Biomass to Fuels and Chemicals

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What is the economic cost of importing petroleum?

- The price tag for the imported oil in 2010 was about $400B
- It cost U.S. about $500B (in 2011 $) to complete building of the entire Federal Interstate Highway System
What else $400B gets you?

This is more than the U.S. expenditure on:

- Manhattan Project
- Apollo Program
- Alaska Pipeline
- Panama Canal
- Transcontinental Railroad
- Marshall Plan
- Union Pacific
- For European Recovery (Marshall Plan)
What else $400B can get you?

- The Big Dig Project: $21B
- World Trade Center: $228
- Hoover Dam: $0.8B
- Golden Gate Bridge: $1.5B

Combined --- and still have about $48B left over!
How much of a financial burden is the fuel cost for an average family?

- For most families, fuel cost is the 2nd largest expense.
- For those making less than $50,000 per year, it constitutes the highest expense – even more than the housing costs!
Can transportation fuels be made from non-petroleum resources?

- Yes – almost any carbonaceous material can be converted to liquid fuels. Things like biomass, landfill gas, animal waste, municipal solid waste, sewage sludge, etc.

- And, there are many processes to accomplish that
What are some of the processes for making liquid fuels from biomass?

- Gasification
  - Fischer-Tropsch → FT Diesel
  - Fermentation → Ethanol
- Pyrolysis
  - Hydro-cracking → Mixed Paraffins
  - APR → LPG
- Sugars
  - Dehydration → Furanics
- Enzymes
  - Fermentation → Ethanol
- Vegetable Oil
  - Trans-esterification → Biodiesel
How much has US DOE invested in biofuels development?

- To date, DOE has invested more than $1B on integrated biorefinery demonstration projects (matched with $1.7B from industry) to field advanced biofuels, bioproducts, and power.
What are the biomass-to-fuels program goals at US DOE?

- Reducing oil imports by 1/3 by 2025
- Diversifying fuel mix
- Establishing Renewable Fuel Standard
- Increasing production to 36B gallons in 2022 (less than 13B gallons/year produced today)
What are the biomass-to-fuels program goals at US DOE?

- Conducting resource assessment to establish geographic and economic criteria under which 130 and 250 million dry tons per year of biomass would be available by 2012 and 2017, respectively
What are the biomass-to-fuels program goals at US DOE?

- Developing feedstock logistics to reduce costs from harvest to chemical plant gate to $35 per dry ton (in 2007$) by 2012
- Achieving those same cost goals for a wider range of biomass feedstocks by 2017
How about the US DOD?

- The primary need is for the jet fuel

DOD Operational Fuel Costs, FY2010 – $11.5B

Is DOD committed to clean energy?

DOD’s Past and Future Investment in Clean Energy

Will it make any difference?

- A lot, since DOD has buying power
- And, from past experience with the development of markets for integrated circuits, it is likely that DOD can influence broader adaptation of biofuels and other clean energy technologies
Total sales and DOD share of US integrated circuit sales

Source: David Mowery, Haas School of Business, University of California Berkeley referenced in: “From Barracks to the Battlefield,” The Pew Charitable Trusts, 2011
What’s UCF doing in biofuels arena?

- Research at FSEC has centered on biomass gasification (a very forgiving process for generating syngas) from various feedstocks (likes of crop residues, forest waste, yard clippings, and energy crops; as well as aquatic biomass) and

- Fischer-Tropsch synthesis to generate liquid hydrocarbon fuels
Why gasification/FT synthesis?

- Process offers many advantages – among them are feedstock flexibility, tech transition capability, etc.
What is the status of work at FSEC?

- We have designed, built and tested a special oxygen-blown gasification and Fischer-Tropsch synthesis system.
- FT reactor has our own proprietary design and catalyst formulation.
- We can convert any pre-treated biomass to clean, wax-free, sulfur-free drop-in fuels.
FSEC’s gasification/FT synthesis pilot plant
What is the composition of the FSEC syncrude?

Gasoline  Kerosene  Diesel  Lube oil & waxes

Total ion count (arb. units)

Carbon number

[Graph showing distribution of carbon numbers for different fuel types]
What are the estimated costs?

- Based on the experimental data and using the AspenPlus™ CPS, we have developed the product cost.

<table>
<thead>
<tr>
<th>Cost component</th>
<th>Cost ($/kg of FT fuel produced)</th>
<th>% of total cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital costs</td>
<td>0.81</td>
<td>39.3</td>
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<tr>
<td>Fixed O &amp; M</td>
<td>0.18</td>
<td>8.6</td>
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<tr>
<td>Feedstock</td>
<td>1.12</td>
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<tr>
<td>Other raw materials</td>
<td>0.06</td>
<td>3.0</td>
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<tr>
<td>Byproduct credits - electricity generation</td>
<td>-0.13</td>
<td>-6.5</td>
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<td>Other variable costs</td>
<td>0.02</td>
<td>1.2</td>
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<td><strong>Synfuel cost (at the gate)</strong></td>
<td><strong>$0.80-2.10</strong></td>
<td><strong>Per kg</strong></td>
</tr>
<tr>
<td></td>
<td><strong>$3.00-7.00</strong></td>
<td><strong>Per gallon</strong></td>
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What are the future plans?

- If additional funding is made available, FSEC will build a larger-scale BTL demonstration plant. Data collected from this activity will give a more realistic capital and operational cost data that will be useful to commercialization of the technology.
Acknowledgements

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