CO$_2$ Reductions from Light Duty Vehicles

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Three Strategies

- Reduce the sector-specific activity
  - Less driving
- Increase energy efficiency
  - Greater fuel economy of vehicles
- Change primary energy source
  - Biomass
  - Hydrogen
  - Electricity

- Reducing mobility is hardest strategy; reducing vehicle miles of light duty vehicles is almost as hard
- Focus on technology-specific changes
U.S. Indices of Light Duty Vehicle Changes

- Vehicle Miles Traveled
- Total Fuel Use
- Average MPG (Entire Fleet)

Indices with 1973 values of 1.0

- 1960
- 1962
- 1964
- 1966
- 1968
- 1970
- 1972
- 1974
- 1976
- 1978
- 1980
- 1982
- 1984
- 1986
- 1988
- 1990
- 1992
- 1994
- 1996
- 1998
- 2000

- EPCA Enacted
- First Year of CAFE
- Passenger car CAFE reaches 27.5 mpg Maximum
Encourage Technology Development

- President Bush state of the Union speech
  - Call for more research and development
  - Primarily supply technologies
- Equally important – if not more important – energy efficiency technologies
  - Rapid change possible through more efficient vehicles
    - Hybrid electric vehicles
    - Possibly plug-in hybrids
    - Possibly all electric vehicles
    - Longer run: Possibly hydrogen vehicles
  - Buildings:
    - Lighting: light emitting diodes
    - Building design, technologies, operating processes
Vehicle Technology: Broad Options

- **Conventional vehicles; possibly new fuels**
  - Internal Combustion Engine (ICE)
  - Liquid Fuels (Gasoline/diesel, Biofuels, Combinations)

- **Hybrid Vehicles**
  - Mostly ICE, Some electrification (regenerative braking)
  - Liquid Fuels
  - In future possibly hydrogen ICE

- **Plug-in Hybrid**
  - Primarily Electric Drive
  - Backup: ICE, Liquid Fuel

- **Dedicated Electric**
  - Electric Drive Only

- **Hydrogen FCV**
  - Electric Drive Only
  - Hydrogen Fuel
Technology Development Paths

- Low Cost Biofuels (Cellulosic Ethanol)
- Low Cost H2 Production and Infrastructure
- Low Cost, Durable Fuel Cells
- Biomass-fueled Conventional or Hybrid Vehicles
- On-board H2 storage
- Plug-in H2 FCV
- Plug-in H2 ICE
- Dedicated Electric
- Plug-in Hybrids
- Medium Cost Batteries
- Regenerative Braking
- Conventional Vehicles
- Hybrid Vehicles
- Low Cost, Long Life Batteries
- Low Cost, Durable Fuel Cells
## Estimated Damages Criteria Pollutants Plus CO₂:
Conventional Gasoline Light Duty Vehicles (20 mpg)

<table>
<thead>
<tr>
<th>Emissions (criteria emissions or CO₂)</th>
<th>Emissions gm/mile (CA LEV II Standards)</th>
<th>Assumed Damages Per Tonne</th>
<th>Tonnes during 150 K miles</th>
<th>Lifetime Costs (Only gasoline discounted)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO</td>
<td>3</td>
<td>$220</td>
<td>0.45</td>
<td>$99</td>
</tr>
<tr>
<td>NOx</td>
<td>0.1</td>
<td>$88,000</td>
<td>0.015</td>
<td>$1,320</td>
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<tr>
<td>VOCs</td>
<td>0.07</td>
<td>$5,000</td>
<td>0.0105</td>
<td>$53</td>
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<tr>
<td>PM</td>
<td>0.01</td>
<td>$48,000</td>
<td>0.0015</td>
<td>$72</td>
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<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td>$1,540</td>
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<tr>
<td>CO₂</td>
<td>2.84 Kg C/gal</td>
<td>$100/ T C</td>
<td>21.3</td>
<td>$2,140</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td>$3,700</td>
</tr>
<tr>
<td><strong>Gasoline</strong></td>
<td><strong>20 mpg</strong></td>
<td><strong>$2.50/gal</strong></td>
<td><strong>7,500 gal</strong></td>
<td><strong>$12,700</strong></td>
</tr>
<tr>
<td><strong>Vehicle Price</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>$25,000</strong></td>
</tr>
</tbody>
</table>
Encourage Entrepreneurial Efforts

