The University of Georgia

Center for Agribusiness and Economic Development
College of Agricultural and Environmental Sciences

“BioFuels – Lessons Learned From Georgia”

www.caed.uga.edu

John McKissick, George Shumaker, and Audrey Luke-Morgan
University of Georgia
Potential BioFuels for Georgia
Results of Studies for State Energy Policy – www.caed.uga.edu

- Ethanol
- Biodiesel
- BioMass Conversion

Ethanol
Electricity
My Granddad's “Ethanol” Production Facility

The original corn value added project!
Conventional Ethanol Plant Using Corn Produces:

- Ethanol
- Distillers Dried Grain and Solubles (DDGS)
- CO₂

\[
\begin{align*}
\text{Corn} & \quad \rightarrow \quad \text{Dry Grind} \\
\text{Bu.} = 56 \text{ lbs} & \quad \rightarrow \quad \text{Ethanol} (2 \ ½ \text{ gal/bu*}) = \$5.00 \\
& \quad \rightarrow \quad \text{CO₂} (16 \text{ lbs/bu*}) \\
& \quad \rightarrow \quad \text{DDGS} (20 \text{ lbs/bu*}) = \$1.50
\end{align*}
\]

* Approximate
"Fueling" the Opportunities and Challenges - Corn Ethanol

Can we Produce 15BG from corn – livestock impact?

70 New Plants in 2007?
Adds 1.25 BB to Corn Demand

$4.25/bu = Ethanol B.E.

2006 - Ga. Use 212 MB, Prod. 26 MB

Million Bushels

### Planting Intentions: Georgia and U.S.

<table>
<thead>
<tr>
<th>CROP</th>
<th>GA 2007 1,000 Ac</th>
<th>GA 2006 1,000 Ac</th>
<th>GA %Chg</th>
<th>US 2007 1,000 Ac</th>
<th>US 2006 1,000 Ac</th>
<th>US %Chg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>500</td>
<td>280</td>
<td>+78.6%</td>
<td>90,454</td>
<td>78,327</td>
<td>+15.5%</td>
</tr>
<tr>
<td>Cotton</td>
<td>1,150</td>
<td>1,400</td>
<td>-17.9%</td>
<td>12,147</td>
<td>15,274</td>
<td>-20.5</td>
</tr>
<tr>
<td>Hay</td>
<td>680</td>
<td>650</td>
<td>+4.6%</td>
<td>63,056</td>
<td>60,807</td>
<td>+3.7%</td>
</tr>
<tr>
<td>Oats</td>
<td>70</td>
<td>70</td>
<td>0%</td>
<td>4,029</td>
<td>4,168</td>
<td>-3.3%</td>
</tr>
<tr>
<td>Peanuts</td>
<td>500</td>
<td>580</td>
<td>-13.8%</td>
<td>1,197</td>
<td>1,240</td>
<td>-3.5%</td>
</tr>
<tr>
<td>Sorghum</td>
<td>40</td>
<td>40</td>
<td>0%</td>
<td>7,109</td>
<td>6,522</td>
<td>+9.0%</td>
</tr>
<tr>
<td>Soybeans</td>
<td>250</td>
<td>155</td>
<td>+61.3%</td>
<td>67,140</td>
<td>75,522</td>
<td>-11.1%</td>
</tr>
<tr>
<td>Tobacco</td>
<td>19</td>
<td>17</td>
<td>+11.8%</td>
<td>344,170</td>
<td>338,950</td>
<td>+1.5%</td>
</tr>
<tr>
<td>Wheat</td>
<td>400</td>
<td>230</td>
<td>+73.9%</td>
<td>60,303</td>
<td>57,344</td>
<td>+5.2%</td>
</tr>
</tbody>
</table>

**Primary data source:** Prospective Plantings, March 2008, NASS
Ethanol Futures vs Spot Regular Gas

Ethanol Futures vs Spot Regular Gas

-0.50
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50

1/4/2006
2/4/2006
7/4/2006
8/4/2006
9/4/2006
10/4/2006
12/4/2006

Ethanol Futures
SE Reg Gas
Basis
ESTIMATED CAPITAL COSTS

$0.90 to $2.20 per gallon of capacity

100,000,000 gal con. plant costs about $175 million
Fractionation Plant - $220 million
<table>
<thead>
<tr>
<th>Costs</th>
<th>Million Dollars</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feedstock Costs</td>
<td>$138</td>
<td>64%</td>
</tr>
<tr>
<td>Variable Costs</td>
<td>$ 57</td>
<td>27%</td>
</tr>
<tr>
<td>Fixed Costs</td>
<td>$ 19</td>
<td>9%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$214</strong></td>
<td></td>
</tr>
<tr>
<td>Per gallon Conv.</td>
<td><strong>$2.14</strong></td>
<td></td>
</tr>
<tr>
<td>Fractionation</td>
<td><strong>$2.26</strong></td>
<td></td>
</tr>
</tbody>
</table>
Costs of Ethanol Production
100 million gallon plant

