However, we still are struggling with how to make this appealing from the perspective of the customer
  - Demand response plus improved energy efficiency may be the solution we are looking for.

Part 3 States Attempt To Take Charge: Global Warming and Cool Communities

For utilities climate change will be very important


Carbon Dioxide Intensity and Per Capita CO2 Emissions -- 2004
(Fossil Fuel Combustion Only)
Metric Tons of CO2 per person
25.00
20.00
15.00
10.00
5.00
0.00
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
Intensity [Metric Tons of CO2 per Thousand U.S. Dollars (constant year 2000 $) at Purchase Power Parity]
United States
Australia
Canada
Netherlands
Belgium
California
Japan
Germany
UK
Spain
Austria
Italy
Switzerland
France
Mexico
China
India


Per Capita CO2 Emissions from Fossil Fuel Combustion 1980 - 2003
Metric Tons per person
25
20
15
10
5
0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
United States
California (with electricity imports)
France

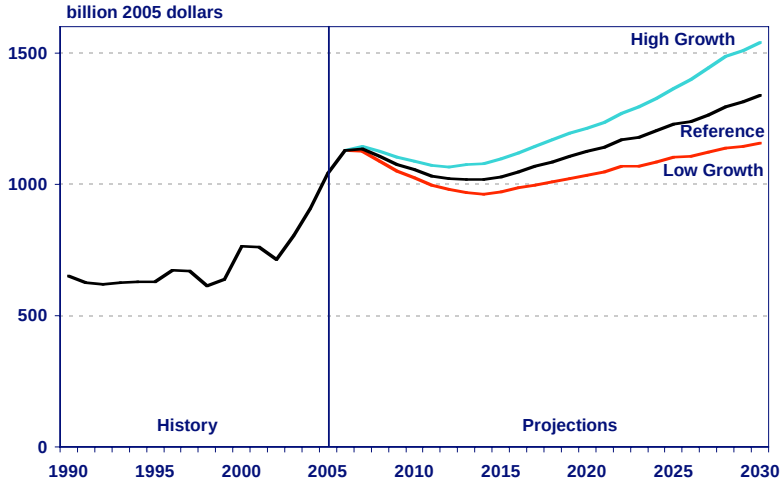

The Economist
Shake-up in Big Pharma
China's space blast
Europe's rotating slump
Serbia's encouraging election
Hating Hillary Clinton
The greening of America

Why even more energy efficiency now?

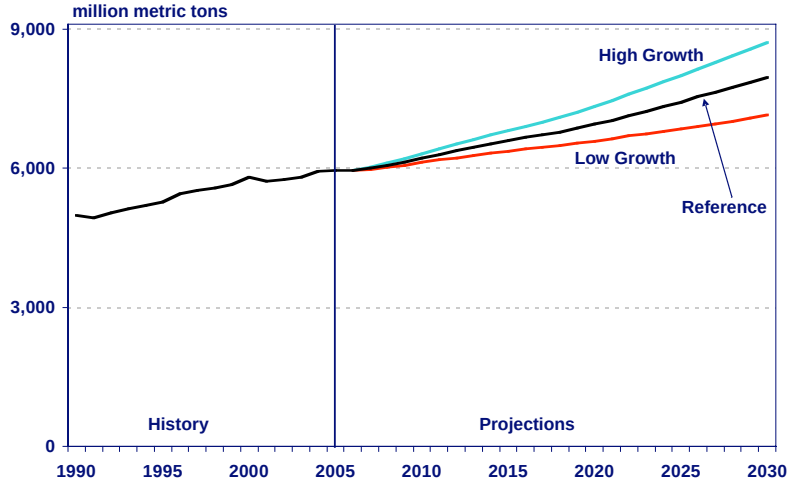
- Possibly a profound long-term change in the energy prices

- Greenhouse Gas Emissions are clearly rising in US
- Vast improvements in control technologies at much less cost

