Sustaining Corn to Ethanol

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Savannah, Georgia, U.S.A.
Are We Running Out of Corn?

U.S. Corn Ending Stocks
(million bushels)

Sources: USDA - National Ag Statistics Service and Economic Research Service
US Ethanol Plants

- **Operating plants**
  - 184 Plants in USA
  - in 26 states, 11.7 BGY
  - 40 Plants in Iowa, 3.2 BGY

- **Construction/expansion**
  - 21 Plants in USA, 1.4 BGY
  - 2 Plants in Iowa, 0.4 BGY

Source: Ethanol Producer magazine
## Iowa Ethanol Production and Corn Usage

<table>
<thead>
<tr>
<th>Summary Statistics May-2010</th>
<th>n</th>
<th>Ethanol Produced mil gal/yr</th>
<th>Corn Used mil bu/yr</th>
<th>DGS 000 tons/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Current Dry-grind Plants</strong></td>
<td>34</td>
<td>3,280</td>
<td>1170</td>
<td>10,237</td>
</tr>
<tr>
<td><strong>Expansions and new construction</strong></td>
<td>1</td>
<td>277</td>
<td>98</td>
<td>857</td>
</tr>
<tr>
<td><strong>Wet Mills</strong></td>
<td>4</td>
<td>500</td>
<td>178</td>
<td>1,557</td>
</tr>
<tr>
<td><strong>Nearby Iowa</strong></td>
<td>11</td>
<td>636</td>
<td>227</td>
<td>1,986</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>50</td>
<td>4,693 (69% of 2009)</td>
<td>1,673</td>
<td>14,637</td>
</tr>
</tbody>
</table>
Overall = 2.1 bu/a/yr; Last 10= 3.5 bu/a/yr; Seed industry = 4-6 bu/a/yr (forward)
~400-500 million bu/year increase
Nitrogen use: 1.0-1.1 lb/bu down to 0.7-0.8 lb/bu
Corn Yield Potential

Source: Monsanto, June 2010
What's in an Acre of Corn?

- Protein (lb/acre)
- Oil (lb/acre)
- Ethanol (gal/acre)

Potential Corn and Ethanol Production
Feed, Food Export @ +1%/yr, 80MM Acres of Corn

Potential Ethanol or Surplus

Other Uses

Year
2005 2010 2015 2020 2025 2030 2035 2040

Billion gal. billion bu
5.0 10.0 15.0 20.0 25.0 30.0 35.0 40.0 45.0

- Gal of Etoh, 4 bu/a/yr
- Total Corn, 4 bu/a/yr
- Gal of EtOH, 6 bu/a/yr
- Total Corn, 6 bu/a/yr
Infrastructure Investments

- 4-8 new 100mgy plants per year ($200MM/plant)
- Storage and Handling ($3-$4/bu cap’y)
- Drying ($250K/dryer)
- Related support
  - Railcars, trucks
  - Roads, other…

$100 Bln+ is conservative
## Corn Ethanol Production

<table>
<thead>
<tr>
<th></th>
<th>2001</th>
<th>2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy BTU/gal</td>
<td>36,000</td>
<td>25,920</td>
</tr>
<tr>
<td>Electricity Kwh/gal</td>
<td>1.09</td>
<td>0.70</td>
</tr>
<tr>
<td>Yield Gal/bu</td>
<td>2.64</td>
<td>2.78</td>
</tr>
<tr>
<td>Water Gal/gal</td>
<td></td>
<td>2.72</td>
</tr>
</tbody>
</table>

## Corn Ethanol vs. Gasoline

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Avg GHG, % red of gasoline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic, Dry DDGS</td>
<td>-17%</td>
</tr>
<tr>
<td>Frac, Membrane, Cold Cook</td>
<td>-36%</td>
</tr>
<tr>
<td>Above plus Wet DGS</td>
<td>-46%</td>
</tr>
</tbody>
</table>

From EPA RFS2 analysis, presented by Moss, FEW, June 2010

Advanced Biofuel = -50% except corn which is defined as not advanced
Typical Fractionation Products

- Ethanol (less); 2% = 0.06 gal/bu
- DDGS @42-47% protein; lower quality but more digestible (IL, SD studies)
- Bran
- Oil; ~1.4 lb/bu @ 80% extraction of germs (up to 0.6 - 0.7 bgy of biodiesel @ 80% conversion on 4 bln bu of corn)
Drying Costs

- EPA estimates (2007): 32,300 BTU/gal
- Equates to 2636 BTU/lb of water
  - 70% moisture DDGS dried to 12%

Impact of Fractionation

<table>
<thead>
<tr>
<th>Lb DDGS/ bu</th>
<th>BTU/bu</th>
<th>% of Ethanol</th>
</tr>
</thead>
<tbody>
<tr>
<td>17.8</td>
<td>90440</td>
<td>43%</td>
</tr>
<tr>
<td>13.5</td>
<td>68785</td>
<td>33%</td>
</tr>
</tbody>
</table>
Capital Costs

- Range from $10 million to $40 million for a 50 million gallon ethanol plant
- The inclusion of corn oil extraction technologies moves costs to the higher end of the spectrum
- Most vendors point to a payback period of under 3 years

Variable Costs

- Decreased energy needs per gallon for:
  - Liquidification and cooking
  - Distillation
  - Drying of distillers grains and solubles
- Possible energy generation from bran
- Could reduce energy demand by nearly 50%
Supply Chain Agronomics: Ethanol Yield

0.1 gal/bu = $6,000,000/yr
(100 mgy plant)
Also 4% yield increase

Predicted ethanol yield against reference ethanol yield for final Protein-Oil-Density equation

<table>
<thead>
<tr>
<th>Component</th>
<th>Final Equation Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>B0</td>
<td>3.23</td>
</tr>
<tr>
<td>Protein</td>
<td>-0.062</td>
</tr>
<tr>
<td>Oil</td>
<td>-0.030</td>
</tr>
<tr>
<td>Density</td>
<td>0.104</td>
</tr>
</tbody>
</table>

Protein, Oil and Density measured by Near-Infrared; about 1 minute/sample
Summary

- Corn production is increasing faster than traditional uses can absorb.
- Increase 4-6 bu/a/yr = 350-500MM bu
- Huge surpluses very quickly if …
- Process improvements approach “advanced” category
- Capital investment in plants and grains infrastructure are the limiting factor.
- So why aren’t we putting R and D support into corn?
Where To Find Us…

Iowa Grain Quality Initiative

Grain Quality Laboratory

www.iowagrain.org

www.grainlab.org

Supporting Services and Technologies for BioProcess Industries

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