Positioning Your Plant to Maximize the Opportunity Created by Low Carbon Fuel Markets

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EcoEngineers
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Low Carbon Fuels in The News

- Pacific Ethanol, Madera, CA
  - 5 MW solar system
  - Kernel Fiber Cellulosic Ethanol

- Calgren Renewable Fuels, Pixley, CA
  - On-site anaerobic digester
  - Cogeneration of 11 MW of electric power
  - On-site biodiesel production facility
  - Pipeline connecting up to a dozen dairy digesters

- Element, Colwich, KS (ICM and The Andersons)
  - Waste wood and combined heat and power to displace 70% of natural gas and 80% of electricity
  - Kernel Fiber Cellulosic Ethanol

- Arkalon Energy, Liberal, KS
  - Enhanced oil recovery carbon capture & sequestration

- Lincolnway Energy, Nevada, IA
  - Rayeman compression dryer
Reasons to Invest in Lower Carbon Intensity

- Market preference & higher credit prices
- Uncertainties in RFS market due to USEPA administration, small refinery waivers, D6 RINs post-2022, EP3 production registration (75 Producers as of Jun 2017)
- Lower energy costs (2nd largest cost, 10% of overall costs of production)
- Reducing carbon footprint by 1 CI point per year to keep pace with the market
- Producer’s are looking for ways to differentiate themselves in the marketplace and be in the bottom 20% of CI values
LCFS Credit Price History

Weekly LCFS Credit Pricing
January 2017 - July 2018

Low
High
Avg. Price
($ per Credit)
Reduce GHG emissions from transportation fuels in California by 10% by 2020, 20% total by 2030

- Incentivize the development of low carbon fuels:
  - Performance based
  - Fuel neutral
- The LCFS is an example for other programs:
  - Oregon
  - British Columbia
  - Proposed Canada national-wide
  - Others
LCFS Credits Generated by Fuel Type

Fig 3. Credits (MT) By Fuel Type
Q1 2011 - Q3 2017

- Ethanol
- Electricity
- Fossil Natural Gas
- Biomethane
- Biodiesel
- Renewable Diesel
- Other (CARBOB, Diesel, Hydrogen, Innovative Crude & Low Complexity / Low Energy Use Refining)
Volume Weighted Sales into CA

Last Updated 04/25/2018
Key Contributors to Ethanol Carbon Intensity

- Indirect land use change (iLUC)
- Corn farming and transportation
  - Fertilizer
  - N2O emissions from field
  - Fuel used
- Ethanol plant
  - Energy (natural gas, electricity, etc.)
  - Chemicals and enzymes
  - Yields of ethanol and co-products
- Transportation and distribution
- End use as transportation fuel
CA-GREET modelling quantifies the GHG emissions which determines the Carbon Intensity (CI)
  - Must be facility specific

LCFS Credits are generated from difference between annual compliance schedule and fuel CI

Annual Compliance Goal – Fuel CI = LCFS Credits

Example: 95.02 – 60 = 35.02*
  - *In g CO₂/MJ, adjusted for volume, other factors

Lower CI fuels earn more credits
## Key Contributors to CI of Ethanol

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Assumed value</th>
<th>Contribution to CI of EtOH</th>
<th>Potential Reduction Method</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>iLUC</td>
<td></td>
<td>19.8</td>
<td>Better and more accurate modeling</td>
<td>Fixed under current LCFS</td>
</tr>
<tr>
<td>Corn farming and transport</td>
<td>Default in CA-GREET 2.0</td>
<td>35.4</td>
<td>No till, less fertilizer, less fuel use</td>
<td>Almost fixed under current LCFS</td>
</tr>
<tr>
<td>At EtOH Plant</td>
<td></td>
<td></td>
<td>-----------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Co-product credit</td>
<td>5.6 dry lbs DGS/gal</td>
<td>-12.6</td>
<td>Higher quality co-products</td>
<td>Almost fixed under current LCFS</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>24,000 btu/gal</td>
<td>21.5</td>
<td>Biogas, biomass boiler, CHP, heat recovery</td>
<td>Plant specific</td>
</tr>
<tr>
<td>Electricity</td>
<td>0.75 kWh/gal</td>
<td>6.1</td>
<td>Onsite renewable power, CHP, higher efficiency</td>
<td>Plant specific</td>
</tr>
<tr>
<td>Chemicals</td>
<td>Industrial typical</td>
<td>1.4</td>
<td>Advanced enzymes, less chemical use</td>
<td>Plant specific</td>
</tr>
<tr>
<td>T&amp;D of EtOH</td>
<td>Midwest to CA by rail</td>
<td>3.9</td>
<td>Higher transportation efficiency</td>
<td>Plant specific, not much flexibility</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>75.5</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## $ Value of Your CI

