Near-Term Solutions for Mitigation of Carbon Dioxide
CARB Symposium
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The greening of America
CO2 Emissions in California: Historical and Projected

Historical

Projected Business as Usual

+1.2%/yr

To Meet AB 32 Goal

-0.9%/yr
Energy Intensity in the United States 1949 - 2005

If intensity dropped at pre-1973 rate of 0.4%/year

Actual (E/GDP drops 2.1%/year)
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
Environmental Equivalent of Avoiding 70 Quads

70 Quads = 33 Mbod (Million barrels of oil per day) = 40% of World oil production of 80 Mbod

70 Quads = 1 Billion cars off the road, impressive since there are only 600 million cars on the road
How Much of The Savings Come from Efficiency?

◆ Easiest to tease out is cars
  – In the early 1970s, only 14 miles per gallons
  – Now about 21 miles per gallon
  – If still at 14 mpg, we’d consume **75 billion gallons more** and pay **$225 Billion more** at 2006 prices
  – But we still pay **$450 Billion per year**
  – If California wins the ”Pavley” suit, and it is implemented nationwide, we’ll save **another $150 Billion per year**

◆ Commercial Aviation improvements save another **$50 Billion per year**

◆ Appliances and Buildings are more complex
  – We must sort out true efficiency gains vs. structural changes (from smokestack to service economy).
How Much of The Savings Come from Efficiency (cont’d)?

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

<table>
<thead>
<tr>
<th></th>
<th>Billion $</th>
</tr>
</thead>
<tbody>
<tr>
<td>Space Heating</td>
<td>40</td>
</tr>
<tr>
<td>Air Conditioning</td>
<td>30</td>
</tr>
<tr>
<td>Refrigerators</td>
<td>15</td>
</tr>
<tr>
<td>Fluorescent Tube Lamps</td>
<td>5</td>
</tr>
<tr>
<td>Compact Fluorescent Lamps</td>
<td>5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>95</strong></td>
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◆ 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.
Carbon Dioxide Intensity and Per Capita CO2 Emissions -- 2001
(Fossil Fuel Combustion Only)
Energy Intensity -- California and the United States

Intensity (thousand Btus per $ measured in year 2000 $)

US down to 54% of 1973 intensity
California down to 46% of 1973 intensity

54%
46%
Per Capita Electricity Sales (not including self-generation)
(kWh/person) (2005 to 2008 are forecast data)

California
United States

= 4,000kWh/yr
= $110/capita
Comparison of Fuel Economy – Passenger Vehicles

MPG Converted to CAFE Test Cycle

Japan

EU

China

Australia

Canada

California (Pavley)

US

(1) dotted lines denote proposed standards
(2) MPG = miles per gallon
Annual Energy Savings from Efficiency Programs and Standards

20 MtCO2

~18% of Annual Electricity Use in IOU areas in 2003

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

Building Standards

Appliance Standards
California Must Expand CEC Staff for Standards

California spends $1B/year on EE and Renewables to reduce electricity use by ~1%/year,

But CEC Standards Office has only 14 staff ($2M/year) to accelerate building and appliance standards, and thus reduce use by ~1/2%/year.
Figure 8
Comparison of EE Program Costs to Supply Generation Costs

Supply Options

$/kWh

0.180
0.160
0.140
0.120
0.100
0.080
0.060
0.040
0.020
0.000

Demand

Average Cost of EE Programs for 2000-2004
Base Load Generation
Shoulder Generation
Peak Generation

0.029
0.058
0.118
0.167
California IOU’s Investment in Energy Efficiency

Profits decoupled from sales

2% of 2004 IOU Electric Revenues

Performance Incentives

Market Restructuring

Crisis

Forecast

IRP

Public Goods Charges
What about Public Utilities – the Other 25%?

- Existing law already requires that IOU electric and gas utilities regulated by the CPUC shall:
  1. Meet resource needs through all available energy efficiency and demand reduction resources that are cost-effective, reliable, and feasible and
  2. Set energy efficiency goals

- AB 2021 (Levine, 2006) now requires that Public Utilities shall follow similar programs and goals, supervised by the CEC
Emissions of CO2 in California by End Use in 2004
Total Emissions = 490 Million metric tons CO2 equivalent

Source: Energy Efficiency in California and the United States -- Chang, Rosenfeld, McAuliffe
CO2 Emissions in California: Historical and Projected

- **Historical**
- **Projected Business as Usual**
  - +1.2%/yr
  - -0.9%/yr

**To Meet AB 32 Goal**
Strategies for Meeting California’s CO2 Goals in 2020
Total Reductions = 174 Million metric Tons CO2 equivalent
i.e. 30% of projected 2020 Business As Usual CO2 emissions

