The Energy and Environment Context

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Motivation and Scope

- **Domestic US attention-grabbers:**
  - Energy costs (size, instability, equity)
  - Energy and national security (revenues to bad actors, constraints on national policies)
  - Local environmental impacts, global warming
  - Government budgets (expenditures, subsidies, tax preferences)
  - Interactions with transportation congestion, land use, infrastructure financing
Motivation and Scope (cont’d)

- International attention-grabbers:
  - Energy availability for basic needs, economic growth
  - Health impacts of air pollution
  - Energy import costs (trade balance, national income and wealth)
  - Access to better technology
  - Government budgets (burden of subsidies, revenues from energy taxes)
Outline of the Presentation

1. Linkages among energy, environment, urban transportation, land use
2. Energy and security
3. Energy and global warming
4. Options for alternative fuels
5. Concluding comments
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Stylized Linkages

- Transportation energy costs depend on energy prices, distances traveled, mode of travel
- Transportation costs, housing costs, and many other factors interact to influence location choice, distances traveled
- Energy prices and location decisions depend on a variety of policy influences
Influences on Transportation Costs

- Energy prices
- Energy policies
- Environmental policies

- Unit energy costs for transportation
- Modal options and costs
- Congestion
- Location choice

- Transportation costs

Road and transit policies
Influences on Location Choice

- Land use policy
- Transportation costs
- Housing costs
- Other locational attributes
- Energy prices
- Income
- Location choice
Summary of Key Policy Linkages

- Energy and environmental policies affect energy prices and thus transportation cost.
- Transportation cost is one factor influencing housing demand, cost.
- Housing and transportation cost influence location choice and thus transportation cost.
- Energy costs can feed back on income and thereby influence transportation and location choices.
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Oil-based fuels raise economic and energy security concerns

- Make up 95 percent of all energy in transportation sector
- Almost 60 percent of liquid fuels are imported
- Significant transfer of wealth to foreign oil producers
Transportation Accounts for 70% of U.S. Oil Consumption

million barrels per day (mbd)

- Residential/Commercial: 0.3 mbd
- Industrial: 5.1 mbd
- Cars: 9.3 mbd
- Trucks: 3.2 mbd
- Aircraft: 1.6 mbd
- Other Transport: 1.1 mbd
- Electric Generation: 0.3 mbd

Energy Information Agency, 2008
China, Other Developing Countries Pushing Up Demand

Energy Information Agency, 2008
OPEC to Account for Rising Share of Global Oil Production Capacity

Energy Information Agency, 2008
Potential Threats to U.S. Security

- Economic Impacts of...
  - disruption in global supplies of oil (price shocks)
  - use of market power by oil producers to raise prices, increase income

- Political and International Security:
  - Coercive use of energy exports
  - Competition among oil consuming nations
  - Flow of wealth to “rogue” oil exporters
  - Financial support for terrorist groups

- My focus today on economic impacts
Economic Threats and Responses

- Rising OPEC market share threatens increased market power
  - Increase fuel efficiency
  - Develop competitive alternatives (globally)

- Oil price disruptions can harm the economy
  - Risks (size, duration) difficult to gauge
  - Increased efficiency lowers vulnerability
  - Increased energy demand flexibility lowers price impacts
  - Strategic stocks are an important global bulwark that needs strengthening
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Fossil fuels in transportation contribute to global warming

- 33 percent of US CO$_2$ emissions come from oil-based transportation fuel use

- US transportation emissions expected to grow ~ 10% over next 20 years
  - Much more rapid growth expected in developing countries
Key Conclusions of IPCC WG I

- Already more than 0.5°C; impossible to avoid another 1°C over this century
- More likely at least 2°C; for high-emission scenarios, could be 2.5 – 6.5°C
- These are global averages; US could be one-third more, the Arctic more still
- Temperature and weather extremes also will intensify
- Rainfall patterns will change
- Sea level will rise
Even if mitigation was sufficient to contain annual emissions at today’s level, the world is likely to experience a 2°C warming above pre-industrial levels by 2050. The risk of serious human impacts increases strongly without mitigation.