Energy Expenditures in the U.S. Economy, 1990-2030

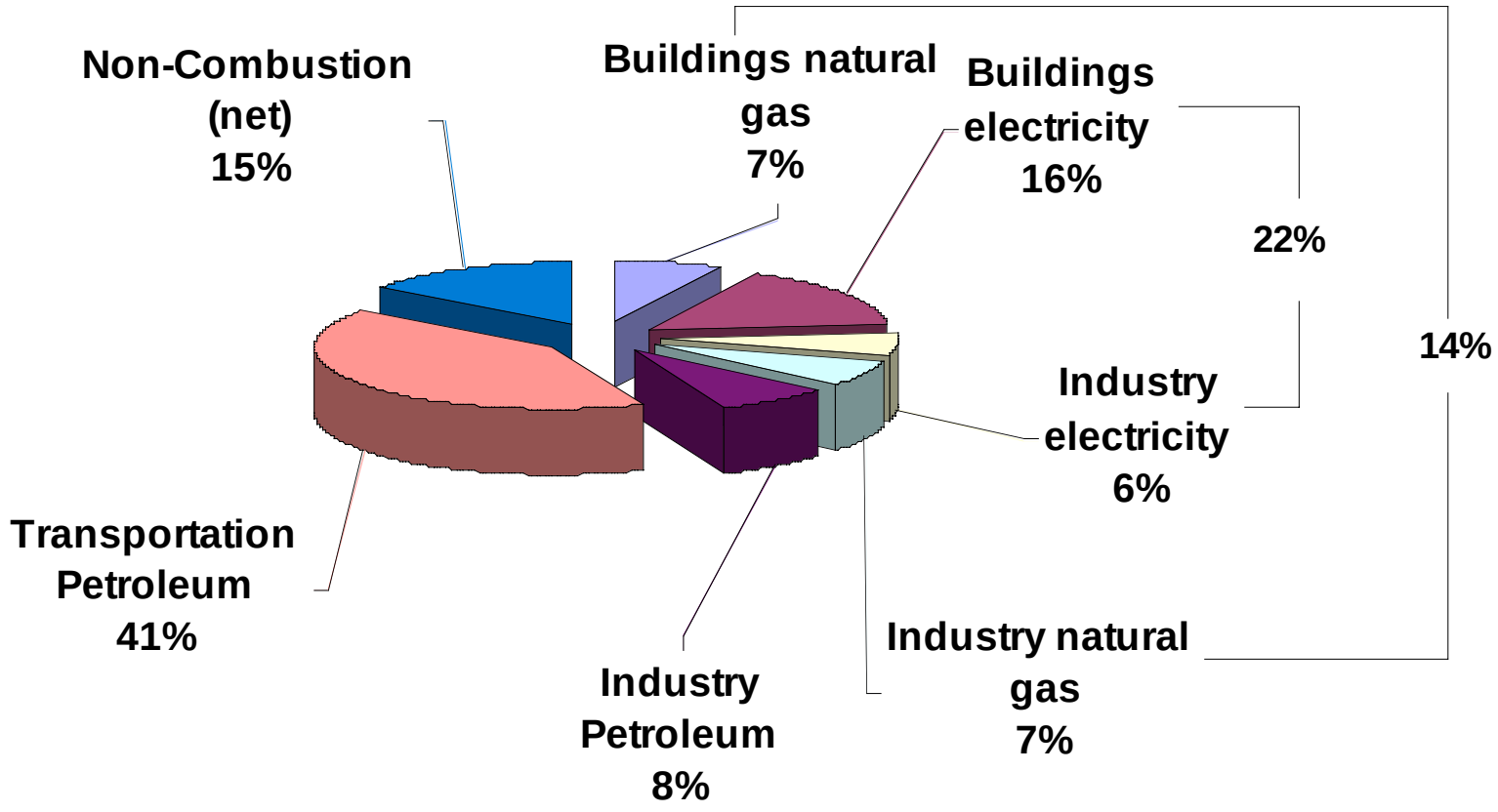


Carbon Dioxide Emissions in Three Economic Growth Cases, 1990-2030



Emissions of CO2 in California by End Use in 2004

Total Emissions = 490 Million metric tons CO2 equivalent



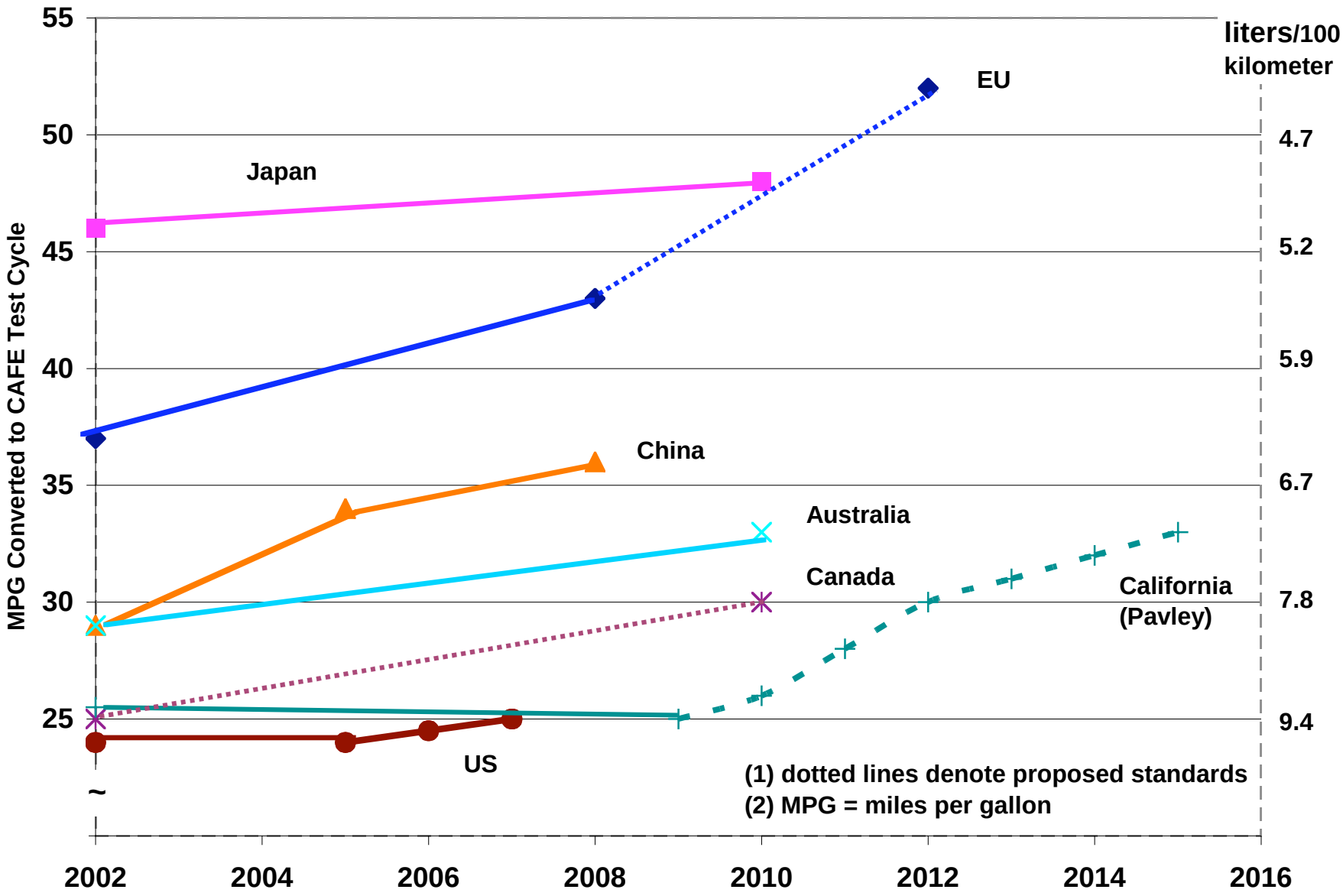
Governor Schwarzenegger's and California's Efforts

- June 2005 Executive Order on Climate Change
  - Reduce greenhouse gases:
    - to 2000 levels by 2010
    - to 1990 levels by 2020
    - to 80 percent below 1990 levels by 2050
- AB 32 – the Global Warming Solutions Act of 2006
  - Confirms the Governor's Executive Order
  - Adopt regulations to achieve maximum feasible and cost-effective GHG reductions
  - Adopt market mechanisms, such as cap and trade
  - Establish mandatory reporting of GHG emissions by major industries
  - Adopt a statewide GHG emissions limit for 2020 matching 1990 emissions
- www.ClimateChange.ca.gov

