The Brazilian Biofuel Experience: Lessons for the Future

DOE/EIA Workshop

August 1, 2012

www.Advancedbiofuelsusa.org
2010-2011 Drought Effects on Brazilian Fuel Market

- Fuel market bifurcated.
- Petroleum products have maximum price established by law. (Gasoline @ $3.20/gallon).
- Ethanol prices not controlled.

**2010-2011 Drought Effects**

- Ethanol prices rose to $6.57/gallon.
- Gasoline sales rose. 1.5 million barrels/day of refined fuels, gasoline and diesel imported at a loss (purchased above controlled $3.20 price).
- Minimum ethanol content of gasoline dropped to 18%.
- 17.9 million gallons of ethanol imported from the US (2010).
- Brazil moving toward regulation of ethanol market.
Future of Biofuels in Brazil

• Expansion of Ethanol Production?
• Production of Advanced Biofuels?
• Improved Vehicle Fleet Efficiency?

What Are The Deployment Issues to be Considered?
Sugar Cane: 8 million hectares (1 hectare=2.47 acres).
While ethanol production grew at 18%/year from 2006 to 2009; uses approximately 1.5% of total agricultural land.
Large increase in Brazilian ethanol production could occur.
Current Federal agricultural land use plans allows up to 62 million hectares for sugar cane.
Federal plans envisioned that additional sugarcane acreage would come primarily from pastureland (74%), with only a small amount (.5%) from natural lands.

Is this increase in sugarcane cultivation realistic?
Issue #1: Land Use

Brazil Land Use
FGV 2011

- Natural Vegetation: 43.4%
- Livestock Activities: 21.4%
- Crops: 6.5%
- Protected Areas: 20.6%
- Silviculture: 0.7%
- Urbanization & Water: 4.2%
- Other Uses: 3.2%
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### Additional Sugar Cane: No Natural Vegetation Land Needed

- 54 million sugar cane hectares in livestock grazing land
- Grazing land decreased by 16%
- No additional grazing land needed through livestock grazing improvements

### Additional Sugar Cane: Natural Vegetation Land Needed

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- Grazing land decreased by 16%
- Additional grazing land needed
“The reaction of the pollution chain transformed the burning and destruction of the Amazon forests into a problem in the South and Southwest of Brazil. The scientific experiments that took place in the last years by the LBA [Large Scale Biosphere-Atmosphere Experiment in the Amazon, under the scientific coordination of INPA] revealed that a reduction of rains in the South and Southwest regions is intimately linked to the existing environmental in the northern region of the country.” (Ottoboni, 2004)

- 2010-2011 Droughts: Pernambuco State (northeastern Brazil) ethanol production fell by 18% and electrical production fell 32%.
- 2010-2011: One-off or indication for the future?
<table>
<thead>
<tr>
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<tbody>
<tr>
<td><strong>Tocantins</strong></td>
<td>13,264</td>
<td>9,945</td>
<td>9,091</td>
<td>6,434</td>
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<td><strong>Amazon</strong></td>
<td>131,047</td>
<td>123,238</td>
<td>111,609</td>
<td>91,930</td>
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<td><strong>Paraguay</strong></td>
<td>2,368</td>
<td>2,145</td>
<td>2,169</td>
<td>3,470</td>
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<td><strong>Oriental Atlantic NE</strong></td>
<td>779</td>
<td>133</td>
<td>83</td>
<td>2</td>
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<td><strong>Atlantic East</strong></td>
<td>1,492</td>
<td>423</td>
<td>375</td>
<td>88</td>
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<td><strong>Paraná</strong></td>
<td>11,453</td>
<td>10,764</td>
<td>9,649</td>
<td>12,669</td>
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<td><strong>Parnaiba</strong></td>
<td>763</td>
<td>261</td>
<td>150</td>
<td>75</td>
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<td><strong>Sao Francisco</strong></td>
<td>2,850</td>
<td>1,223</td>
<td>1,227</td>
<td>1,504</td>
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<tr>
<td><strong>Atlantic South</strong></td>
<td>4,174</td>
<td>4,659</td>
<td>4,496</td>
<td>4,599</td>
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<tr>
<td><strong>Uruguay</strong></td>
<td>4,121</td>
<td>4,435</td>
<td>4,511</td>
<td>4,342</td>
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<td><strong>Southeast Atlantic</strong></td>
<td>3,179</td>
<td>3,174</td>
<td>2,674</td>
<td>3,036</td>
</tr>
<tr>
<td><strong>Occident Atlantic NE</strong></td>
<td>2,683</td>
<td>1,915</td>
<td>1,670</td>
<td>1,250</td>
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<tr>
<td><strong>Total</strong></td>
<td>178,173</td>
<td>162,315</td>
<td>147,704</td>
<td>129,399</td>
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<tr>
<td><strong>(% Reduction)</strong></td>
<td>8.9%</td>
<td>17.1%</td>
<td>27.4%</td>
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Fundação Getúlio Vargas (FGV) Center for Sustainability Studies; *Public Policy Proposals by the Business Sector for a Low Carbon Economy in Brazil: Energy, Transportation, and Agriculture*, 2011
Issue #3: Competing Brazilian Agricultural Goals

- Sugar cane acreage distant third behind corn and soybeans.
- Between 2000 and 2008, agribusiness exports increased from 4.1% to 7% of global total. Ranked 3\textsuperscript{rd} in 2010. (FAO, 2010)
- In 2011, Brazil's soy exports to China increased 7 percent, now leads US as China's leading soy provider.
**Sugar Costs For Biofuels: Compared to Oil and Soybean Prices**