5°C without significant mitigation, on current business as usual trends, there will be a 50-50 chance of a 5°C temperature increase by the end of the 21st Century. There will be an increasing severity in the number of people dying from hunger, water shortages, heat-related stress and malaria.

2°C

5°C is the difference between temperatures now and the last ice age.
Global emissions (GtCO₂e)

- The Stern Review recommends a stabilisation goal of 450ppm-550ppm CO₂e
- To achieve this would require that global emissions peak in the next 10-20 years
- Delaying the peak in emissions by 10 years would double the rate of reduction required
- UK targets are broadly consistent with the Stern goal

Developing countries: 25% growth on 1990 levels by 2050 (on 550ppm path)

Developed countries: 60% cut from 1990 levels by 2050

Business as usual
Economic and Policy Context for Reducing GHGs in Transportation

- Significant share in developed countries; rapidly growing share in most developing countries
- In near-to-medium term, more cost-effective mitigation options in electricity
- Key challenge for deeper long-term cuts is lowering cost for transportation options
- Various vehicle and fuel options in medium to longer term
  - Major changes in land use, modal choice only in longer term
Options for Reducing GHGs in Transportation

- CO2 pricing (cap-and-trade, tax)
  - Cost-effective vehicle and travel choices
  - Significant responses only over longer term

- Fuel economy standards
  - Also phase-in
  - May capture some “low fruit” but likely costlier than pricing per unit of CO2 reduced

- New technology development and deployment
  - Increases range of cost-effective vehicle and fuel choices for reducing GHGs
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Different Alternatives Over Time

Nearer-Term

- Improving fuel economy

Medium-Term (10–20 Yrs)

- Biomass-based fuels (ethanol and biodiesel)
- Unconventional fossil fuels

  - Heavy oils, synthetic crude oil from oil sands (SCO), coal-to-liquids (CTL), oil shale

- Advanced plug-in hybrids

Long-Term (+20 Yrs)

- Highly advanced vehicle designs; H₂
Potential for Carbon Capture and Storage (CCS) Is Key

CCS brings life cycle CO₂ emissions for SCO and CTL down to levels comparable to conventional petroleum
Key Findings

- SCO is plentiful and highly cost-competitive with oil even in a CO$_2$-constrained world

- CTL is plentiful but its competitiveness in a CO$_2$-constrained world depends on CCS

- CCS is not yet an established option technically or economically for large-scale CO$_2$ mitigation
Key Findings (cont’d)

- Even with CCS, neither fuel is consistent with deep longer-term GHG cuts

- Biomass-based options can lower transportation sector emissions, *if* feedstock is available and affordable
  - Using coal *and* biomass to liquid (CBTL), *and* CCS in liquefaction plants
  - 100% renewable biofuels (ethanol, biodiesel, BTL)
Policy Implications

- Both SCO and CTL can mitigate energy security concerns from high/unstable oil prices
- But their CO₂ emissions creates a dilemma for policymakers concerned also about global warming

  - Major expansions in production could become uneconomic once tougher CO₂ limits introduced
Policy Implications (cont’d)

- Additional steps are needed
  
  - Reduce uncertainty about economic/technical viability of large-scale CO₂ sequestration
  
  - Reduce uncertainty about future availability, cost, side effects of significantly expanded biomass use
What about Biofuels?