States vs. U.S. Federal Government

- Some Western and Northeastern states are trying to move forward to reduce Carbon emissions
- However, the U.S. Federal Government claims jurisdiction in such matters as appliance efficiency standards (certain appliances) and automotive efficiency standards
- In 2002, California passed legislation that would require improvements in auto efficiency – actually reductions in CO2 per kilometer driven
  - This is being challenged by automakers and the federal government
- More broadly, the Federal EPA had claimed the Clean Air Act did not authorize it to regulate CO2. However, the US Supreme Court (Massachusetts v. EPA) recently ruled that the EPA must reconsider this position

Comparison of Fuel Economy – Passenger Vehicles



Many Efforts in the Electricity Sector

- Of course, increased efficiency (details on next slide)
- Prohibition on Distribution Companies from signing long term contracts if source of power has CO2 emission rate greater than 0.5 metric tons per MWH.
  - Clearly with an aim to discourage new coal plants without sequestration
- Studying how to place a cap on distribution companies
  - Generation is controlled by non-utility sources and beyond jurisdiction of the California Public Utilities Commission
  - This pre-dated AB 32 and ultimate implementation not clear
- California Solar Roof Initiative
- Renewable portfolio requirements

California's Future Energy Efficiency Policies

- CEC building and appliance standards
  - 5% savings every three years
- Utility demand-side management programs
  - PUC decision: $6 billion over next 10 years
  - Reduce energy use 1%/yr, 10+% over 10 years
- Governor's Green Buildings Initiative
  - 20% reduction in commercial buildings by 2015
- Renewable energy
  - Renewable portfolio standard, 20% by 2010
- Improved lighting efficiency – more lumens per watt
- Longer term energy efficiency goals with financial rewards to utilities and secure funding for multiple years

California Solar Initiative :“Zero energy” new homes

- $ 3 Billion Dollars over 10 years
  - Current rebate of $2.80 per watt but tied to improved home efficiency for new homes
  - Goal of 3,000 MW within 10 years, mostly residential locations
- A 2 kW Alternating Current PV system on a home with a 3 kW central air conditioning on an annual basis

  7,500 kWh (typical new home in California)

  -3,000 kWh (PV output)

  4,500 kWh remaining load

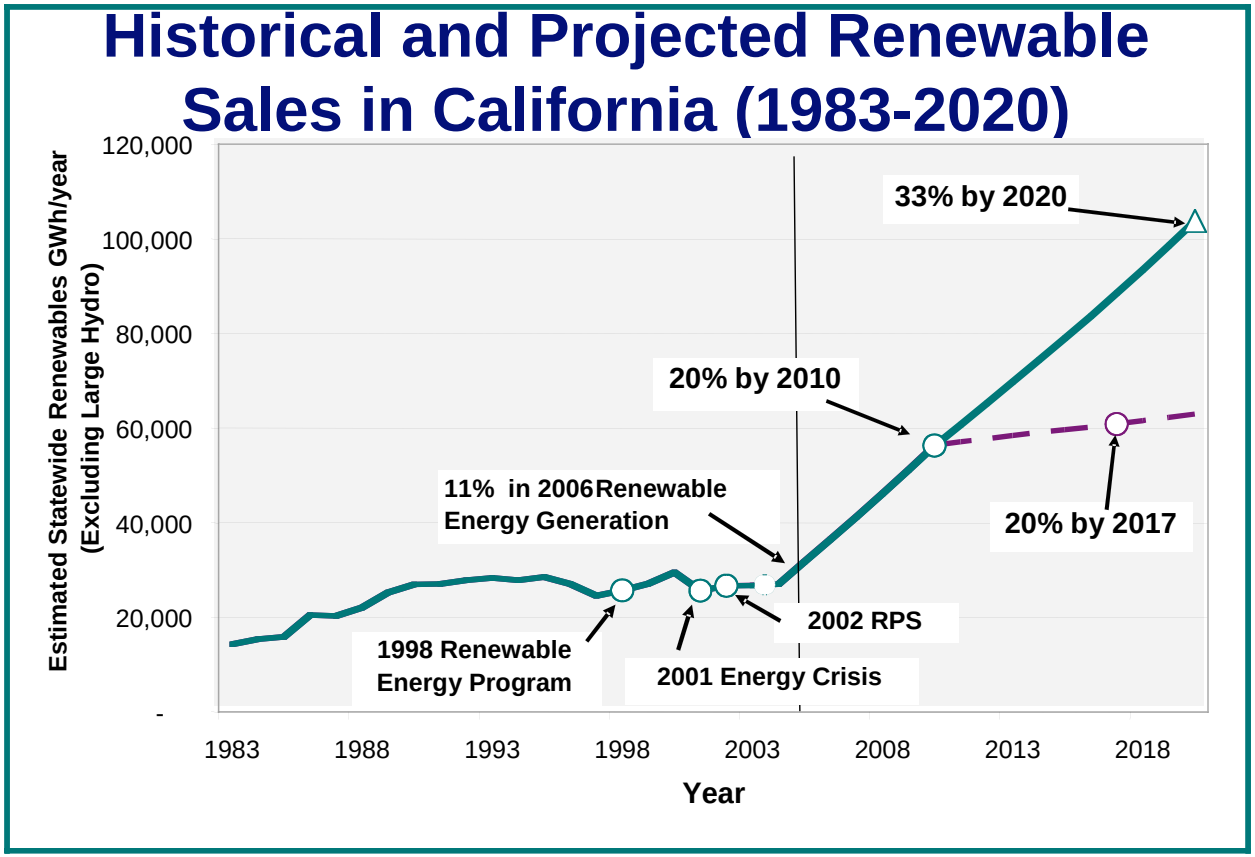
  -2,500 kWh reduction in load due to **extra energy efficiency**

  2,000 kWh (Net purchase of utility energy)