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Natural Gas</th>
<th>Electricity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assumed Usage</td>
<td>24,000 btu/gal</td>
<td>0.75 kwh/gal</td>
</tr>
<tr>
<td>Contribution to CI of Ethanol (g CO2e/MJ)</td>
<td>21</td>
<td>6</td>
</tr>
<tr>
<td>$/gal value for 50% reduction based on $180/MT CO2 LCFS credit</td>
<td>$0.153</td>
<td>$0.043</td>
</tr>
<tr>
<td>$/100 MGY value for 50% reduction based on $180/MT CO2 LCFS credit</td>
<td>$15.3M</td>
<td>$4.3M</td>
</tr>
<tr>
<td>Potential GHG reduction method</td>
<td>Biogas, Biomass Boiler, CHP better heat integration</td>
<td>Onsite solar power, Onsite wind power, CHP higher electricity use efficiency</td>
</tr>
</tbody>
</table>

Average LCFS credit price on 07/26/2018: $188.50/MT CO2
### Ethanol Pathways Under the LCFS

<table>
<thead>
<tr>
<th>Feedstock Types</th>
<th>Less than 30</th>
<th>30 - 40</th>
<th>40 - 50</th>
<th>50 – 60</th>
<th>60 – 70</th>
<th>70 - 75</th>
<th>75- 80</th>
<th>80+</th>
</tr>
</thead>
<tbody>
<tr>
<td># of Pathways</td>
<td>6</td>
<td>7</td>
<td>87</td>
<td>16</td>
<td>26</td>
<td>32</td>
<td>34</td>
<td>15</td>
</tr>
<tr>
<td>Feedstock Types</td>
<td>Waste Wine, Corn Kernel Fiber, Sugar Beets, Stover</td>
<td>Sugarcane, Molasses, Stover, Corn Kernel Fiber, Sorghum</td>
<td>Sugarcane, Molasses, Waste Wheat Slurry</td>
<td>Corn, Molasses, Spent Seed, Sugar Cane, Waste Wheat Slurry</td>
<td>Corn, Sorghum, Waste Beverage</td>
<td>Corn, Sorghum</td>
<td>Corn, Sorghum</td>
<td>Corn, Sorghum</td>
</tr>
<tr>
<td>Percentage</td>
<td>2.7%</td>
<td>3.1%</td>
<td>39%</td>
<td>7.2%</td>
<td>11.7%</td>
<td>14.3%</td>
<td>15.2%</td>
<td>6.7%</td>
</tr>
</tbody>
</table>

**Energy Efficiency**
- WDG, On-site Solar, Wind
- CHP, Biomass, Onsite Power, CCS
- Biogas, Kernel Fiber
Updates on D3 Cellulosic Ethanol from Kernel Fiber
# RFS Pathways 2 IN-SITU VS. Separate Processing

<table>
<thead>
<tr>
<th>Comparison Category</th>
<th>In-Situ Processing</th>
<th>Separate Processing</th>
</tr>
</thead>
<tbody>
<tr>
<td>D3 Pathway Available</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>D3 Ethanol Lift</td>
<td>1-3%</td>
<td>7-10%</td>
</tr>
<tr>
<td>Capital Cost</td>
<td>0 – 300K$</td>
<td>10-20M$</td>
</tr>
<tr>
<td>Implementation Time</td>
<td>4 to 6 months from starting trials to EPA Registration Approval</td>
<td>12 – 18 months</td>
</tr>
<tr>
<td>System Requirements</td>
<td>Optional enhanced milling technology, Optional Cellulase Enzyme, measurement of Converted Fraction of Cellulase and Starch</td>
<td>Best practices for starch separation, Separate Hydrolysis, mass balance based on reasonably accurate feedstock and process data, Cellulase Enzyme</td>
</tr>
<tr>
<td>Registration Requirements</td>
<td>Process diagram; process description; Peer Review of Non-VCSB lab methods; Initial converted fraction for first 500,000 gallons of D3 production; overall fuel yield; cellulosic converted fraction; methods for determining cellulosic converted fraction; 3rd party engineering review and registration update</td>
<td>Process diagram; process description; measurement of D3 gallons; mass balance method; 3rd party engineering review at substantial completion and registration update</td>
</tr>
<tr>
<td>Recalculation Requirements</td>
<td>Sampling, analysis, and calculation of Cellulosic converted fraction must be performed every 500,000 gallons</td>
<td>Not Applicable.</td>
</tr>
<tr>
<td>Record Keeping Requirements</td>
<td>5 year requirement to retain laboratory results and duplicate samples</td>
<td>D3 Volume Measurements, Mass balance, D3 ledger</td>
</tr>
</tbody>
</table>
Kernel Fiber Now™ connects you to our team of professionals who can help answer your questions & assist with the following services:

