Drop-in biofuels in the AEO

EIA Biofuels Workshop
Mac Statton, Industrial Process Analyst
March 20, 2013 | Washington, DC
Overview

• What are drop-in biofuels?

• Technology assessment methodology
  – Technology descriptions
  – Process design review
  – Planned capacity
  – Production cost with learning

• Projections and implications

• Summary and look to the future
What are drop-in biofuels?

• Approved fuels
  – Meet ASTM specifications
  – Have received all necessary EPA approvals

• Infrastructure compatible
  – Can move in pipelines, trucks, and barges without equipment modification
  – Usable in existing fueling stations without modification
  – Usable by existing vehicle fleet without modification

• There is a continuum based on the above characteristics

Note: FAME stands for fatty acid methyl esters. HRJ stands for hydrotreated renewable jet. HEFA stands for hydrotreated esterified fatty acids.
How do you make drop-in biofuels?

- Biomass Handling
- Pyrolysis
- Gasification
- Fuel Synthesis
- Seed Crushing
- Green Diesel Hydrotreating
- Saccharification/Fermentation
- Liquid Phase Reforming
- Hydrotreating

- ‘Designer’ hydrocarbons
- Aromatic hydrocarbons
- Paraffinic hydrocarbons

Cellulosic or starch biomass

Seed crops

Waste greases

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Three pyrolysis technology options

• Non-catalytic fast pyrolysis
  – Produces 10% oxygen content product for sale to existing refineries
  – Used as process model for AEO2012
  – Several projects in Canada for producing food products, not fuels

• Biomass catalytic cracking (pyrolytic)
  – Produces zero oxygen content fuels for blending
  – Used as process model for AEO2013
  – Several planned projects by KiOR

• Integrated hydropyrolysis
  – Produces zero oxygen content fuels for blending
  – For consideration in future AEOs
  – No announced projects at this time
## Process Design Review - Pyrolysis

<table>
<thead>
<tr>
<th></th>
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</thead>
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<tr>
<td>Nameplate capacity</td>
<td>b/d</td>
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<td>4,957</td>
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<td>3,796</td>
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<td>65</td>
<td>50</td>
<td>50</td>
<td>40</td>
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<tr>
<td>Capacity factor</td>
<td>%</td>
<td>90</td>
<td>90</td>
<td>90</td>
<td>90</td>
<td>90</td>
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<tr>
<td>Economic lifetime</td>
<td>Years</td>
<td>15</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>15</td>
</tr>
<tr>
<td>Construction lead time</td>
<td>Years</td>
<td>4</td>
<td>2.5</td>
<td>&lt;2</td>
<td>&lt;2</td>
<td>4</td>
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<tr>
<td>Feedstock</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Biomass</td>
<td>tons/day</td>
<td>438</td>
<td>2,205</td>
<td>2,205</td>
<td>2,205</td>
<td>1,128</td>
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<tr>
<td>Hydrogen</td>
<td>mcf/day</td>
<td>-</td>
<td>2,186</td>
<td>ND</td>
<td>ND</td>
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<tr>
<td>Electricity</td>
<td>MW</td>
<td>-</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>-</td>
</tr>
<tr>
<td>Products</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Light ends</td>
<td>b/d</td>
<td>48</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
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<tr>
<td>Gasoline</td>
<td>b/d</td>
<td>618</td>
<td>2,073</td>
<td>ND</td>
<td>ND</td>
<td>652</td>
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<tr>
<td>Diesel</td>
<td>b/d</td>
<td>21</td>
<td>2,884</td>
<td>ND</td>
<td>ND</td>
<td>652</td>
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</table>

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Two gasification technology options

• Fischer-Tropsch (FT) Synthesis
  – Used beginning in AEO2011 due to high quality diesel product
  – Recently there have been several project cancelations and decommissionings (e.g., Rentech, Choren)

• Methanol to Gasoline (MTG)
  – Produces light hydrocarbon product (~90% gasoline)
  – At least one new project has been announced
  – Co-integration of natural gas feedstock
### Process Design Review - Gasification