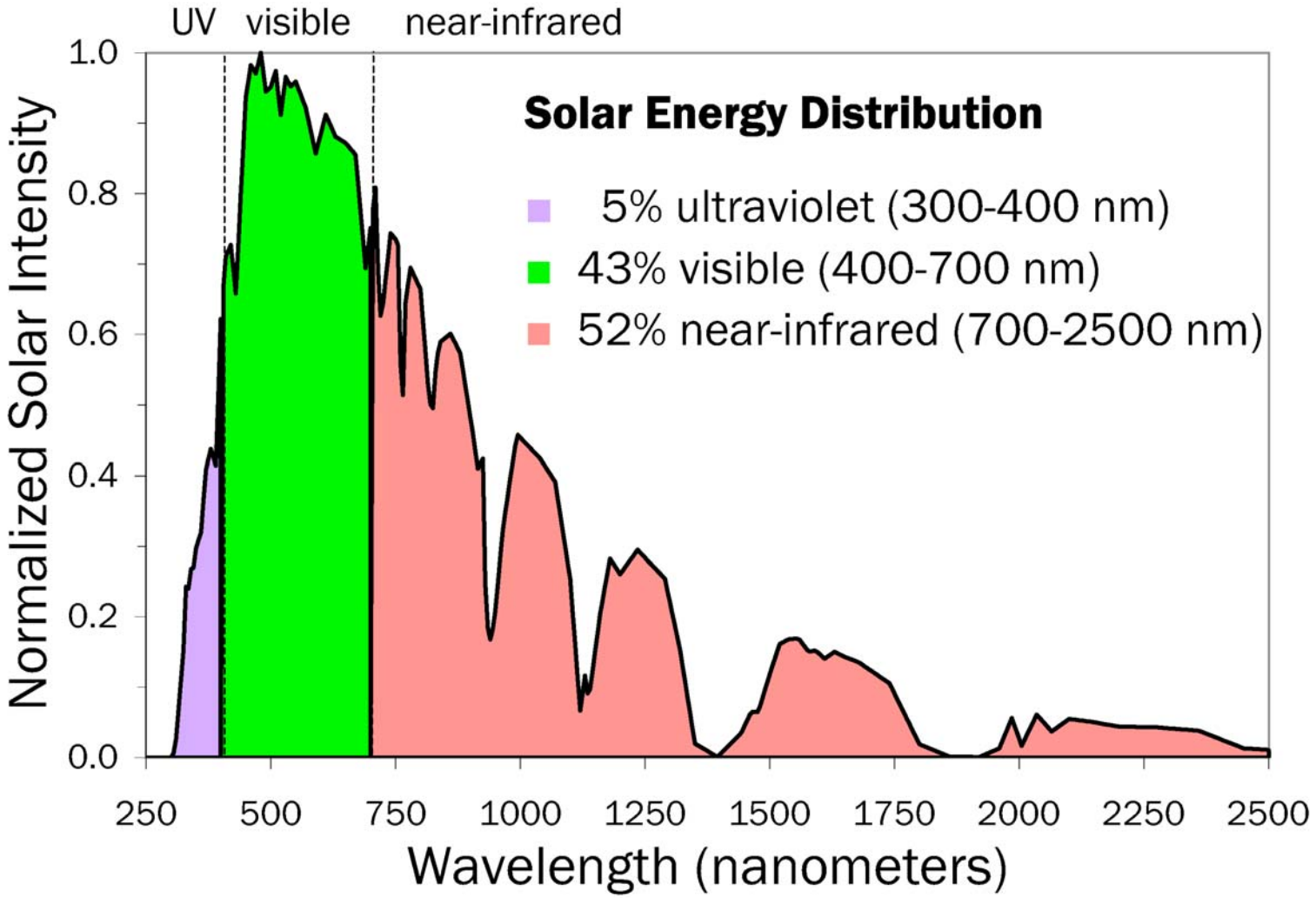
- www.GoSolarCalifornia.ca.gov

California Renewables Portfolio Standard

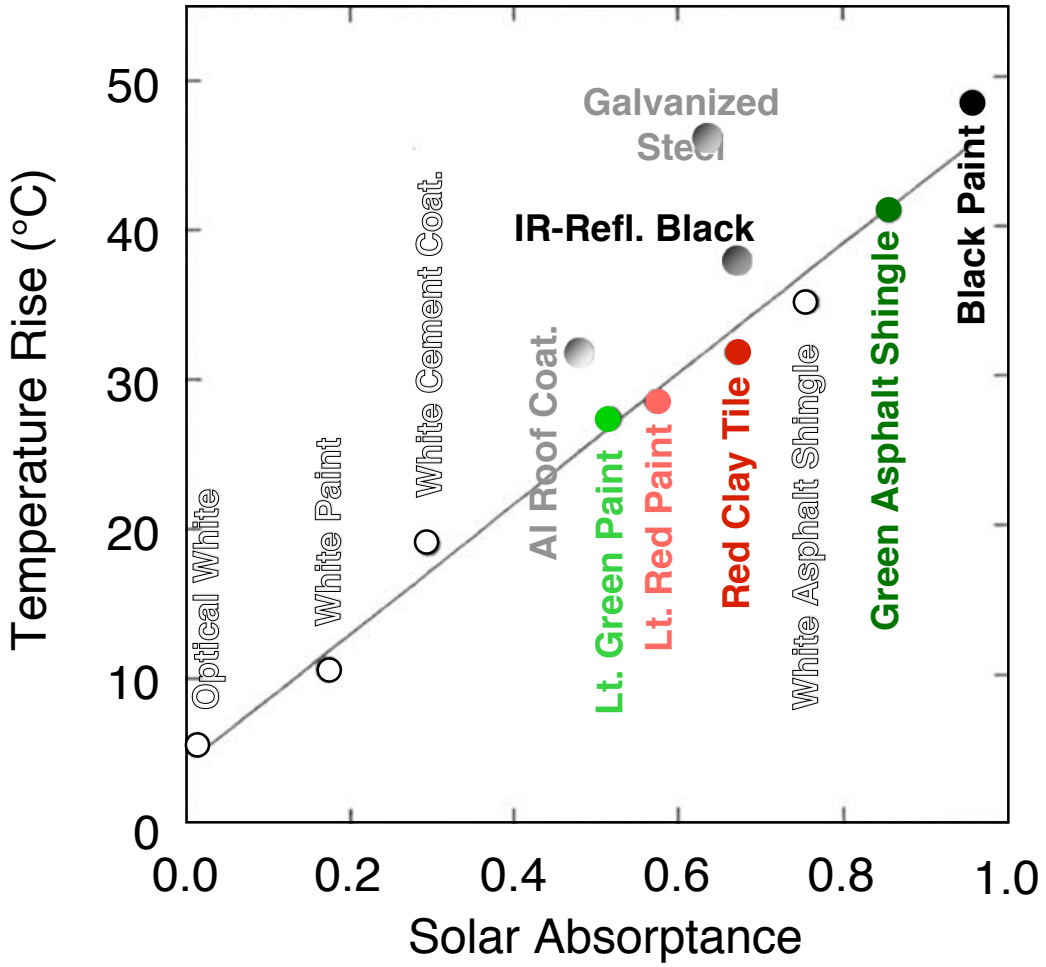
- **Designed to increase diversity, reliability, public health and environmental benefits of California's energy mix.**
- **Current legislative goal of 20% of retail sales from renewables by 2010; increase by at least 1% per year.**
- **Some discussion of increasing the goal to 33% by 2020**