- Feedstock: 65%
- Fixed: 15%
- Other: Variable: 15%
- Energy: 15%
ESTIMATED REVENUE
@ $2.37/gal Sales Price

Million Dollars

Ethanol $237
By-products- DDGS $32.8
Total $269.8

Per gallon Conv. $2.70
Fractionation $3.00
Breakeven Price Matrix for 100 mm Gallon Plant

<table>
<thead>
<tr>
<th>Corn</th>
<th>Ethanol Sales Price</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$1.50</td>
</tr>
<tr>
<td>$3.00</td>
<td>$13,123</td>
</tr>
<tr>
<td>$3.50</td>
<td>($17,777,139)</td>
</tr>
<tr>
<td>$4.00</td>
<td>($35,567,401)</td>
</tr>
<tr>
<td>$4.50</td>
<td>($53,357,663)</td>
</tr>
<tr>
<td>$5.00</td>
<td>($71,147,925)</td>
</tr>
</tbody>
</table>
Biodiesel

A diesel fuel substitute made by combining alcohol with vegetable oils or animal fats.
Potential Feedstocks

*Biodiesel can be produced from any type of vegetable or animal fat.

Soybean Oil, Cottonseed oil, Canola Oil, Corn Oil, Peanut Oil, Spent Restaurant Fats, Rendered Poultry Fat, Rendered Pork fat, beef Tallow
Comparison of Biodiesel & Diesel Prices
Jan 4, 2006 to Date

SE B100
Spot Gulf Diesel
Basis
TECHNICAL CONSIDERATIONS

1 bushel of soybeans yields @ 10.5 lbs oil
   1.31 gal per bushel

1 ton peanuts yields about 960 lbs oil
   128 gal per ton

1 ton cotton seed yields about 520 lbs oil
   69 gals per ton

Veg oils weigh about 7 ½ lbs per gallon
Methyl Ester Process

Feedstock -> Process -> Products

100 lbs fat/oil
13.8 lbs Methanol
1.15 lbs Catalyst

Methyl Ester Process

Methyl Ester 98.9 lbs
Glycerine 10.35 lbs
Feed Fat 1.15 lbs
Methanol 4.6 lbs

For each unit of energy used to produce biodiesel, about 3.2 units of energy are gained. Ratio for ethanol is about 1.25.
ESTIMATED CAPITAL COSTS

$0.90 to $2.50 per gallon of capacity

15,000,000 gal plant costs about $33.5 million
## ESTIMATED PRODUCTION COST

@ $.36/lb Feedstock cost
30 million gallon plant

<table>
<thead>
<tr>
<th>Million Dollars</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Feedstock Costs</td>
<td>$83.1</td>
</tr>
<tr>
<td>Variable Costs</td>
<td>$14.1</td>
</tr>
<tr>
<td>Fixed Costs</td>
<td>$ 6.3</td>
</tr>
<tr>
<td>Total</td>
<td>$103.5</td>
</tr>
</tbody>
</table>

Per gallon $3.46
Costs of Biodiesel Production
60 million gallon plant

- Feedstock Costs (81%)
- Chemicals
- Utilities
- Supplies and Services
- Labor plus Benefits
- Repairs & Maintenance
- Insurance
- Other/Gen./Admin
- Fixed Cost
Total Cost Per Gallon

Million Gallons of Biodiesel

- 0.5 Million Gallons: $3.10
- 15 Million Gallons: $2.90
- 30 Million Gallons: $2.70
- 60 Million Gallons: $2.50

$2.40
ESTIMATED REVENUE
@ $3.35/gal Sales Price

Million Dollars

Biodiesel $97.5
By-products $ 4.1
Total $101.5

Per gallon $3.39
# Breakeven Price Matrix for 60 mm Gallon Plant

<table>
<thead>
<tr>
<th>Feedstock Price</th>
<th>Biodiesel Sales Price</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$2.50</td>
</tr>
<tr>
<td>$0.20</td>
<td>$31,596,282</td>
</tr>
<tr>
<td>$0.23</td>
<td>$17,761,727</td>
</tr>
<tr>
<td>$0.26</td>
<td>$3,927,172</td>
</tr>
<tr>
<td>$0.29</td>
<td>($9,907,383)</td>
</tr>
<tr>
<td>$0.32</td>
<td>($23,741,938)</td>
</tr>
<tr>
<td>$0.35</td>
<td>($37,576,493)</td>
</tr>
</tbody>
</table>
BioMass Conversion

- Convert Biomass into Ethanol called “Cellulosic Ethanol”
  - Not yet proven on industrial scale
  - Very energy dependent, capital cost Ga.
    - Plant 50mg = $275 Mil.!

