Potential for Producing Liquid Fuels from Coal and Biomass

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National Energy Objectives

- **Energy security** – we import over 60% of our oil, much of it from sources that are not necessarily friendly, stable, or reliable.

- **Reducing GHG emissions** – climate change and energy policy are inextricably intertwined.
To what extent do the objectives overlap?

- Energy Security
- Climate

Technology:
- Coal with CCS
- Coal liquids
- PHEV
- Biofuels
- Renewable energy
- Energy efficiency
- Offshore drilling
- Nuclear
Coal and Biomass Liquid Fuels

- A 2009 NAS study entitled *Liquid Transportation Fuels from Coal and Biomass* covered these options in detail.
- We are doing work at Purdue on combined coal and liquid fuels using MARKAL, a detailed energy model.
NAS Study Findings

• Technologies for the indirect liquefaction of coal to transportation fuels are commercially deployable today; but without CCS, GHG emissions would be about twice that of petroleum-based fuels.
NAS Study Findings

• Indirect liquefaction of combined coal and biomass to transportation fuels is close to being commercially deployable today. Coal can be combined with biomass at a 60:40 ratio on an energy basis to produce liquid fuels that have GHG emissions comparable with those of petroleum based fuels if CCS is not used, and carbon neutral with CCS,
### NAS Quantitative Results

<table>
<thead>
<tr>
<th></th>
<th>CTL FT wo CCS</th>
<th>CBTL wo CCS</th>
<th>CTL w CCS</th>
<th>CBTL w CCS</th>
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</thead>
<tbody>
<tr>
<td>Production (mil gal/yr)</td>
<td>756</td>
<td>151</td>
<td>756</td>
<td>151</td>
</tr>
<tr>
<td>Capital cost (bil $)</td>
<td>4.88</td>
<td>1.32</td>
<td>4.95</td>
<td>1.34</td>
</tr>
<tr>
<td>Breakeven oil price ($/bbl)</td>
<td>56</td>
<td>93</td>
<td>68</td>
<td>103</td>
</tr>
<tr>
<td>Fuel cost ($/gal)</td>
<td>1.50</td>
<td>2.31</td>
<td>1.64</td>
<td>2.52</td>
</tr>
<tr>
<td>GHG emissions (kg CO2 eq/gal)</td>
<td>205</td>
<td>118</td>
<td>98</td>
<td>-2.3</td>
</tr>
<tr>
<td>Fuel cost w $50/ton CO2</td>
<td>2.58</td>
<td>2.86</td>
<td>2.12</td>
<td>2.41</td>
</tr>
</tbody>
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Gasoline wholesale Dec. 7 - $2.31
MARKAL-GTAP Analysis

• We are now doing economic and policy analysis using MARKAL and GTAP.
  – MARKAL is a bottom up energy model, with 1000s of energy technologies. Users specify a demand to be met, and the model develops the optimum (least cost) pathway to meet the demand.
  – GTAP is a top down CGE global model that is used for a wide range of policy analyses.
Analytical Procedure

- Essentially we are using GTAP to develop land supply curves for corn ethanol and cellulosic biomass.
- The GTAP land data base has been incorporated in MARKAL so that MARKAL now can be used realistically for economic and policy analysis of biofuels and coal-biomass combinations.
- We now are at the stage of having some preliminary results.
Total system cost increase per gallon ethanol equivalent fuel due to RFS targets
Policy Issues

• There are complicated policy issues:
  – There is a RFS for biofuels but not for CTL.
  – Would need to allocate the portion of total fuel that is from biomass so that could be counted towards the RFS.
  – Similarly, there are subsidies, loan guarantees, and other incentives for biofuels that would not apply to the coal portion.
  – However, there is increasing interest in coal/biomass combinations.
Lugar Energy and Climate Plan

• Increased fuel efficiency standards for both passenger cars and trucks with CH$_4$ use for trucks encouraged
• Reverse auction for biofuels
• Flex fuel vehicle mandate
• Building energy efficiency standards and incentives
• Appliance energy efficiency standards
• Diverse energy standard – replacing coal with renewables, nuclear, and coal with CCS and using market trading mechanisms
• Retire inefficient coal plants
• Loan guarantees for nuclear power
• Mandatory measurement of progress
Thank you!
Questions and Comments

For more information:
http://www.ces.purdue.edu/bioenergy