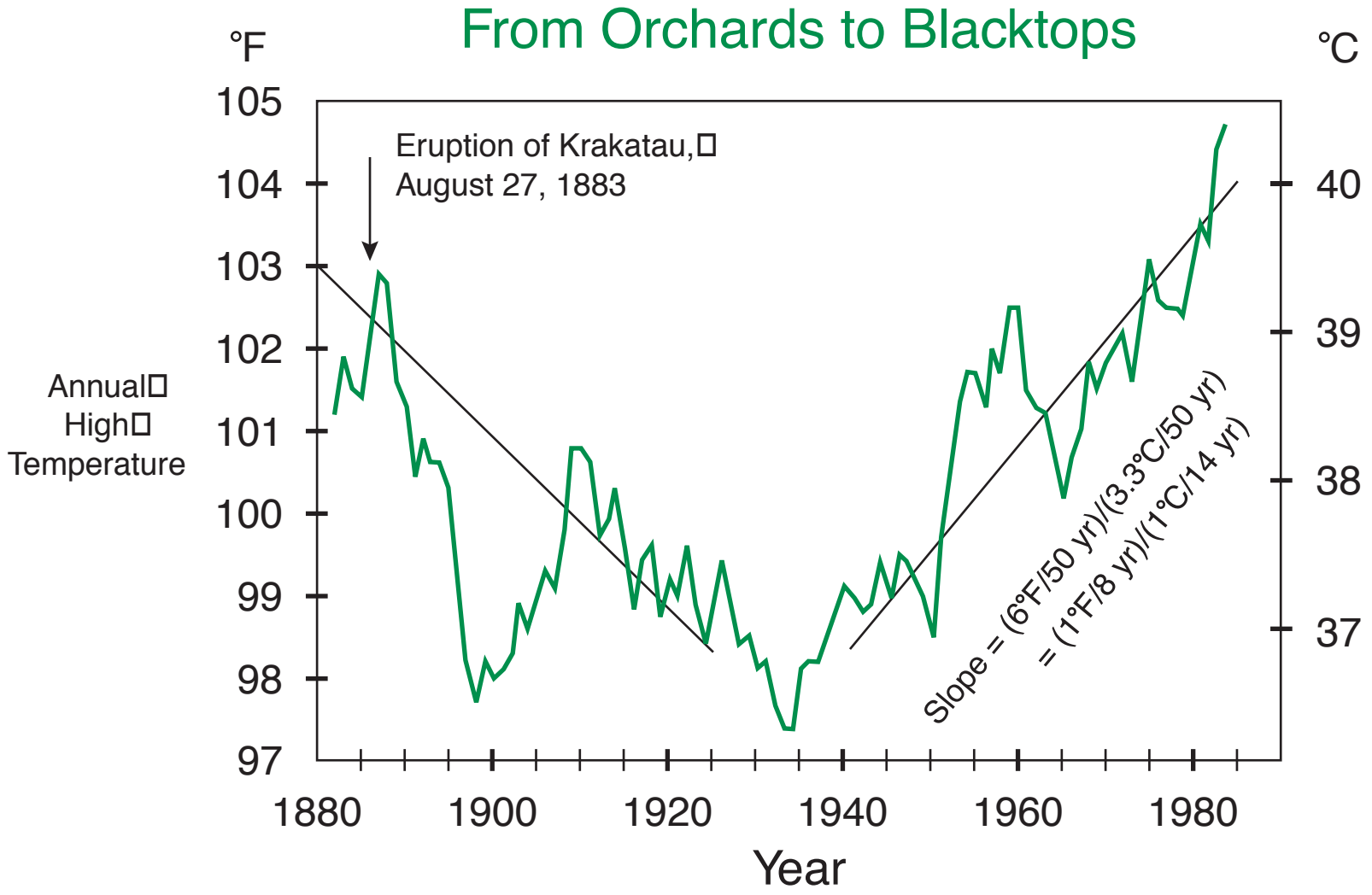
Cool Colors Reflect Invisible Near-Infrared Sunlight



Temperature Rise of Various Materials in Sunlight
Dr. Hashem Akbari, LBNL Heat Island Group
Google "Hashem Akbari" LBNL