- May look like no policy at all.
- Encourage technical and market experimentations
  - Some will ultimately make it big; others will not.
  - But the genius of American economy involves entrepreneurial efforts, risk-taking, pioneering efforts.
  - Some of these will be failures, some successes.
  - Successes will live, grow to become household names.
    - will spawn more entrepreneurial challenges
    - The failures will typically lead to different attempts, some successes, some failures.
  - Ahead of time impossible to know which will disappear and which will be the next Google.
  - Lighting, vehicles are poised for fundamental change.
Technology Specific Options

- California should continue encouraging electrification
- California should continue backing off away from the hydrogen highway
- PIER should stay connected to battery research
- California should find ways of being friendly to plug-in hybrids
Fuel Economy Increases:
Conventional Vehicles
Effectiveness and Impact of Corporate Average Fuel Economy (CAFE) Standards (National Research Council)

www.nap.edu/catalog/10172.html

Final Version January, 2002
Passenger Car Fuel Economy Cost Curves

Retail Price Increase

Increase in Passenger Car MPG

- NRC 2001 Lower
- NRC 2001 Mid
- NRC 2001 Upper
- 2014 Sierra Res.
- 2020 MIT
- ACEEE-Advanced
- 2013-15 EEA
- EEA w/o wgt
Estimated Cost-Minimizing MPG vs. Current Passenger Cars: $1.50 and $2.50/Gal Gasoline
Automobile-Efficiency-Specific Policies

• Federally
  – Higher CAFE standards
  – Restructuring of CAFE
    • Marketable credits
    • Attribute-based standards
    • The process must give incentives to NEW market participants, not just existing companies
      – E.g. Tesla Motors

• California
  – Defend the Pavley Bill
  – Backup in case California loses in the courts
  – Enact a cap-and-trade system for the carbon commitment of new vehicles
Gasoline/Diesel Prices and Taxes
Oil Price Uncertainty (From Options Prices) (as of 4/19/2006)

- Probabilities for different price ranges:
  - Below $45
  - $45 - $60
  - $60 - $80
  - $80 - $95
  - Above $95

Legend:
- Dec. 2006 Delivery
- Dec. 2007 Delivery
- Dec. 2010 Delivery
Get Gasoline/Diesel Prices Right

- The world oil price is passed through to gasoline/diesel prices
- International security externality not included
- \( \text{CO}_2 \) externality not included
- Other travel externalities not included
- Congestion
- Highway/Road mortality/injury
- Criteria pollutants

Thus price we pay for gasoline is too low, not too high
- Cost to economy – oil import cost and environmental cost – is too high
- Price to consumer is too low
Get Carbon Dioxide Prices Right

• Need US national carbon dioxide cap-and-trade system
  – The United States could implement a cap and trade system even if we do not ratify Kyoto protocol
• System can be implemented
  – The nations that have ratified the Kyoto protocol now are operating such a system
  – Currently California examining such systems, but a national system would be preferable
  – We have experience in cap-and-trade
    • Acid Rain SOx trading
    • RECLAIM program for criteria pollutants
    • Chicago Climate Exchange
I believe California should implement a gasoline/Diesel tax of about $1.00 per gallon.

• Incentive for more fuel efficient vehicles
• Incentive for less driving
  – Car pooling
  – Transit
• Revenue increase recycle
  – Reduce income taxes
In Summary

• Our problems are important
• But the three sets of problems might engage many political constituencies
  • International security
  • Environmental problems of global climate change
  • High costs
• The good news
  – Many new energy supply or energy efficiency technologies seem on verge of becoming economical
  – Economical technologies may be adopted on an international scale