<table>
<thead>
<tr>
<th>Biofuel Production Systems</th>
<th>Lbs of Sugar for 1 Gallon Biofuel</th>
<th>Cost of Sugar/Gallon Biofuel</th>
<th>Maximum Price 1 Pound of Biofuel Sugar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cellulosic Ethanol</td>
<td>15.6</td>
<td>$ 2.14</td>
<td>$ 0.14/lb</td>
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<tr>
<td>Heterotrophic Algae</td>
<td>17.5</td>
<td>$ 2.14</td>
<td>$ 0.12/lb</td>
</tr>
<tr>
<td>Aqueous Reforming</td>
<td>21.2</td>
<td>$ 2.14</td>
<td>$ 0.10/lb</td>
</tr>
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</table>

Sugar Cost = Input Oil Cost per Gallon/Sugar Required per Gallon

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<thead>
<tr>
<th>Biofuel Production Systems</th>
<th>Soybean Price/lb (July 2012 Price)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude Oil (DOE Target Price)</td>
<td>$ 90.00</td>
</tr>
</tbody>
</table>

Soybean Price/lb (@$15.50 Bushel) $ 0.26/lb
Brazil Transportation Fuels
A Bagasse/Advanced Biofuel Future?

- 40-45% of fuel produced is sugar cane ethanol.
- 48% of total fuel use is for diesel powered vehicles.
- No significant renewable diesel production. Several US advanced biofuel technologies being tested.
- Much diesel fuel has to be imported because of a lack of refining capacity (additional scheduled by Petrobras for 2013) and crude oil supply (deep-sea oil exploitation delayed by lack of investments post 2008).
- Sugar cane bagasse, corn stover, soy bean hulls could be feedstock.
- If available at < $.14-$1.12/lb.
Brazil Electrical Sector
Competing Bagasse User

• Annual use projected to grow at 6%/year.
• Approximately 90% of electricity is from hydroelectric installations.
• Approximately 10% is imported annually from Paraguay.
• Additional projects under construction in adjacent countries.
• 5% of electricity is from biomass combustion (primarily sugar cane bagasse).
• Bagasse boilers and processing equipment being upgraded to increase electrical production.
• Additional bagasse produced from new sugar cane and other crops planned to be used for electrical production.
Will Value of Ethanol in Fuel Be Utilized?

High octane number ethanol-gasoline blends: Quantifying the potential benefits in the United States


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Abstract

Ethanol provides a significant contribution to road transportation fuel in the US, Brazil, and elsewhere. Renewable fuels regulations in the US and EU imply that ethanol use will continue to increase in the near future. The high octane rating of ethanol could be used in a mid-level ethanol blend to increase the minimum octane number (Research Octane Number, RON) of regular-grade gasoline. Higher RON would enable greater thermal efficiency in future engines through higher compression ratio (CR) and/or more aggressive turbocharging and downsizing, and in current engines on the road today through more aggressive spark timing under some driving conditions. Such an approach would differ from the current practice of blending ethanol into a gasoline blendstock formulated with lower octane rating such that the net octane rating of the resulting final blend is unchanged from historical levels.

Developing scenarios of future ethanol availability, we estimate that large increases (4–7 points) in the RON of US gasoline are possible by blending in an additional 10–20% ethanol above the 10% already present. Keeping the blendstock RON at 88 (which provides E10 with ~92.5 RON), we estimate RON would be increased to 94.3 for E15 to as much as 98.6 for E20. Even further RON increases may be achievable assuming changes to the blendstock RON and/or hydrocarbon composition. For example, an increase in blendstock RON from 88 to 92 would increase the RON of E10 from 92.5 to 95.6, and would provide higher RON with additional ethanol content (e.g., RON of 97.1 for E15 to 100.6 for E30). Potential CR increases are estimated for the different estimates of future octane number, including the effect of increased evaporative cooling from ethanol in direct injection engines. For the ethanol and blendstock RON scenarios considered, CR increases were estimated to be on the order of 1–3 CR-units for port fuel injection engines as well as for direct injection engines in which the greater evaporative cooling of ethanol can be fully utilized. Impacts to the fuel refining and blending sector and transition considerations are discussed. While additional work is needed to quantify and optimize the costs and benefits for both the automotive and refining sectors and for consumers, it appears that substantial societal benefits may be associated with capitalizing on the inherent high octane rating of ethanol in future higher octane number ethanol-gasoline blends.
Will Vehicle Fleet Change to Optimize Ethanol?

- Current “Flex-Fuel Vehicles” (FFVs) are only **Compliant** with ethanol mixtures. No mileage benefits.
- Essentially tuned for gasoline with alcohol tolerant components.
- **Optimized** FFVs would use on-board computers, DFI, and turbocharging to optimize ethanol for efficiency and mileage. Are 2nd Gen Ecoboost /Ecotec based.
- Current non-turbo technology can produce equivalent ethanol fuel economy at E-30.
- US adoption because of 54 mpg fuel mileage standards.
- Brazil would need similar standards.

Brazilian IndyCar Driver Anna Beatriz IndyCar uses E-85 for octane and cooling
## Future of Biofuels and Economies in Brazil and US Choices

### Low-Tech Food Based Biofuels?
- US: Corn-to-Ethanol
- Brazil: Sugar Cane to Ethanol

### High-Tech Biofuels?
- Total Biomass non-food feedstocks
- Jetfuels, diesel, optimized ethanol

### Economy Based on Resource Exports?
- Extracted energy exports
- Commodity crop exports

### Economy Based on Value-Added Exports?
- Energy conversion system exports
- Biomass genetic technology exports

### Investment Choices?
- Extracted energy industries
- Commodity farming
- Basic science
- Biofuel technology
- Sustainable agriculture
Many Thanks

Bob Kozak