- Convert Biomass into electricity – What About Renewable Fuels Portfolio of 15%?
  - Gasification
  - Pyrolysis
Gasification Costs

$25/ton Feedstock Cost
# Biomass Sources & Costs

- Pecan Hulls: $17.78
- Poultry Litter: $24.46
- Gin Trash: $19.94
- Wood Chips: $27.28
- Bark: $24.62
- Wood Residue: $26.46
- Peanut Hulls: $44.63
- Cotton Stalks: $50.96
- Hay: $61.25
- Switch Grass: $91.25
Biomass Feed Stock Availability
<table>
<thead>
<tr>
<th>Plant Size</th>
<th>160 WTPD</th>
<th>267 WTPD</th>
<th>533 WTPD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gasification</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Production Capacity (kW)</td>
<td>5,956</td>
<td>9,924</td>
<td>19,848</td>
</tr>
<tr>
<td>KiloWatt Hours Per Year</td>
<td>50,032,000</td>
<td>83,360,000</td>
<td>166,720,000</td>
</tr>
<tr>
<td>Total Estimated Capital Cost</td>
<td>$19,564,260</td>
<td>$29,340,948</td>
<td>$43,777,740</td>
</tr>
<tr>
<td>Capital Cost per kW</td>
<td>$3,285</td>
<td>$2,957</td>
<td>$2,206</td>
</tr>
<tr>
<td>Estimated Operating Costs</td>
<td>$5,452,557</td>
<td>$8,128,049</td>
<td>$13,240,628</td>
</tr>
<tr>
<td>Operating Cost per kWhr</td>
<td>$0.109</td>
<td>$0.098</td>
<td>$0.079</td>
</tr>
</tbody>
</table>
# Feedstock Cost Impact on Electricity Cost

**533 WTPD Gasification Plant**

<table>
<thead>
<tr>
<th>Feedstock Price</th>
<th>Electricity Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>$0.051</td>
</tr>
<tr>
<td>$5</td>
<td>$0.057</td>
</tr>
<tr>
<td>$10</td>
<td>$0.063</td>
</tr>
<tr>
<td>$15</td>
<td>$0.068</td>
</tr>
<tr>
<td>$20</td>
<td>$0.074</td>
</tr>
<tr>
<td>$25</td>
<td>$0.079</td>
</tr>
<tr>
<td>$30</td>
<td>$0.085</td>
</tr>
</tbody>
</table>
Georgia Average Retail Prices
(2005 cents per KWhr) by Sector

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>9.90</td>
<td>9.22</td>
<td>8.23</td>
<td>8.64</td>
</tr>
<tr>
<td>Commercial</td>
<td>9.73</td>
<td>8.60</td>
<td>7.03</td>
<td>7.67</td>
</tr>
<tr>
<td>Industrial</td>
<td>6.41</td>
<td>5.31</td>
<td>4.44</td>
<td>5.28</td>
</tr>
<tr>
<td>Other</td>
<td>10.76</td>
<td>10.10</td>
<td>9.22</td>
<td>6.90</td>
</tr>
<tr>
<td>All Sectors</td>
<td>8.70</td>
<td>7.77</td>
<td>6.72</td>
<td>7.43</td>
</tr>
</tbody>
</table>
Biomass Generation Balance By County – Key Using Multiple Feedstocks
## Economic Impact of Biofuel Production Per Million Gallons

<table>
<thead>
<tr>
<th></th>
<th>Corn Based Ethanol</th>
<th>Corn Feedstock</th>
<th>Cellulosic Ethanol</th>
<th>Cellulosic Feedstock</th>
<th>Biodiesel Feedstock</th>
<th>Soybean Oil Feedstock</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Output ($)</strong></td>
<td>2,666,419</td>
<td>1,896,621</td>
<td>2,527,717</td>
<td>539,212</td>
<td>3,529,303</td>
<td>3,331,927</td>
</tr>
<tr>
<td><strong>Labor Income ($)</strong></td>
<td>227,929</td>
<td>847,172</td>
<td>242,274</td>
<td>116,499</td>
<td>224,310</td>
<td>800,837</td>
</tr>
<tr>
<td><strong>Employment</strong></td>
<td>5</td>
<td>43</td>
<td>6</td>
<td>3</td>
<td>4</td>
<td>25</td>
</tr>
<tr>
<td><strong>State Taxes¹ ($)</strong></td>
<td>23,057</td>
<td>56,209</td>
<td>24,052</td>
<td>9,547</td>
<td>18,710</td>
<td>73,431</td>
</tr>
<tr>
<td><strong>Local Taxes¹ ($)</strong></td>
<td>20,242</td>
<td>41,048</td>
<td>20,834</td>
<td>5,956</td>
<td>14,793</td>
<td>57,042</td>
</tr>
<tr>
<td><strong>Sum of Taxes¹ ($)</strong></td>
<td>43,299</td>
<td>97,256</td>
<td>44,886</td>
<td>15,503</td>
<td>33,503</td>
<td>130,473</td>
</tr>
</tbody>
</table>
Any Questions?