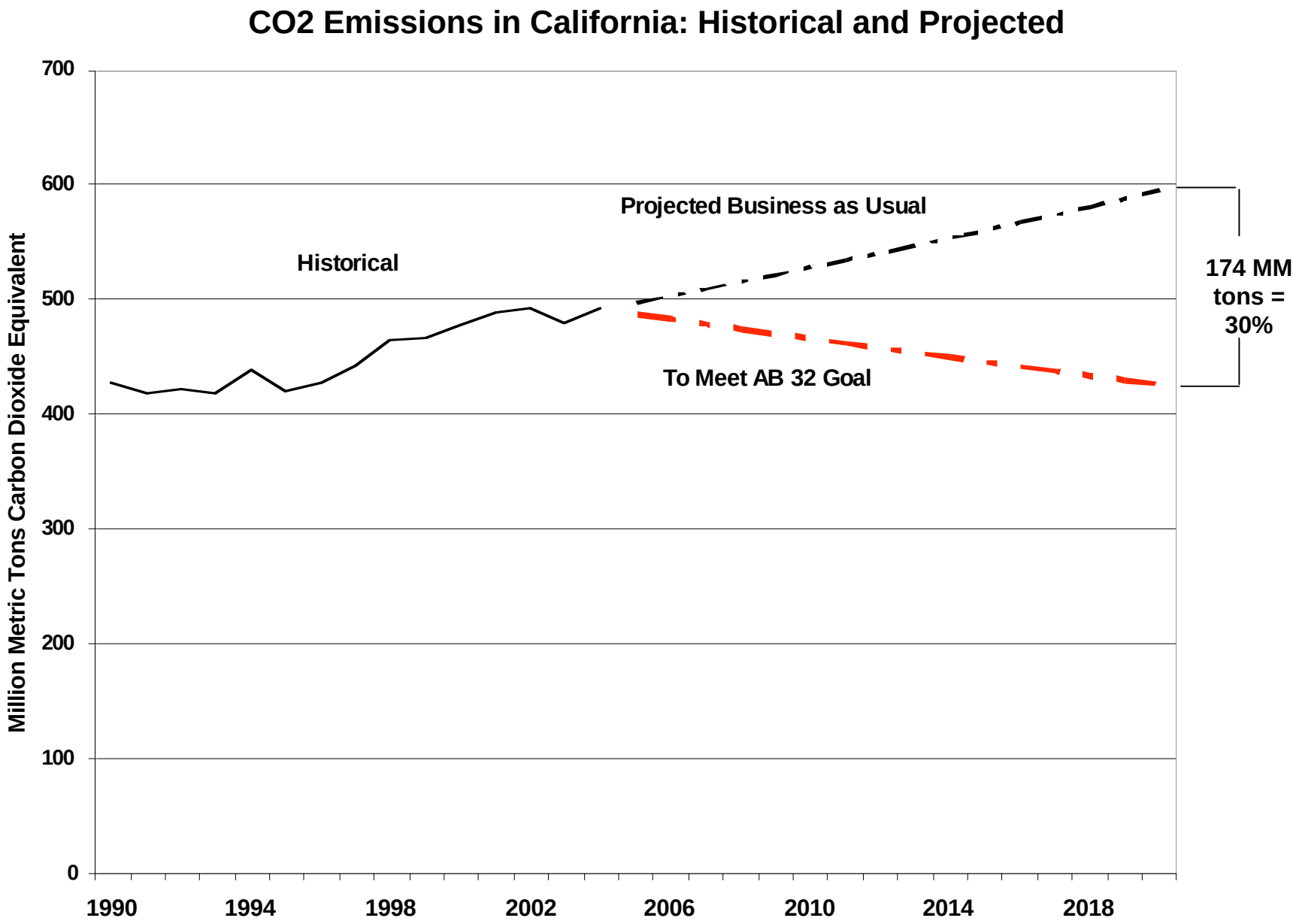
Temperature Trends in Downtown Los Angeles



http://www.nwhi.net/Vinyl_Windows/Low_E_Glass.htm

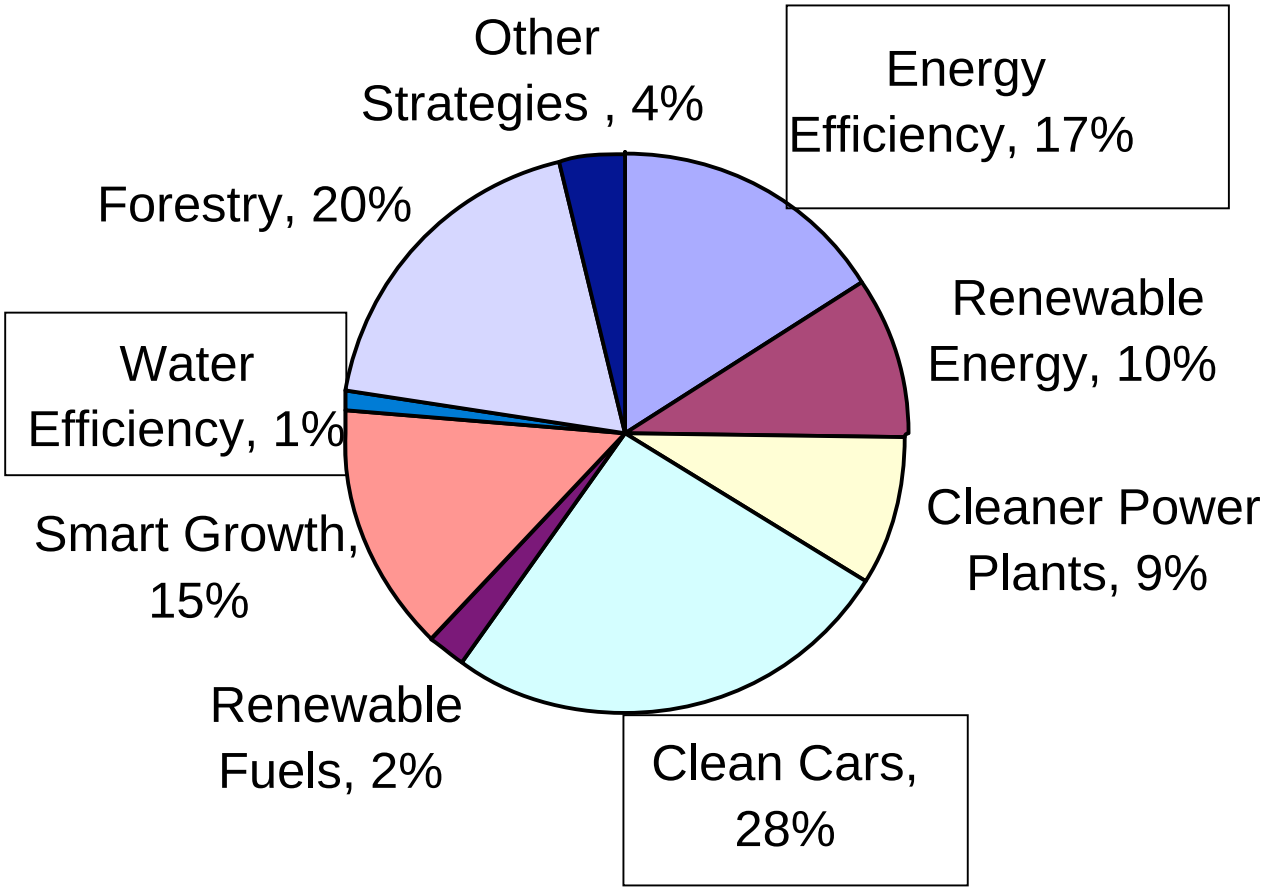
Heat Mirror Windows – Steve Selkowitz, LBNL