- Energy Efficiency, 17%
- Renewable Energy, 10%
- Cleaner Power Plants, 9%
- Renewable Fuels, 2%
- Clean Cars, 28%
- Smart Growth, 15%
- Forestry, 20%
- Water Efficiency, 1%
- Other Strategies, 4%
2011 Energy Efficiency Goals for the IOUs

◆ CPUC OIR to implement 2009-2011 energy efficiency goals
  – Portfolio development over the next few months
  – Should support “significant, bold progress toward measurable market penetration goals”
  – Proposed new measures:
    1. Conversion of general purpose lighting to high efficiency by 2017
    2. A specific % of residential construction to exceed 2008 Title 24 by 35% and thereby set new levels for Title 24 updates in 2011
    3. A specific % of existing commercial building to improve energy efficiency by 20% (through benchmarking)
    4. A specific penetration of 80%-efficient gas water heaters (SEGWHAI) by 2011 and beyond
Title 20 Appliance Standards

◆ Lighting
  – 5% improvement in incandescent lamps already underway
  – Eventually, a fleet average of all lighting, measured in lumens/watt
    • Moving toward very limited use of incandescent bulbs and T-12s
◆ Reductions in Stand-by losses also underway
  – Currently running 10% of residential use
◆ Clothes washers. In CA, 29% of electr & 30% of nat gas → water.
  – Less water use leads to reduced energy use
  – Department of Energy is considering California petition for waiver of rather weak federal standard
Title 24 – Building Standards

- White roofs already required in T-24 2005 for ‘flat’ roofs
- Cool **colored** roofs will be required in 2008 updates
  - Possible utility incentive programs to go beyond colored roof all the way to white
- California Solar Initiative. Don’t put expensive PV on a new home which is optimized for relatively cheap grid electricity.
  - Rebates will require that new homes beat Title 24 by at least 15%
Public Interest Energy Research

◆ Cool colored paints
  – Not only for use in roofs
  – But, also on cars
    • Reduce fuel use by 2% (of ~100 MtCO2 for gasoline)
    • Can reduce first costs by reducing AC system size
◆ Working with the EPA to deliver a “benchmark” tools for non-residential buildings called ‘Energy Star Portfolio Manager’
  – Hand over to utilities for implementation
◆ Hot Dry Air Conditioning Standards
  – Break up US into three AC climate zones
  – At no cost, could improve EER up to 20%
  – Legislation or a waiver is needed though
◆ Super Efficient Gas Hot Water Heater Appliance Initiative-SEGWHAI
  – Will save >20%
From Cool Color Roofs to Cool Color Cars

- Toyota experiment (surface temperature 10C = 18F cooler)
- Ford and Fiat are also working on the technology
Replacement Gas Storage Water Heater
- Conventional technology: simple but antiquated design that wastes energy
- 85% of water heater sales are replacement units, 60% of these are emergency replacements
- Current advanced technologies not appropriate for replacement market

SEGWHAI Goals:
- 30% increase in efficiency
- 70% decrease in NO\textsubscript{x}
- Cost effective market price, pay back less than 5 years
- Equivalent to standard water heaters for the customer and installing plumber
Benefits to California

- Savings per water heater (over the equipment lifetime):
  - 400 - 700 therms
  - 2.4 – 4.1 metric tons CO2
  - 13 pounds of NOx
- If 50% of existing water heaters in CA are replaced w/ SEGWHAI Tier 1 units:
  - $154 M in natural gas costs saved each year
  - **900,000 metric tons of CO2** avoided each year
  - 5 M pounds of NOx avoided each year
- These emission reductions are valued at more than $30M per year
Temperature Rise of Various Materials in Sunlight

Dr. Hashem Akbari, LBNL Heat Island Group
Cool Colors Reflect Invisible Near-Infrared Sunlight

Solar Energy Distribution

- 5% ultraviolet (300-400 nm)
- 43% visible (400-700 nm)
- 52% near-infrared (700-2500 nm)
Temperature Trends in Downtown Los Angeles

From Orchards to Blacktops

Eruption of Krakatau, August 27, 1883

Slope = \( \frac{6^\circ F/50 \text{ yr}}{3.3^\circ C/50 \text{ yr}} \)

\[ = \frac{1^\circ F/8 \text{ yr}}{1^\circ C/14 \text{ yr}} \]
Potential Savings in LA

◆ **Savings for Los Angeles**
  - Direct, $200M/year
  - Indirect, $140M/year
  - Smog, $360M/year
  - CO2, ~2 MtCO2/year
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