Intellulose: An Innovative Approach to Your Plant’s Profitability

2019 Distillers Grains Symposium
May 15, 2019
Jim Kacmar
Director of Engineering and Operations

6332 South 118th Street
Omaha, NE 68137
Edeniq.com
Edeniq Company Overview

- Edeniq is a leading biotechnology company that develops processes for producing and measuring cellulosic ethanol from corn kernel fiber.

- Edeniq’s lab and headquarters is in Visalia, California with a field office serving the Midwest in Omaha, Nebraska.

Strategically located to serve concentration of ethanol plants in the Midwest.
Company Highlights

2008: Company founded
2012: Successfully produces first ethanol gallons from DOE-funded pilot plant
2013: Successful continuous operation of pilot facility leads to key (improvements) for developing Intellulose (formerly Pathway) technology
2014: EPA confirms corn kernel fiber as cellulosic ethanol feedstock; Intellulose validation facility completed
2015: Edeniq submits analytical methods to EPA and completes commercial testing of Intellulose
2016: EPA approval for first Intellulose registration
2017: Edeniq completed 25 trials with an average cellulosic conversion of 1%
2018: Edeniq submits updated analytical methods to EPA and CARB
Ethanol Plants – Searching for Value

- Ethanol
- Initial diversification to DDG / WDG
- Corn oil

- Plant’s today are looking to get more value out of their existing feedstock

- Policy is asking for more biofuels
  - Low CI is desired
Edeniq’s Solution: Intellulose

- Intellulose technology adds value to ethanol production facilities by creating cellulosic ethanol (worth $3.65/gal) from the corn kernel fiber they’re already using today.
- Diversifies products made from the corn ethanol plant.
- We help our customers realize the value of opportunities created by biofuels policy.
  - Close working relationship with USEPA and CARB.
Intellulose Implementation

- Uses existing plant - No CAPEX required
- Add cellulase to produce cellulosic ethanol from corn fiber
- Edeniq’s Intellulose technology measures cellulosic ethanol
- Proven technology – millions of cellulosic gallons produced
Why Corn Kernel Fiber?

- Already at the plant – no transportation cost
- Up to 17% more ethanol possible from the fiber
  - 7% from the C6
- C6 sugars can be fermented using existing yeast process to ethanol.
- Cellulosic feedstock eligible to make D3 RINs
- Ethanol produced has low CI score
Edeniq’s EPA Approved Path for Regulatory Credits

Before Plant Validation
6-8 Weeks

- Work with plant operations team to prepare for trial

Validation
2-4 Weeks

- Onsite engineering review
- Conduct enzyme validation trial

Lab Results and EPA Report
4-6 Weeks

- Use EPA approved mass balance to determine D3 RINs eligible ethanol
- Plant registers with EPA

EPA Approval
6-8 Weeks

- Generate D3 RINs upon EPA approval
- Collect LCFS Data
How does an Intellulose Trial Work?

- Sample fermenter inlet and outlet
- Proprietary analytical methods determine starch and cellulose
- Mass balance around fermenters
- Follows EPA regulations for simultaneous conversion of starch and cellulose.
- Cellulosic ethanol fraction – fraction of total plant ethanol production eligible for cellulosic D3 RINs

![Flowchart of the process](chart.png)
Intellulose Case Study – Results

- 2.50% average relative increase observed in ethanol titer compared to control (14.461 → 14.822 %wt/vol).
- Corn oil recovery increased by 0.102 lb/bu compared to control (0.848 → 0.949 lb/bu).
- Cellulosic ethanol fraction (CEF) of 1.5%
Intellulose Case Study – DDGs Composition

- Observe less fiber in DDGs as cellulase converts fibers into sugars
- Increase in protein percentage and other non-fiber components
Intellulose Economics – 120 MGPY

Revenue Changes

<table>
<thead>
<tr>
<th>Item</th>
<th>Revenue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethanol</td>
<td>$4,243,000</td>
</tr>
<tr>
<td>Corn Oil</td>
<td>$1,031,000</td>
</tr>
<tr>
<td>D3 RINs</td>
<td>$3,780,000</td>
</tr>
<tr>
<td>LCFS</td>
<td>$1,440,000</td>
</tr>
<tr>
<td>Increase Revenue</td>
<td>$10,494,000</td>
</tr>
</tbody>
</table>

Cost Changes

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>$-</td>
</tr>
<tr>
<td>Enzyme</td>
<td>$1,400,000</td>
</tr>
<tr>
<td>Net Change Cost</td>
<td>$1,400,000</td>
</tr>
</tbody>
</table>

Decreased DDGs Revenue $ (3,941,000)

Total Benefit (before License Fee) $ 5,153,000

- Over $5 million in extra profit (before license fee)
- Increased ethanol and corn oil production
- Production of low CI ethanol (CI about 30)
Maximizing Value from Policy

- Edeniq provides required reports for EPA registration
- 3rd party engineering review (partnered with EcoEngineers)
- Edeniq maintains frozen samples and data required by EPA for audit
- EcoEngineers and Weaver EPA approved as QAP for QRINs
- Support recalculation at 500,000 gal of cellulosic ethanol per EPA and CARB regulation
- Support LCFS applications
Credits for Cellulosic Ethanol

**D3 RINs**

Cellulosic Ethanol

- CWC set at $1.77 per gallon for 2018
- D3 ethanol currently selling at a $1.55 premium to starch ethanol
- Six plants registered

**LCFS**

Low Carbon Gallons

- Administered by CARB
- Estimated from 50 - 75 cents per gallon value
  - CI between 25 and 40
- Four plants registered with additional plants under review
Intellulose Development

• Leveraging our laboratory methods to help enzyme companies develop optimized cocktails for corn fiber
• Working with plant partners to optimize AA, GA, and plant operating conditions for cellulosic ethanol production
• Improving our analytical and trial methods to further increase precision and lower variability
THANK YOU!