US Corn Ethanol: Emerging Technologies at the Biorefinery and Field Level

Briefing

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• The Production Technologies of First and Second Generation Biofuels are Rapidly Advancing
  – At the Plant Level
  – During Feedstock Production

• Main Drivers Are:
  – RFS2, Innovation Cycles, Access to Capital

• Technologies also Ensure Long-Term Sustainability
2013 Corn Ethanol: New Technologies

Ethanol Plant Level as well as Corn Production

- Front End Oil Recovery - BOS (Brix Oil Separation)
- Protein Recovery - MSC - Maximum Stillage Co-Products
- Fiber Bypassing/Separation - Pre and Post-Fermentation - to be used in conjunction with SGT/Front End Oil and MSC
- Fiber Bypassing/Separation
- Process - Pre Fermentation
- CHP - Combined Heat and Power - 200 psig steam
- CHP - Combined Heat and Power - 400-600 psig steam
- Super Heated Steam Dryers
- Additional Energy and Yield Projects
- Liquefaction Mash Exchanger Plate Expansion
- Fermentation Exchanger Plate Expansion
- CO2 Scrubber Ethanol Reclaim
- 200 Proof Denaturing
- VFD Drive Addition
- DDGS Cooling
- Central Vent Condensing
- Corn Replacement Feed
- Nitrogen Stabilizers
- Control Release Nitrogen
- Soil Testing
- Remote Sensing
- Farm Machinery Technologies Using GPS Tracking Technology
- Modern Hybrids and GEO Traits
- Enzymes Contained in Corn Endosperm
Impact of New Technologies: Plant Level

From 2001 to 2013:

• 34% reduction in thermal energy use and
• a 31% reduction in electricity while
• increasing yield by 7%
• but RFS2 uses 2007 data

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<tr>
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<th>2001</th>
<th>2008</th>
<th>2012</th>
<th>Trend</th>
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</thead>
<tbody>
<tr>
<td>Yield (undenatured, gallon/bushel)</td>
<td>2.64</td>
<td>2.78</td>
<td>2.82</td>
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<tr>
<td>Thermal Energy (Btu/gallon, LHV)</td>
<td>36,000</td>
<td>26,206</td>
<td>23,862</td>
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<tr>
<td>Electricity Use (kWh/gallon)</td>
<td>1.09</td>
<td>0.73</td>
<td>0.75</td>
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<tr>
<td>DDG Yield (dry) incl. corn oil (lbs/bu)</td>
<td>15.81</td>
<td>15.73</td>
<td></td>
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<tr>
<td>Corn Oil Separated (lbs/bushel)</td>
<td>0</td>
<td>0.11</td>
<td>0.53</td>
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<tr>
<td>Corn Oil Separated (% of Plants)</td>
<td>0%</td>
<td>33%</td>
<td>74%</td>
<td></td>
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<tr>
<td>Water Use (gallon/gallon)</td>
<td>5</td>
<td>2.72</td>
<td>2.7</td>
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</tbody>
</table>
• Impact of New Technologies: Ag Level
• Record 2014 Yield Projections: 171.7 bu/acre (USDA 9/11/14)
Example 1: Corn Kernel Fiber to Ethanol

- Fiber in corn kernel is processed into cellulosic ethanol at existing starch ethanol plants
- Potential to produce 1 billion plus gallons of cellulosic ethanol out of existing dry grind plants
- Quad County Corn Processors just started commercial operation
- Rapid adoption expected mirroring the rate of corn oil separation technologies
Example 2: Corn Replacement Feed

• Higher corn yields have also increased the amount of plant residue (stover etc.) produced by modern hybrids
  – Stover is becoming a management issue

• Growers have started to remove corn stover for use as animal feed in nearby feedlot operations

• Stover, pretreated with ~5% lime substitutes for corn and other feed
Land Use Impact: CRF

• A simplified insight into the co-product impact of stover:
  • A corn field with a yield of 170 bu/acre produces 4.75 tons of corn and approximately an equivalent amount of corn stover
  • If 30% or 1.43 tons of that stover can be sustainably removed for CRF (a reasonable removal rate for many areas) this is equivalent to producing an extra 50+ bushel of corn on that acre (assuming 1:1 substitution in animal diets)
  • In this case this would constitute a 30% land credit form this field
Land Use Impact: DDG


Mumm et al: “Although 40.5% of corn grain was channeled to ethanol processing in 2011, only 25% of U.S. corn acreage was attributable to ethanol when accounting for feed co-product utilization.”
Technologies that Ensure Sustainability

• Verification of Biorefinery Process Integrity
  – Sophisticated process monitoring and quality assurance programs (QAP) including third party verifiers (for example Genscape Inc.)
  – Emerging under RFS2 for starch and cellulosic ethanol

• Agricultural sustainability such as third party verifiers (for example International Sustainability and Carbon Certification) or benchmarking (for example Field to Market)
Contact

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