Energy Efficiency for California, the US, the World
No. 1 in the California “Loading Order”

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

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

Avoided Supply = 70 Quads in 2005

If E/GDP had dropped 0.4% per year

Actual (E/GDP drops 2.1% per year)

70 Quads per year saved or avoided corresponds to 1 Billion cars off the road

New Physical Supply = 25 Q

$1.0 Trillion

$1.7 Trillion
A cost curve for greenhouse gas reduction

A global study of the size and cost of measures to reduce greenhouse gas emissions yields important insights for businesses and policy makers.

Per-Anders Enkvist, Tomas Naoclér, and Jerker Rosander

http://www.mckinseyquarterly.com/Energy_Resources_Materials/A_cost_curve_for_greenhouse_gas_reduction_abstract
CO2 Conservation Supply Curves Explained

Start with conservation & supply curves for electricity or natural gas
Net benefit = annual saved bills – annualized first cost of measure
(of course saved bills depends on price of electricity).
Then convert kWh or therms to CO2

• **Policy Implications of Greenhouse Warming:**
• **Policy Implications of Greenhouse Warming**: Mitigation, Adaptation, and the Science Base (1992) Committee on Science, Engineering, and Public Policy (COSEPUP ...
books.nap.edu/books/0309043867/html - 42k - Cached - Similar pages
Global cost curve for greenhouse gas abatement measures beyond ‘business as usual’; greenhouse gases measured in GtCO$_2$e$^1$

- Approximate abatement required beyond ‘business as usual,’ 2030

- Carbon capture and storage (CCS); new coal
- Medium-cost forestation
- Cofiring biomass
- Wind; low penetration
- Industrial feedstock substitution
- CCS, enhanced oil recovery, new coal
- Low-cost forestation
- Livestock
- Nuclear
- Industrial non-$\text{CO}_2$
- Standby losses
- Sugarcane biofuel
- Fuel efficiency in vehicles
- Water heating
- Air-conditioning
- Lighting systems
- Fuel efficiency in commercial vehicles
- Building insulation
- Biodiesel
- Industrial CCS
- Waste
- Coal-to-gas shift
- CCS; coal retrofit
- Industrial motor systems
- Avoided deforestation
- Higher-cost abatement

Further potential$^3$

Marginal cost,$^5$ € per tCO$_2$e$^2$

- 550 ppm$^4$
- 450 ppm$^4$
- 400 ppm$^4$

- ~25
- ~40
- ~50

Abatement beyond ‘business as usual,’ GtCO$_2$e$^1$ per year in 2030
Supply Curve for CO2, Conserved thru Energy Efficiency in Electricity Sector in California - Potential in 2011 at 1 kwh = 0.454 kg of CO2

15% of Electricity Sales in 2011

$3.5 Billion/year

Million Metric Tons of CO2 eq. per year
Per Capita Electricity Sales (not including self-generation) (kWh/person) (2006 to 2008 are forecast data)

United States

California

2005 Differences
= 5,300kWh/yr
= $165/capita

Per Capita Income in Constant 2000 $

<table>
<thead>
<tr>
<th></th>
<th>1975</th>
<th>2005</th>
<th>% change</th>
</tr>
</thead>
<tbody>
<tr>
<td>US GDP/capita</td>
<td>16,241</td>
<td>31,442</td>
<td>94%</td>
</tr>
<tr>
<td>Cal GSP/capita</td>
<td>18,760</td>
<td>33,536</td>
<td>79%</td>
</tr>
</tbody>
</table>
New United States Refrigerator Use v. Time and Retail Prices

Source: David Goldstein
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)

Billion $ (US)/year in 2005

- Energy Saved Refrigerator Stds
- 100 Million 1 KW PV systems
- conventional hydro
- renewables
- nuclear energy
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

Wholesale (3 Gorges) at 3.6 c/kWh
Retail (AC + Ref) at 7.2 c/kWh

Value of TWh

<table>
<thead>
<tr>
<th></th>
<th>TWh/Year</th>
<th>Value (billion $/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 Gorges</td>
<td>100</td>
<td>7.5</td>
</tr>
<tr>
<td>Refrigerators</td>
<td>80</td>
<td>3.0</td>
</tr>
<tr>
<td>Air Conditioners</td>
<td>60</td>
<td>4.5</td>
</tr>
</tbody>
</table>

If Energy Star

2005 Stds
2000 Stds

Wholesale (3 Gorges) at 3.6 c/kWh
Retail (AC + Ref) at 7.2 c/kWh

标准生效后，10年节约电量
Annual Energy Savings from Efficiency Programs and Standards

~15% of Annual Electricity Use in California in 2003

Utility Efficiency Programs at a cost of ~1% of electric bill

Building Standards

Appliance Standards

GWh/year

Based Upon Exhibit 11: Updated Estimates for 2020 for the Climate Strategies Included in the 2006 CAT Report UPDATED MACROECONOMIC ANALYSIS OF CLIMATE STRATEGIES...
Possible Strategies to Reduce Electricity Sector Carbon Emissions in California, ignoring ramp up times and other implementation issues -- The CARBON Perspective

Source: Pat McAuliffe, pmcaulif@energy.state.ca.us