US Biofuels Exports to Asia and Sustainability Requirements
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Implementation of Sustainable Supply Chains

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Introduction

• Export markets often set **stringent sustainability standards** for foreign products including biofuels.
• Diverse production pathways must be reviewed. Industry average for US fuels may not always meet most stringent requirements but significant volumes may.
• Opportunity to explore different modeling approaches
• Japan currently only sourcing Brazilian sugarcane ethanol due to GHG profile.
  - Determined Volume of US Ethanol that meets 50% GHG Reduction threshold set by Japan.
Introduction

• Japan is a key biofuels market because it is closely watched by other Asian countries
  o Japan is developing new multi-year energy policy right now
  o High import of food calories and primary energy leads thorough analysis of biofuels and petroleum fuels sustainability

• Many of the Japanese LCA guidelines are closely in line with the European Union’s Renewable Energy Directive (RED)

• In the past for corn ethanol significant volumes of US-produced fuel could meet the 35% greenhouse gas (GHG) reduction threshold over gasoline set by the European RED (increasing to a 50% threshold by 2018) and

• our latest data shows that this is also the case for the 50% GHG reduction threshold set by the Japanese “Judgment Criteria for Oil Refiners on the Use of Non-Fossil Energy Sources, Ministry of Economy, Trade and Industry Public Notice No. 242 of 2010.”
Employed Life Cycle Model

• The Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation Model by Argonne National Laboratory (a US Department of Energy laboratory) is the gold standard for life cycle analysis in the US and it contains the most up to date databases on US production methods and the efficiency of the US agriculture and energy sectors.

• GREET is a flexible LCA model that can be and has been adapted to fit regulation-specific guidelines including those set by the CA Low Carbon Fuel Standard, the EPA RFS2 and the RED.

• In light of the Japanese alignment with the RED we assumed that GREET based modeling would be accepted by Japanese regulators.

• As with modifications for LCFS, RFS2, and RED type pathway modeling GREET can be adjusted to fit the Japanese “Judgement Criteria.”
Leading-Edge US Ethanol Plant Technologies that Provide GHG Reductions
Introduction to Life Cycle Modeling:
System Boundary for Selected Corn Ethanol Pathway
Qualifying Technologies that Provide CO$_2$ Reductions

- Corn Oil Separation at Ethanol Plant going into Biodiesel Production
- Energy Efficiency Improvements
- CO$_2$ Recovery for Food Industry or Enhanced Oil Recovery
- Wet DDG
- Anaerobic Digesters
- Direct Land Use Change
Corn Oil to Biodiesel

- Corn oil separated at ethanol plants provides feedstock for biodiesel production
- Two Uses:
  - Sale into Animal Feed Markets
  - Substitution for petroleum based diesel fuel

2015 Biomass Based Diesel Feedstocks

- Soybean Oil 49%
- Corn Oil 14%
- Used Cooking Oil 15%
- Animal Fat 15%
- Canola 6%
- Other, Recycled 1%
Syngenta’s Enogen product has directly incorporated enzymes into its corn traits.

The technology is now used by 18 plants producing 1.3 billion gallon of corn ethanol (EPM 12/2015).

According to Syngenta Enogen raises ethanol yield per bushel by up to 3%, reduces electricity use up to 3%, and lowers natural gas use up to 10%.

Example: Western Plains Energy
CO$_2$ Recovery at Ethanol Plants for Food Industry Use and Enhanced Oil Recovery

- About 40 percent of the North American merchant market for CO$_2$ is sourced from ethanol plants.
- Each bushel of corn produces 17 lbs of CO$_2$ during fermentation.
- Ethanol plants produce CO$_2$ for both:
  - Food/Beverage Industry as well as for
  - Enhanced Oil Recovery
- If not recovered as a by-product CO$_2$ must be produced in conventional CO$_2$ and Dry Ice Production Plants:
  - Fuel source: low Sulphur content diesel, kerosene or natural gas.

Conventional CO2 plant fired by fossil fuels
Wet DDG and Anaerobic Digesters

Wet DDG
• Nebraska Plants collocated with feed lots
• Skip the drying step of Distillers Dried Grains and ship feed wet to feedlots
• Significant energy savings

Anaerobic Digesters
• Anaerobic digestion of syrup, DGS, and manure
• Digester produces biogas for energy production offsetting onsite energy use
• Example: Western Plains Energy LLC in Kansas (also uses Enogen)
Direct Land Use Change

- Direct land use change to high corn on corn rotations around plants provide annual carbon sequestration
- Derive state-specific carbon sequestration factors based on the GREET CCLUB database
- Soil carbon changes for mixed cropland going into corn on corn rotations under conventional tillage; 100 cm soil depth; CCLUB Version 2015; C-Database Tab Column “CH”)
- Recommendation: Credit under Japanese Direct Land Use Provisions could be applied if transitions to high corn on corn transitions around the plant are verified
Model Inputs and Results
Technology Combinations

