(Energy Use Leading To)
Air Pollution as Climate Forcing
East-West Center
Honolulu
April 5, 2005

Arthur H. Rosenfeld, Commissioner
California Energy Commission
(916) 654-4930
ARosenfe@Energy.State.CA.US
For my Autobiography, visit
http://www.energy.ca.gov/commission/commissioners/rosenfeld.html
California Peak Power Demand: Planned in 1974, and Actual to 1984
Per Capita Electricity Consumption

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

United States

California

Efficiency
Energy for the Future
United States Refrigerator Use v. Time

- **Refrigerator Size (cubic ft)**
- **Energy Use per Unit (KWH/Year)**
- **Refrigerator Price in 1983 $**

Source: David Goldstein
Efficiency
Energy for the Future

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

- Nuclear
- Conventional Hydro
- 100 Million Rooftop PV System @ 1kW
- Existing Renewables
- ANWR @ 10,000 Btu/kWh

Graph showing billion kWh per year for various energy sources.
The Value of Energy Saved and Produced
(production @ .03 and savings @ .085 $/kWh)

- 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

Efficiency
Energy for the Future
Impact of Standards on Efficiency of 3 Appliances

Annual Usage of Air Conditioning in New Homes in California
Average drop of 3% per year while House size grew 1% per year

Source: CEC Demand Analysis Office
After Saturation (16 years)
Impact of Standards on Residential Central A/C and Roof Top A/C Units in the United States

Index (1972 = 100)
EER = 13

100 GW of U.S. Nuclear Power Stations

300 GW
200 GW

EER = 13

Efficiency
Energy for the Future
Costs and Pollution Saved by Avoiding a 50% expansion of California Electric System.

- Avoids 18 Million tons/year of Carbon
- Equivalent to getting 12 million cars off the road,
  - along with their NOx, CO, and particulate emissions.
- California has ~25 million motor vehicles,
  - avoided 50% more equivalent pollution.
- The Pavley bill, starting in model year ’09, should start to reduce another 30%.

- California annual electric bill in 2004 ~ $30 Billion
- Avoided ~$16 Billion of bills, but net saving is only ~$12 Billion/year, i.e. $1000/family.
GWh Impacts from Programs Begun Prior to 2001

~ 14% of Annual Use in California

Program Costs and Savings in 2004

<table>
<thead>
<tr>
<th>Type</th>
<th>Cost</th>
<th>Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Utility Programs</td>
<td>$250M</td>
<td>~18,000 GWH</td>
</tr>
<tr>
<td>Standards</td>
<td>$10M</td>
<td>~18,000 GWH</td>
</tr>
</tbody>
</table>

Utility Programs: at a cost of ~1% of Electric Bill

Building Standards

Appliance Standards

Utility Programs $ 250 Million ~18,000 GWH
Standards $  10 Million ~18,000 GWH
Extending Efficiency to Developing Countries:--- Standards are 25 times cheaper than Energy Efficiency Programs

- The entire California Energy Efficiency Strategy costs 1% of annual electric bills and less than 0.75% of total electric and natural gas bills
- But Standards Development, Training and Inspection yield 50% of the savings for only $10 million per year
  - That’s 4% of the total costs
  - So, this is 25 x more cost effective that utility programs
- $10 M / $30 B electric bill, is 1/3000 of our bill, or 1/3 cent per $100.

How does this apply to Developing Countries?

- At a minimum, Standards should be extended to Developing Countries with funding matched by developed countries (0.1% of electric bills)
- Better yet, 1% of electric bills in developing countries should be set aside for utility programs and standard development
  - With matching funds provided by developed countries
Efficiency
Energy for the Future
Illuminating Space vs. the Street
United States Refrigerator Use (Actual) and Estimated Household Standby Use v. Time

Average Energy Use per Unit Sold (kWh per year)

Refrigerator Use per Unit


Estimated Standby Power (per house)

1978 Cal Standard
1980 Cal Standard
1987 Cal Standard
1990 Federal Standard
1993 Federal Standard
2001 Federal Standard

Efficiency
Energy for the Future

Arthur Rosenfeld, page 17
United States Energy Consumption 1949 to 2001
Source: Table 1.5 Annual Energy Review; data for 2001 is preliminary
United States
Energy Consumption Per Person 1949 to 2001
Source: Table 1.5 Annual Energy Review; data for 2001 is preliminary
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

Energy Costs = 6% of GDP in 1999 or $6000/family
World Primary Energy Consumption
1980 to 2001
Source: EIA

20-year annual growth was 1.7%
Annual Rate of Change in Energy/GDP for the United States
International Energy Agency (IEA) and EIA (Energy Information Agency)

- 3.4%
Average = - 0.7%
- 2.7%

IEA data  EIA data

Efficiency
Energy for the Future
Annual Rate of Change in Energy/Gross State Product for California
(Sources: EIA and California Department of Finance)

Average = -1.0%

-4.5%

-3.9%
Annual Rate of Change in Energy/GDP for Europe

IEA (Energy/Purchasing Power Parity) for European Union and Western Europe
EIA (Energy/Market Exchange Rate)

<table>
<thead>
<tr>
<th>Year</th>
<th>IEA Data</th>
<th>EIA Data</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>1981</td>
<td></td>
<td></td>
<td>-1.2%</td>
</tr>
<tr>
<td>1982</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1983</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1984</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1985</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1986</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1987</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1988</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1989</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1990</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1991</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1992</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1993</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1994</td>
<td></td>
<td></td>
<td>-1.4%</td>
</tr>
<tr>
<td>1995</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1996</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1997</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1998</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1999</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2001</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Efficiency
Energy for the Future

Arthur Rosenfeld, page 24
Annual Rate of Change in Energy/GDP for China
IEA (Energy/Purchasing Power Parity) and EIA (Energy/Market Exchange Rate)

- 4.8%
Average = - 5.0%
- 5.3%

IEA data
EIA data

Efficiency
Energy for the Future
Oil Demand in Million Barrels per Day
Change from previous year

- United States
- China
- World

<table>
<thead>
<tr>
<th>Year</th>
<th>US and China</th>
<th>Change from previous year</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>United States: 20</td>
<td>-0.3%</td>
</tr>
<tr>
<td>2001</td>
<td>United States: 25</td>
<td>1.5%</td>
</tr>
<tr>
<td>2002</td>
<td>United States: 20</td>
<td>0.6%</td>
</tr>
<tr>
<td>2003</td>
<td>United States: 20</td>
<td>1.4%</td>
</tr>
<tr>
<td>2004 (thru 3 quarters)</td>
<td>United States: 20</td>
<td>1.8%</td>
</tr>
</tbody>
</table>

World:
- 2000: 0.6%
- 2001: 4.9%
- 2002: 7.6%
- 2003: 17.7%
- 2004 (thru 3 quarters): 2.5%
Annual Rate of Change in Energy/GDP for the World
IEA (Energy/Purchasing Power Parity) and EIA (Energy/Market Exchange Rate)

- 1.3%
Average = - 0.7%
- 1.3%

note: Russia not included until 1992 in IEA data and 1993 in EIA data
Efficiency

Energy for the Future

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

Growth = 1.5%/yr
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
Temperature Trends in Downtown Los Angeles

From Orchards to Blacktops

Eruption of Krakatau, August 27, 1883

Slope = \( \frac{6^\circ F/50 \text{ yr}}{3.9^\circ C/50 \text{ yr}} \)

= \( \frac{1^\circ F/8 \text{ yr}}{1^\circ C/14 \text{ yr}} \)
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