- Third-Party Engineering Review & Registration
- Optional Quality Protocols
- Optional Quality Assurance Programs
- GREET Pathway Modeling
- Technology Integration
- Feasibility Assessment

EcoEngineers has partnered with several technology providers to support the seamless integration of the kernel fiber pathway and to effectively measure the production of cellulosic ethanol and generation of D3 RINs.
Kernel Fiber Summary

- Separate processing
  - QCCP the first to get EPA Approved
  - ACE Ethanol implementing D3MAX
- Co-processing
  - Five producers using Edeniq’s technology approved
  - A handful of pending applications
  - EPA is reviewing registration requirements
- QAP is important for D3 RIN

For more information please contact:
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jramm@ecoengineers.us
515.985.1266
Evaluating Kernel Fiber Ethanol CI for CA LCFS

- No iLUC (Indirect Land Use Change, 19.8 gCO2e/MJ for Corn Ethanol)
- No corn farming and transportation burden
- Generally speaking, the CI is in the range of 10-40 gCO2e/MJ
- Exact CI depends on the specific facility and specific technology selected
- Recently obtaining 29 g/MJ and 31 g/MJ for D3 KF
Updates on EP3 and D3
USEPA Clarifications on EP3 and D3

USEPA Clarifications in a Sep 2017 letter to Little Sioux Corn Processors:

- One of the conditions of the EP3 determination letter is that the EP3 applies only to “ethanol...produced...using only corn starch as feedstock, during the averaging time period”.

- The USEPA clarified “that this condition (of EP3) is not violated when cellulosic components of corn kernel are converted to ethanol provided that no RINs other than D6 RINs are generated for all of the ethanol produced”.

- The EP3 conditions “would be violated if cellulosic biofuel D3 RINs are generated for any ethanol produced from corn kernel fiber at your facility”.

- Concurrent EP3 and D3 requires a registration update in the form of a revised compliance monitoring plan be submitted and activated by EPA before RINs could be generated.
USEPA Clarifications on EP3 and D3

USEPA Guidance on “How to Prepare an EP3 Version 1.2”:
Updated “to include ...producers who co-produce cellulosic ethanol from corn kernel fiber” and allows for the following two options:

**OPTION 1:** Modification to an existing corn starch EP3 pathway

**OPTION 2:** Submission of a new EP3 pathway for a facility that seeks to co-produce D3 cellulosic ethanol from kernel fiber
The USEPA EP3 model has assumed corn starch only is used as feedstock so that following cases apply for combined EP3 and D3 kernel fiber.

**Case 1:** Deduct D3 ethanol gallons from 365 day rolling average – expedited EP3 review line

**Case 2:** Deduct D3 ethanol gallons and proportion amount of natural gas and electricity from 365 day rolling average - D6 pathway petition review line
Biogas and Biomass as Process Energy
Dairy and Swine manure biomethane can have a CI as low as -300 g/MJ, compared to 75-80 g/MJ for natural gas.

- **Waste** biomass can have a CI close to 0.

Use of biogas and biomass as process energy can dramatically reduce the CI of ethanol, even possible to reach negative CI and therefore capture LCFS credits value.

- Potential to set up phase 2 for biogas projects which may include pipeline injection and earning **RINs and LCFS credits** for the injected biomethane.
Areas for Further Study and Progress

- Corn farming and transportation burden of 35.4 g/MJ
- Establish standards for low CI farming practices;
  - No till, fertilizer usage, nutrient runoff prevention, carbon sequestration
- Establish farm practices verification program for Midwest
- The farm practices verification program must be recognized by other LCFS programs
- Carbon Capture and Sequestration (CCS)
Carbon Capture and Sequestration (CCS)

- CCS is an emerging technology gaining traction in the renewable fuel industry as a method to greatly reduce CI emissions
- CCS protocol issued by CARB with rulemaking for 2019 and beyond
- 50 year window for reporting on integrity of CCS project and to ensure that there is no leakage based on 6/20/2018 proposed regulation
- Strong incentives being laid out by CARB
The CI Tracking Expert program enables renewable fuel producers to accurately track their own Carbon Intensity
- Accurately track ongoing CI
- Receive plant specific training on use of Tier 1 LCA model provided by CARB
- Prepare for CA verification requirements effective Jan 2020
- Access expert life-cycle analysis modeling for CI tracking and business planning
- Receive semi-annual updates on the LCFS programs
- Demonstrate CI to stakeholders and external auditors

LCFS Verification: Training, Consulting, and Audit
Creating sustainable solutions for a better tomorrow