Moving Forward

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U.S. Sources of Energy

- **Petroleum**: 39 quadrillion Btu
- **Coal**: 23 quadrillion Btu
- **Natural Gas**: 23 quadrillion Btu
- **Nuclear Electric Power**: 8 quadrillion Btu
- **Wood, Waste, Alcohol**: 3 quadrillion Btu
- **Hydroelectric Power\(^1\)**: 3 quadrillion Btu
- **Geothermal, Solar, Wind**: (s) Less than 0.5 quadrillion Btu.

\(^1\) Conventional and pumped-storage hydroelectric power.
(s) = Less than 0.5 quadrillion Btu.
Energy Supply Difficulties

- **Coal**
  - Carbon dioxide releases and global climate change
- **Natural gas**
  - Limited supply
  - Large price variability over time
- **Nuclear power**
  - Disposition of spent fuel
  - High capital cost
  - Internationally proliferation: mask nuclear weapons
- **Hydropower**
  - Limited supply
- **Other renewables**
  - High cost
  - Quantities to replace fossil fuel are huge
Four Issues Encourage Reduction of Oil Use

• Environmental
  – Carbon dioxide releases and resulting global climate change
  – Oil spills (relatively rare)
• International security
  – Possible supply disruptions
  – Linked to international terrorism
  – Limits on US foreign policy
• High cost
• Future conventional oil supply decline, at least from non-OPEC nations (The End of Oil?)
Environmental
Fossil fuels account for

- 98% of the US carbon dioxide net releases into the atmosphere
- 82% of the releases of greenhouse gases, measured on a carbon equivalent basis.
U.S. CO₂ Emissions by Sector and Fuels 2003

Source: U.S. EPA Inventory of Greenhouse Gas Emissions, April 2005
Three Strategies to Reduce CO2 emissions in transportation and electricity generation

• Reduce the sector-specific activity
  – Less driving
  – Less electricity used

• Increase energy efficiency
  – Greater fuel economy of vehicles
  – Higher electricity conversion efficiency

• Change primary energy source
  – Renewables for electricity
  – Biomass or hydrogen for transportation
Security Issues
World Oil Supply, 2004, Total: 83 mmb/d

- North Sea: 7%
- Mexico: 5%
- Canada: 4%
- US: 11%
- Other Non-OECD: 15%
- China: 4%
- Former USSR: 14%
- Iran: 5%
- Iraq: 2%
- Kuwait: 3%
- Libya: 2%
- Qatar: 1%
- Saudi Arabia: 11%
- UAE: 3%
- Algeria: 2%
- Nigeria: 3%
- Venezuela: 3%
- Indonesia: 1%
- OPEC NG Plnt Lqds: 3%
## Oil and Gas Reserves, Billion Barrels Oil Equivalent

<table>
<thead>
<tr>
<th>Company</th>
<th>Reserve (Billion Barrels)</th>
<th>Company</th>
<th>Reserve (Billion Barrels)</th>
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<tr>
<td>Saudi Aramco (Saudi Arabia)</td>
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<td>ExxonMobil</td>
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<td>National Iranian Oil Co</td>
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<td>Kuwait Petroleum Co</td>
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<td>Petroleos de Venezuela</td>
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<tr>
<td>Adnoc (Abu Dhabi)</td>
<td>80</td>
<td>Yukos (Russia)</td>
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<td>Nigerian Natnl Petroleum Co</td>
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<td>Chevron</td>
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<tr>
<td>Sonatrach (Algeria)</td>
<td>38</td>
<td>Petrobras (Brazil)</td>
<td>12</td>
</tr>
<tr>
<td>Libya NOC</td>
<td>31</td>
<td>Total (France)</td>
<td>11</td>
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<tr>
<td>Rosneft (Russia)</td>
<td>28</td>
<td>Surgutneftgas (Russia)</td>
<td>9</td>
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<tr>
<td>Petronas (Malaysia)</td>
<td>26</td>
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</tbody>
</table>

**State Owned/Controlling Interest.**  
**Private Sector Ownership.**
Oil Prices
Crude Oil Futures Prices (as of 3/1/2006)
Oil Price Uncertainty (From Options Prices)

Below $40 | $40 - $55 | $55 - $75 | $75 - $90 | Above $90

Dec. 2006 Delivery | Dec. 2007 Delivery
Oil Price Uncertainty (From Options Prices)

Below $40

$40 - $55

$55 - $75

$75 - $90

Above $90

Probability of Being in Range

Dec. 2006 Delivery

Dec. 2007 Delivery

Dec. 2010 Delivery
Solution Strategies

- Energy Efficiency
- Energy Conservation
- Substitutes for oil
  - Fuel switching
  - New technologies
- Increases in oil supply
  - U.S. production of oil and gas
  - Production in secure, friendly areas of the world
  - Reduction in demand for oil
Energy Consumption per Dollar of Gross Domestic Product, 1949-2003

MBtu \(^1\) per Chained (2000) Dollar


Graph shows a downward trend in energy consumption per dollar of GDP from 1949 to 2003.
Energy Consumption per Dollar of Gross Domestic Product, 1949-2003

Pre-Energy-Crisis, Low Prices

Energy-Crisis, High Prices

Low Prices Through 2003
Per Capita Electricity Consumption

**United States**

**California**

kWh/person

Source: http://www.eia.doe.gov/emeu/states/sep_use/total/csv/use_csv.html
Policy Agenda
Get Prices Right

- Oil
  - The world oil price is passed through to drivers
  - International security externality not included
  - 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
Get Prices Right

• US oil price should include an international security externality premium/tax/fee
  – Gasoline tax
  – Higher CAFE standards on light duty vehicles

• Prices for oil substitutes should not be kept artificially high
  – Import tax on ethanol -- $.54 per gallon -- should be eliminated
    • Import Ethanol from Brazil instead of subsidizing it in the U.S.
Get Prices Right

• CO₂
  – 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 states are beginning to implement 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
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
Encourage Technology Development

- Governmental R&D
  - Federal
  - States (California Public Interest Energy Research Program)
- R&D incentives
  - In energy bill
- Technology competitions
- Green labeling
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 Silicon Valley involves entrepreneurial efforts, risk-taking, pioneering efforts.
  - Some of these will be failures, some successes.
  - Successes will live on, grow to become the 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.
  - Examples
Manage Risk

• National oil companies have incentive to increase uncertainty of oil prices
  – Uncertainty reduces investment in capital intensive energy supply alternatives

• Need short run shock absorbers, such as strategic petroleum reserve, to mitigate impacts of supply disruptions

• Consider variable gasoline tax to assure automakers and drivers that price of gasoline will remain high and therefore to encourage purchase of more fuel-efficient vehicles
Adopt Sector-Specific policies

- Autos
  - Higher CAFE standards
- Electricity
  - Renewable Portfolio Standards; Carbon Dioxide Adders
- Buildings
  - Building Efficiency Standards
- Appliances
  - Appliance efficiency standards; Energy Star labeling
- Transportation Fuels
  - Biomass required percentage
- Solar
  - Tax credits; Subsidies (Million Solar Roofs Initiative)