New Sources for Biofuels: What Are They?

Rick Zalesky
Vice President
Chevron Technology Ventures

U.S. Department of Agriculture
2008 Outlook Forum
Arlington, Virginia – February 21, 2008
Framing the Future of Energy

- Significant growth is expected in global energy demand
- Adding and accelerating diversification is essential
- Scale matters and scaling up has effects
- Infrastructure development is often overlooked
- Renewable energy requires different business models
- Energy strategies and solutions require a holistic view, including addressing carbon constraints

For a comprehensive analysis of the future of energy to 2030, see the major new study at: www.npc.org
The Dimensions of Energy

<table>
<thead>
<tr>
<th>Scale</th>
<th>Time</th>
<th>Capital</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global fuel volume:</td>
<td>Manufacturing and infrastructure:</td>
<td>Estimates of future investment call for $20+ trillion over the next 30 years</td>
</tr>
<tr>
<td><strong>Today:</strong></td>
<td>• Takes decades to develop at scale; lasts generations</td>
<td></td>
</tr>
<tr>
<td>• One thousand barrels per second</td>
<td>• Large ethanol plant: 100 MM gal/yr</td>
<td></td>
</tr>
<tr>
<td>• &gt; 1 trillion gal/yr</td>
<td>• Large crude refinery: 3000 MM gal/yr</td>
<td></td>
</tr>
<tr>
<td>• 0.5 gal for every human, every day</td>
<td><strong>Tomorrow – 2030</strong></td>
<td></td>
</tr>
<tr>
<td>• Mid-range growth forecasts at + 50%</td>
<td><strong>Technology:</strong></td>
<td></td>
</tr>
<tr>
<td>• Low-range growth forecasts at +30%</td>
<td>• Avg. &gt;15 yrs from invention to large scale deployment</td>
<td></td>
</tr>
</tbody>
</table>
Chevron’s View of the Next Generation of Global Energy

Conventional Fuels
Finding and Developing the Next Trillion Barrels

Alternative Fuels
Converting Unconventional Resources with Molecular Transformation

Renewable Fuels
Building Industrial-Scale, Sustainable Business Models
Fuels from Unconventional Resources

Global Production - Million Barrels Per Day

- Biofuels
- Oil Sands/Bitumen
- Extra Heavy Oil
- Coal-to-Liquids
- Gas-to-Liquids

Source: Data From EIA 2007 Reference.
Fuels from Unconventional Resources

Global Production - Million Barrels Per Day

How much and when?

- Biofuels
- Oil Sands/Bitumen
- Extra Heavy Oil
- Coal-to-Liquids
- Gas-to-Liquids

Source: Data From EIA 2007 Reference.
Synthetic Alternative Fuels
Carbon management at scale is in the critical path
Advanced Biofuels Development

Key Components

- Industrial-scale Infrastructure
- 2nd Generation Technology
- Large, concentrated supplies of feedstock
Advanced Biofuels Development

Key Components

- Industrial-scale Infrastructure
- 2nd Generation Technology
- Large, concentrated supplies of feedstock

Plus sustainable business models
Feedstock Challenges

Develop cost-advantaged access to scalable feedstock supply to support industrial scale volumes:

- Scale and economic viability
- New vs. existing infrastructure
- Crop threats and seasonality
- Food vs. fuel competition
- Land availability
- Level and persistence of subsidies
- Water supplies
- LCA & LUC

Algae, which require no arable land at all, potentially can produce much more oil per acre than any terrestrial crop.

However, algae is still some years from being a commercially viable feedstock source.
Conventional and Green Crude Process

**Conventional Crude**
- Bury, wait 50 million years
- Explore, drill, produce — local infrastructure
- *Stable, flowable, energy dense liquid*
- Pre-treat at refinery site as needed
- Distribute regionally through established infrastructure — pipeline, tanker, barge, or rail

**Green Crude**
- Harvest and gather — locally
- Produce — local infrastructure
- *Stable, flowable, energy dense liquid*
- Pre-treat at refinery site as needed
- Transport over long distances — pipeline, tanker, barge, or rail
- Refine into consistent, high-quality liquid fuel products — gasoline, diesel, etc.
- Market via established network of service stations

**Conventional Crude**
- Sunshine + water + CO₂ + nutrients + plant life

**Green Crude**
- Sunshine + water + CO₂ + nutrients + plant life
With all the excitement about alternative energy sources ...
... it’s important to keep perspective ...
... and we’re going to need it all.
Fundamentals of the Energy System

- A complex blend of economics, geopolitics, technology and the environment
- World’s largest supply chain
- Highly integrated infrastructures
- Capital- and technology- intensive
- Very long-lived assets