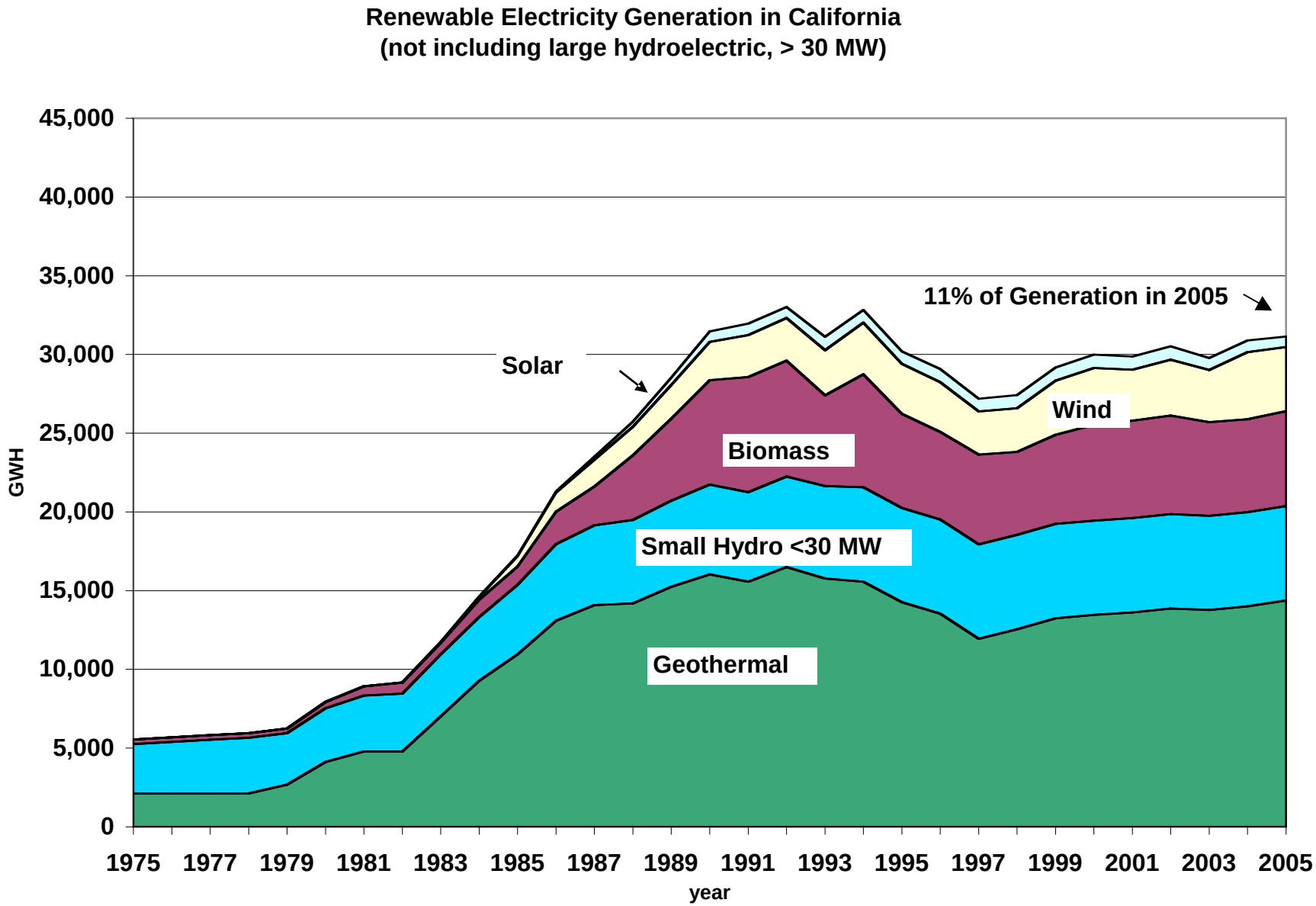
- Low Emissivity films are required by building standards world-wide. They reflect far infrared radiation. Retain indoor heat in winter, reflect outdoor heat in summer. They double the R-value of double glazing, and the inside pane is warm to the touch – more comfortable
- Before low-E, windows were 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 though windows; including car windshields in BMW's etc.
- **Modern windows save ~1 Mbod of oil equivalent, = Alaskan oil.**


CO2 Emissions in California: Historical and Projected
Million Metric Tons Carbon Dioxide Equivalent
700
600
500
400
300
200
100
0
1990
1994
1998
2002
2006
2010
2014
2018
Historical
Projected Business as Usual
To Meet AB 32 Goal
174 MM tons = 30%

