Produce Cellulosic Ethanol in Existing Plants with Edeniq's Pathway Platform

James Kacmar, Pathway Program Director

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Over 10 million tons of cellulose at U.S. ethanol plants from the corn kernel fiber

Edeniq’s Pathway Technology converts this fiber into cellulosic ethanol with low CAPEX using existing plant fermenters.

Potential for 300-400 MGPY cellulosic ethanol if adopted in all corn ethanol plants

Cellulosic ethanol could a $3/gal premium in 2017
In situ Combination of Mechanical Pretreatment and Cellulase

**Enzyme**
1. Converts Fiber to Fermentable Sugar
2. Edeniq protocol to measure cellulosic ethanol

Pathway Bolt On Step 1
Pathway Bolt On Step 2

In situ Combination of Mechanical Pretreatment and Cellulase

Cellunator
1. Proprietary Mill
2. “Right Sizes” particles
3. Homogenizes slurry
4. Shears fibers

Hammermill → Mix Tank → Liquefaction → Fermentation → Corn/Cellulosic/Ethanol

DDGS
Pathway Benefits

Cellunator™
- "Right sized" particles with increased surface area for enzymes
- Liberates recalcitrant starch
- Frees up the corn kernel fiber for cellulase enzymes
- Proven technology at 7 plants

Cellulase
- Converts corn kernel fiber into fermentable sugars
- Frees up additional starch for conversion into ethanol
- Demonstrated at 3 plants

Platform Benefits
- Increases overall ethanol production
- Produces cellulosic ethanol from fiber
  - Eligible for D3 RINs
- Increases corn oil production
Path to Cellulosic Ethanol

2011
- Edeniq petitions EPA for corn kernel fiber Pathway

2012
- Edeniq continues R&D for analytical protocols to quantify cellulosic ethanol

2013
- Pathway pilot plant built
- EPA issues proposed rule: corn kernel fiber ethanol is cellulosic

2014
- 40 + enzymes screened
- Lab D3 RINs Protocols refined
- EPA issues final rule

1H 2015
- Plant testing
- EPA issues guidance on co-production

2H 2015
- Protocols confirmed during commercial trials
- Dec/Jan 16 registration filed
Cellulosic Credits

**D3 RINs**
- Cellulosic Ethanol
- $1.33 per gallon for Waiver Credit in 2016
- Estimated at $1.99 per gallon for 2017
- Registration underway at first plant

**SGBPTC**
- Cellulosic Ethanol
- Second Generation Biofuel Producer Tax Credit
- $1.01 per gallon – 2017 requires legislative re-approval

**LCFS**
- Low Carbon Gallons
- Estimated from 45 - 90 cents per gallon
- 6 to 12 months to complete registration
• Designed to permit same conditions for different fermentations

• Goals –
  • Prove D3 RINs protocols
  • Emulate commercial plant results
  • Process Development
Pilot Plant Results (Optimizing Doses)

- Cellunator resulted in 3.6% increase in ethanol production.
- Complete Pathway implementation increases ethanol production 4.9% – 5.8%
- Analytical protocols successful at measuring cellulosic ethanol
- Concluded that the technology was ready for commercial testing
Commercial Trials - Overview

- **Trial Objectives:**
  - Demonstrate increase in ethanol production
  - Measure cellulosic ethanol and validate D3 RINs protocols
  - Ensure “normal operations” during trial

- **Edeniq’s Approach:**
  - Dedicated Edeniq trial team
  - Collaborate with plants on trial plan
  - Prescribe and prepare operational adjustments
  - On site team to ensure RINs protocols are followed
  - Determine via D3 RINs protocols the **cellulose converted fraction** and **cellulosic ethanol fraction**
Commercial Pathway Results

- Results similar to pilot plant
- Observed a lift in starch ethanol and cellulosic ethanol
- Confirmed D3 RINs protocols at commercial scale
- Cellulosic ethanol fraction between 0.5% and 2.5%, depending upon enzyme dose
- Continue to work to optimize performance for each plant
# Pathway Economics – 120 MGPY

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<tr>
<th>Revenue Changes</th>
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<tr>
<td>Ethanol</td>
<td>$9,651,840</td>
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<tr>
<td>Oil</td>
<td>$2,400,000</td>
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<td>Cellulosic RINs</td>
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<td><strong>Sub Total Revenue</strong></td>
<td><strong>$15,893,040</strong></td>
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<table>
<thead>
<tr>
<th>Cost Changes</th>
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<tbody>
<tr>
<td>Corn</td>
<td>$ -</td>
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<tr>
<td>Other Costs (Enzyme &amp; Maintenance)</td>
<td>$2,315,636</td>
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<td>License Fee</td>
<td>$1,280,400</td>
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<tr>
<td><strong>SubTotal Costs</strong></td>
<td><strong>$3,596,036</strong></td>
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</tbody>
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| Change in Margin                  | $12,297,004 |
| Reduction in DDGs                | $5,801,916 |
| **Net Benefit**                   | **$6,495,087** |

**Enzyme Only Net Benefit** $2,000,000
Edeniq Pathway Offerings

- Ethanol Production
  - Cellulosic
  - Starch

- Analytical Protocols
  - Validations
  - Recalculation

- Regulatory Support
  - EPA
  - CA LCFS

- Enzyme Evaluation
  - Dosing
  - Economics

- Cellunator
  - Installation
  - Financing

- Credit Monetization
  - Support
We are now commercially producing cellulosic ethanol using Edeniq’s Pathway Technology at our Stockton facility. We are working with Edeniq and the Environmental Protection Agency to qualify these gallons for generating D3 cellulosic RINs, which carry a premium over conventional ethanol, and we look forward to receiving their approval.

Neil Koehler
Pacific Ethanol president and CEO
Thank You!