- RAND study assessed impacts of requiring 25% renewables in electricity and motor fuels by 2025
  - Represent about 65% of total energy consumption
- Focus in transportation was on cellulosic ethanol (or BTL)
- Key finding: while meeting the 25% requirement seems to be technically feasible, the expenditure impact is uncertain and potentially quite large
In Many Scenarios, Renewable Fuels Cost More Than Fossil Alternatives

- Demand for low-cost biomass exceeded capacity even with optimistic assumptions

- Higher-cost biomass could be obtained by converting agricultural or grazing land
  - Or prime land could be converted – low biomass input cost but larger impact on food

- Biomass demand also would come from power sector

- Cellulosic ethanol conversion is some distance away from commercial testing
Renewable Fuel Costs Depend on Government Policy for Fuel Pricing

- Fossil fuel tax: large consumer price change, more demand reduction
- Renewable energy subsidy: no consumer price jump, significant government outlay
- Revenue-neutral combination of taxes and subsidies falls in between
<table>
<thead>
<tr>
<th>Policy Scenario</th>
<th>Price ($2004)</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>$2.13</td>
<td>NA</td>
</tr>
<tr>
<td>Revenue Neutral Tax/Subsidy</td>
<td>$2.13 to $2.96</td>
<td>0% to 39%</td>
</tr>
<tr>
<td>Renewable Fuel Subsidy</td>
<td>$1.95 to $2.27</td>
<td>-8% to 7%</td>
</tr>
<tr>
<td>Fossil Fuel Tax</td>
<td>$2.45 to $6.39</td>
<td>15% to 200%</td>
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Price impacts reflect net effect of changes in demand for motor fuels due to pricing policy and lower world oil prices.

Tax case illustrates marginal cost of renewables.
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Policy Options Are Inter-Connected

- Energy cost and GHG mitigation will influence transportation, land use
  - Location choices, development patterns
  - Demands for transportation capacity

- Market-based energy and GHG mitigation policies can generate needed revenue
  - Carbon pricing → trust fund, transit revenues
  - Petroleum “insecurity” tax → revenues for developing alternative energy sources
  - Energy efficiency incentives
  - Complementarities in energy and congestion pricing
Backup Slides
IPCC Uses Standard Scenarios to Understand Different Futures

- **A1B**: rapid economic growth, peaking population, rapid intro of new technologies, mix of new fossil and non-fossil energy sources
- **A2**: less globalization, slower economic growth, more population growth
- **B1**: A1 except much lower material-intensity
Multi-model averages and assessed ranges for surface warming

- A2
- A1B
- B1
- Year 2000 Constant Concentrations
- 20th century

Global surface warming (°C)

Year

1900 2000 2100
## Temp Change Linked to GHG Concentration, Emissions Trends

<table>
<thead>
<tr>
<th>Level of GHGs (ppm Co2-eq)</th>
<th>Change in Average Global Temp (°C)</th>
<th>Year of Max Global Emissions</th>
<th>% Change in Global Emissions, 2000 to 2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>445 – 490</td>
<td>2.0 – 2.4</td>
<td>2000 – 2015</td>
<td>-85 to -50</td>
</tr>
<tr>
<td>535 – 590</td>
<td>2.8 – 3.2</td>
<td>2010 – 2030</td>
<td>-30 to +5</td>
</tr>
<tr>
<td>710 – 855</td>
<td>4.0 – 4.9</td>
<td>2050 – 2080</td>
<td>+25 to +85</td>
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Source: IPCC. Note: the concentration of CO2-eq. Before the Industrial Revolution was ~ 290 ppm.
RAND Study Examines Economics and GHG Impacts of SCO and CTL

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<tr>
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<th>SCO</th>
<th>CTL</th>
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<tr>
<td><strong>How Produced</strong></td>
<td>Synthetic crude is extracted from porous rock, then refined</td>
<td>Coal is gasified then converted directly to products, particularly diesel fuel</td>
</tr>
<tr>
<td><strong>State of Technology</strong></td>
<td>Well-established technology (over 1 million bbl./day production in Canada)</td>
<td>Well-understood technology, but no modern commercial-scale plants currently operating</td>
</tr>
<tr>
<td><strong>CO₂ Emissions Involved</strong></td>
<td>CO₂ emissions are 10–30% larger than for conventional petroleum</td>
<td>CO₂ emissions are roughly twice as large as for conventional diesel fuel</td>
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