<table>
<thead>
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<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Nameplate capacity</td>
<td>b/d</td>
<td>3,143</td>
<td>1,882</td>
<td>2,609</td>
<td>3,235</td>
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<td>Overnight capital cost</td>
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<td>$350,434</td>
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<tr>
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<td>%</td>
<td>51</td>
<td>51</td>
<td>47</td>
<td>50</td>
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<tr>
<td>Capacity factor</td>
<td>%</td>
<td>90</td>
<td>96</td>
<td>96</td>
<td>96</td>
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<tr>
<td>Economic lifetime</td>
<td>Years</td>
<td>15</td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Construction lead time</td>
<td>Years</td>
<td>4</td>
<td>3</td>
<td>2.5</td>
<td>2.5</td>
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<tr>
<td>Process Inputs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biomass</td>
<td>tons/day</td>
<td>2,027</td>
<td>2,000</td>
<td>2,000</td>
<td>2,000</td>
</tr>
<tr>
<td>Natural gas</td>
<td>mcf/day</td>
<td>-</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Products</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LPG</td>
<td>b/d</td>
<td>-</td>
<td>ND</td>
<td>ND</td>
<td>463</td>
</tr>
<tr>
<td>Naphtha</td>
<td>b/d</td>
<td>864</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
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<tr>
<td>Gasoline</td>
<td>b/d</td>
<td>-</td>
<td>ND</td>
<td>2,609</td>
<td>2,772</td>
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<tr>
<td>Diesel</td>
<td>b/d</td>
<td>2,279</td>
<td>ND</td>
<td>ND</td>
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<tr>
<td>Electricity</td>
<td>MW</td>
<td>32</td>
<td>51</td>
<td>32</td>
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Technology Description – Green Diesel

• **Process steps**
  – Fatty acids are mixed with hydrogen and begin their conversion to hydrocarbons. CO2 and water are produced as well and are separated by lowering the pressure.
  – The partially converted fatty acids are mixed with more hydrogen in a second reactor, removing the rest of the oxygen.
  – Hydrocarbons are then separated into LPG and distillate range material.
  – Distillate range material is sometimes sent to a third reactor where it is isomerized for better fuel characteristics.

• **Process technologies**
  – Syntroleum (licensor for Dynamic Fuels)
  – UOP/Eni Ecofining (licensor for Diamond Green Diesel)
  – Neste NexBTL
## Existing and near-term planned capacity

<table>
<thead>
<tr>
<th>Process</th>
<th>Company</th>
<th>Status</th>
<th>Online Year</th>
<th>Plant Location</th>
<th>Nameplate (bpd)</th>
<th>US$</th>
<th>$/bd</th>
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</thead>
<tbody>
<tr>
<td>Pyrolysis (gasoline, diesel)</td>
<td>KiOR</td>
<td>Startup</td>
<td>2012</td>
<td>Columbus</td>
<td>717</td>
<td>215</td>
<td>$270,000</td>
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<tr>
<td></td>
<td>KiOR</td>
<td>Construction</td>
<td>2014</td>
<td>Natchez</td>
<td>2,609</td>
<td>ND</td>
<td>ND</td>
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<tr>
<td>Gasification (gasoline)</td>
<td>Sundrop</td>
<td>Construction</td>
<td>2015</td>
<td>Alexandria</td>
<td>2,609</td>
<td>500</td>
<td>$191,625</td>
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<tr>
<td>Diamond Green Diesel</td>
<td>Dynamic Fuels</td>
<td>Complete</td>
<td>2011</td>
<td>Geismar</td>
<td>4,809</td>
<td>127</td>
<td>$25,959</td>
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<tr>
<td>Emerald Biofuels</td>
<td>Diamond Green Diesel</td>
<td>Construction</td>
<td>2013</td>
<td>Norco</td>
<td>8,937</td>
<td>427</td>
<td>$47,778</td>
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<tr>
<td></td>
<td>Emerald Biofuels</td>
<td>Development</td>
<td>TBD</td>
<td>Plaquemine</td>
<td>5,544</td>
<td>ND</td>
<td>ND</td>
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</tbody>
</table>

While no projects have yet been announced, CRI/Criterion (refinery technology company related to Royal Dutch Shell) is marketing a pyrolysis technology called Integrated Hydropyrolysis and Hydroconversion (IH2).
If significant plant builds occur, production costs for certain drop-in biofuel technologies could fall due to process learning.

Notes: Feedstock costs assumptions are $0.50/lb for renewable oils and $50/ton for cellulosic biomass.
With NEMS, we transition from production cost point estimates to projections over time
Current projections indicate rapid growth of drop-in biofuels after 2030 as petroleum prices move higher than biofuel production costs.

Source: EIA, AEO2013 Early Release
Summary and look to the future

- The biofuels industry is dynamic

- Potential technology changes for future AEOs
  - Update gasification and pyrolysis models
  - Conversions of ethanol plants to butanol plants
  - Improved yield, energy efficiency, and water use

- Potential competition between fuels and chemicals
For more information


Short-Term Energy Outlook | www.eia.gov/steo

Annual Energy Outlook | www.eia.gov/aeo

International Energy Outlook | www.eia.gov/ieo

Monthly Energy Review | www.eia.gov/mer

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