- **Base Case: Corn Ethanol Dry Mill**
  - Dry DGS production
  - Corn oil extracted for biodiesel and biodiesel displaces diesel
- **Wet DGS with Efficiency Improvements**
  - Corn Ethanol Dry Mill with Primary wet DGS production, Located near cattle feeding (Nebraska)
  - Corn oil extracted for biodiesel (1 lb/bu corn) and Biodiesel displaces diesel
  - Enogen and efficiency improvements (+3% yield, -10% NG, -3% power)
- **Corn Ethanol Dry Mill with CO₂ collected for dry ice and beverage**
- **Wet DGS with Enhanced Oil Recovery**
  - Corn Ethanol Dry Mill with Primary wet DGS production
  - Located near oil production (Kansas)
  - Corn oil extracted for biodiesel and Biodiesel displaces diesel
- **Wet DGS with Anaerobic Digestion**
  - Corn Ethanol Dry Mill with Primary wet DGS production
  - Located near cattle feeding (Nebraska)
  - Corn oil extracted for biodiesel and Biodiesel displaces diesel
  - Anaerobic digestion of syrup, DGS, and manure
- **All Technology Combinations modeled with and without Direct Land Use Change Credit**
81.7 g/MJ Petroleum Basecase Without Land Use Credit

-42.7%  -52.2%  -85.5%  -74.2%  -60.5%  -65.0%  0.0%
81.7 g/MJ Petroleum Basecase With Land Use Credit

- Base Corn Ethanol: -59.2%
- High Efficiency: -67.6%
- DDGS: -102.0%
- CO2 EOR: -90.8%
- Digester: -77.0%
- Brazil Sugarcane: -65.0%
- Petroleum: 0.0%
# Volume that Meets Japanese GHG Reduction Criteria

<table>
<thead>
<tr>
<th>Base Plant: Dry DGS</th>
<th>Plants Meeting 50% GHG Reduction With Direct Land Use Credit</th>
<th>Plants Meeting 50% GHG Reduction Without Direct Land Use Credit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn Oil to Biodiesel</td>
<td>30</td>
<td>0</td>
</tr>
<tr>
<td>Wet DGS</td>
<td>Enogen / Efficiency Improvements</td>
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<tr>
<td>Corn Oil to Biodiesel</td>
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<td>10</td>
</tr>
<tr>
<td>Mixed DGS</td>
<td>CO₂ Food Markets</td>
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<tr>
<td>Corn Oil to Biodiesel</td>
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</tr>
<tr>
<td>Wet DGS</td>
<td>CO₂ EOR</td>
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<tr>
<td>Corn Oil to Biodiesel</td>
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<td>5</td>
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<tr>
<td>Less DGS</td>
<td>Anaerobic Digester</td>
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<tr>
<td>Corn Oil to Biodiesel</td>
<td>2</td>
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</table>

<table>
<thead>
<tr>
<th></th>
<th><strong>Total # of Plants</strong></th>
<th><strong>Volume (gallons)</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>82</strong></td>
<td><strong>6,068,000,000</strong></td>
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<tr>
<td></td>
<td><strong>52</strong></td>
<td><strong>3,848,000,000</strong></td>
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</tbody>
</table>

=22.8 Billion Liters
= 14.4 Billion Liters
Land Use Change and Sustainability Verification and Documentation Using New Remote Sensing Tools
New Software for Sustainability Assessment: Global Risk Assessment Services Tool (GRAS) for United States Domestic LUC Analysis

- Feedstocks are not grown on deforested lands; Verify use of large, mature crop areas
- Applicable for US corn/soy feedstocks
- Use of NAIP Imagery (1-2 m resolution)
- Side by side viewer of pre 2008 and current image for direct comparison
- Overlay protected areas, carbon masks, LUC risk masks
New Software: GRAS Tool for Global Land Use Analysis – Ensure Biofuels Feedstocks Do not come from Deforested Lands

- Particularly applicable for South American Feedstocks (sugarcane, corn, soy) and S/E Asia (Palm, etc.)
- Use of MODIS Enhanced Vegetation Index (300 Images) going back to 2000.
- Differentiate among the types of green cover, see the history of the land, assess double cropping and detect LUC.
- Grassland has EVI value of 0.3-0.4. The same would apply for perennial trees such as rain forests but on a higher EVI value of about 0.6. Conversion would appear as a clear change in
Summary

• Significant volumes of US produced corn ethanol can meet diverse international sustainability standards
• However, detailed pathway analysis is required and thorough understanding of international sustainability modeling approaches
• New remote sensing tools are now available to verify and confirm direct luc.