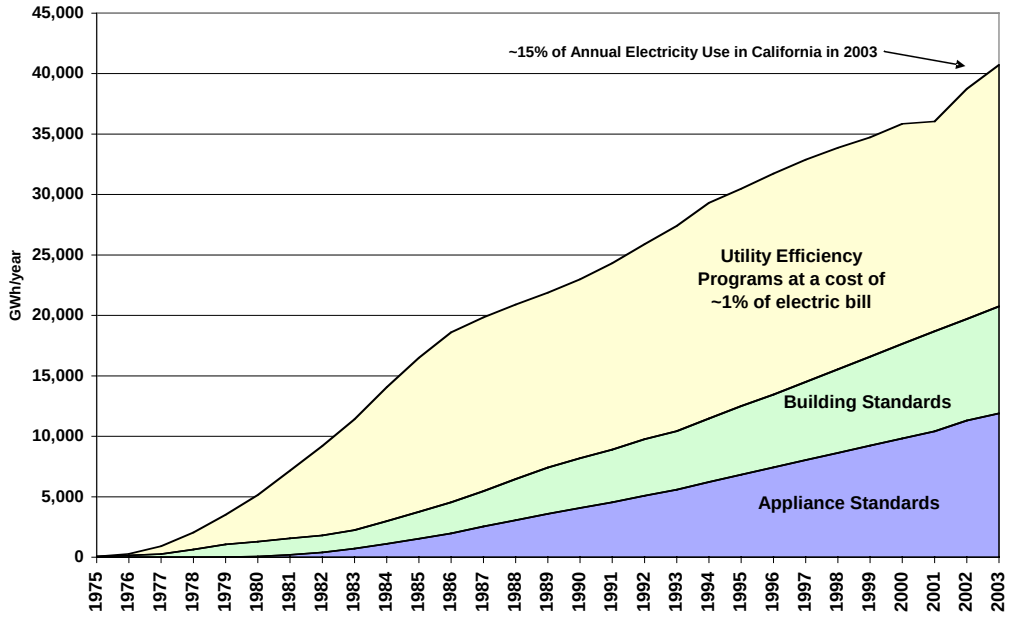
Strategies for Meeting California's CO2 Goals in 2020

Total Reductions = 174 Million metric Tons CO2 equivalent

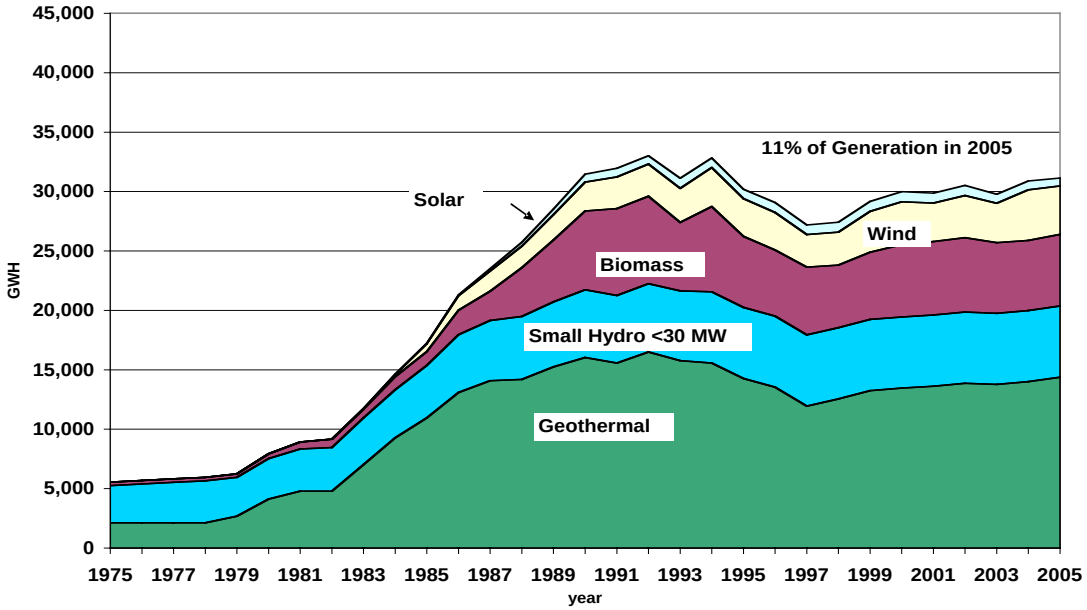



Renewable Electricity Generation in California
(not including large hydroelectric, > 30 MW)
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
GWH
11% of Generation in 2005
Solar
Wind
Biomass
Small Hydro <30 MW
Geothermal
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
year

Annual Energy Savings from Efficiency Programs and Standards



Renewable Electricity Generation in California
(not including large hydroelectric, > 30 MW)



Conclusion Part 3

- California is providing much needed leadership to move the United States to reduce Greenhouse Gas Emissions
- Major efforts will be needed in all sectors if our goals are to be achieved
- And again efficiency will be a critical component
  - About 50% of the reduction due to efficiency improvements

Concluding Thoughts

- "Energy Efficiency Portfolio Standard" should **precede** renewable portfolio standard
  - Certainly more cost-effective in most cases
  - Secure, stable funding is important
- Customers can and do respond to price, especially in the longer-term
  - Impressive State-wide pilot tested only short term response.
- Retail rate design is a critical component
  - Correct price signals can encourage response and provide a important link between retail and wholesale markets
- Automation is important
- California is making a major effort to lead the United States toward reducing Greenhouse Gas Emissions
  - This will involve all sectors of the economy
  - With efficiency improvements contributing about one-half of the expected reductions

California Energy Commission References

- Building Standards – Title 24: http://www.energy.ca.gov/title24/index.html
- Appliance Standards – Title 20: http://www.energy.ca.gov/appliances/index.html
- R&D : http://www.energy.ca.gov/research/index.html
- Greenhouse Gas Reduction Efforts: http://www.climatechange.ca.gov/
- Energy Efficiency in California and the United States, Chang, Rosenfeld, McAuliffe in Schneider, Rosencranz & Mastrandrea (eds.), CLIMATE CHANGE SCIENCE AND POLICY (forthcoming in 2007)
  - http://www.energy.ca.gov/2007publications/CEC-999-2007-007/CEC-999-2007-007.PDF
- Renewable Portfolio Stnd. --http://www.energy.ca.gov/portfolio/index.html
- Solar Energy Program --http://www.gosolarcalifornia.ca.gov/
- Arthur Rosenfeld's web site -- http://www.energy.ca.gov/commission/commissioners/rosenfeld.html
- For Cool Communities (Lawrence Berkeley National Lab) -- http://eetd.lbl.gov/HeatIsland/