CCUS: Use of CO$_2$ from Ethanol Production for EOR

Conestoga Energy Partners, LLC

An overview of a Kansas-based carbon capture, use, and storage project.

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Conestoga Energy Partners, LLC.

- Conestoga Energy Partners, LLC founded in 2006
- Originally founded by feeders and farmers
- Composed of 480 investors representing teachers, farmers, parents & community leaders
- Annual production of 205 million gallons of low carbon renewable ethanol across three plants

Arkalon Ethanol 110 MG  
Bonanza BioEnergy 55 MG  
Diamond Energy 40 MG
Focused on Low Carbon Fuel Production

Points of differentiation:
- Largest domestic user of grain sorghum
- Locally sourced feedstock
- First ethanol company to capture and store CO₂
- Four fuel pathways registered with LCFS since 2011
- Carbon Intensities range from 67 gCO₂e/MJ - 79 gCO₂e/MJ

<table>
<thead>
<tr>
<th>Farming and Processing</th>
<th>Feedstock Transport</th>
<th>Ethanol Production</th>
<th>Ethanol Transport</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Non-irrigated</td>
<td>• Locally sourced and transported</td>
<td>• CO₂ CCS</td>
<td>• Exclusively on rail</td>
</tr>
<tr>
<td>• Minimal fertilizer</td>
<td></td>
<td>• NG-fired CHP</td>
<td></td>
</tr>
<tr>
<td>• No drying</td>
<td></td>
<td>• High efficiency APCs</td>
<td></td>
</tr>
<tr>
<td>• Large scale production</td>
<td></td>
<td>• WDG transported locally</td>
<td></td>
</tr>
</tbody>
</table>
Conestoga’s Goal for CCUS

Capture, Use, & Store CO₂ from fermentation process

Create cleaner environment

Reduce demand for foreign oil

Lowest carbon ethanol on the market

Table 3-1: Industrial Plants in the US with CCS

<table>
<thead>
<tr>
<th>Anthropogenic CO₂ Emission Source</th>
<th>No. of Plants</th>
<th>Estimated CO₂ Emissions (1,000 Metric tonnes per day)</th>
<th>No. of Plants with CCS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fossil fuel-fired Power Plants</td>
<td>2,802</td>
<td>6,254</td>
<td>1</td>
</tr>
<tr>
<td>Gas Processing Plants</td>
<td>516</td>
<td>230</td>
<td>8</td>
</tr>
<tr>
<td>Ethanol Plants</td>
<td>210</td>
<td>100</td>
<td>2</td>
</tr>
<tr>
<td>Hydrogen Plants (non-refinery)</td>
<td>74</td>
<td>25</td>
<td>1</td>
</tr>
<tr>
<td>Hydrogen Plants (refinery)</td>
<td>70</td>
<td>55</td>
<td>0</td>
</tr>
<tr>
<td>Ammonia Plants</td>
<td>27</td>
<td>28</td>
<td>3</td>
</tr>
<tr>
<td>Ethylene Oxide Plants</td>
<td>10</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>TOTAL</td>
<td>3,709</td>
<td>6,699</td>
<td>16</td>
</tr>
</tbody>
</table>

ACR Methodology for GHG Emission Reductions From CCS Projects v1.0
Bonanza BioEnergy CCUS EOR

- Occurs within 15 mile radius of Garden City, KS
- Operational since 2012
- Captures ~ 100,000 tCO₂ annually

**CAPTURE**
CO₂ produced via fermentation of sorghum and corn feedstocks

**TREATMENT**
Dehydration and compression of CO₂

**TRANSPORT**
Via dedicated pipeline

**USE AND STORAGE**
CO₂ utilized for EOR and recycled.
Bonanza BioEnergy

Ethanol Plant ➔ Blower ➔ Compression & Dehydration ➔ Pipeline (15 miles) ➔ Injection Wells ➔ Sandstone Reservoir

Oil Tankers ➔ Recycle Skid ➔ Separation & Treatment Skid ➔ Producing Wells ➔ Sandstone Reservoir

Oil Tankers ➔ Oil

CO₂
CO₂ Capture at Ethanol Plant

- 20 million bushels of grain processed
- [CO₂] > 99%
- Captured from fermenter stacks in 24” header pipe
- Blowers direct CO₂ to treatment & compression plant
CO₂ Treatment and Compression

- Dehydration
- 3-stage compression to 1500 psi
- Powered by electricity
- Custody transfer meter and in-line analyzer after skid.
CO$_2$ Transport

- 15 miles
- Dedicated 4” line
- Federally regulated
- Metering:
  - Metered on both ends
- Monitoring:
  - Fully automated pressure monitoring
  - Auto shut-off if pressure exceeds +/- 10%
CO₂ Use and Storage

- WAG injection at 4800 ft
- Stainless steel casing per KS state CO₂ EOR requirements
- Powered by electricity and associated NG
- Metering & Monitoring
  - Metered at pipeline outlet, post-producing wells, post-recycle skid
  - Oil / H₂O / CO₂ composition analyzed pre Separation & Treatment
  - In-line analyzer post recycle skid
  - All lines monitored for pressure fluctuation with auto shut-off
  - Mass balance calculations conducted by independent 3rd party
## Considerations for QM Development

<table>
<thead>
<tr>
<th>QM Objective</th>
<th>Commercial Considerations</th>
<th>Suggested Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ensure permanence</td>
<td>• O&amp;G operators may retrieve CO₂ for use at a new site.</td>
<td>• Require a covenant to be filed which prohibits release of stored CO₂.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• If no covenant, allow for projects to compensate for reversal.</td>
</tr>
</tbody>
</table>
| Provide approach to quantify EOR-specific CO₂ leak/venting | • Scheduled maintenance on pipelines may require purging.  
• Lightning strikes in the field, etc. may lead to fire and require gas blow down.  
• Injection equipment may fail.                                                                                                                        | • Include specific equations in the QM to quantify venting events based on parameters that can be verified.                                                                                                           |
|                                           |                                                                                                                                                                                                                           | • Ensure Monitoring Plan addresses how operational disruptions are identified, documented, and mitigated.                                                                                                          |
| Appropriately define physical boundary for EOR projects | • Capture sites are unique.  
• Project may source multiple CO₂ streams.                                                                                                               | • Clearly define project emission sources directly associated with capture activity.                                                                                                                                |
|                                           |                                                                                                                                                                                                                           | • Be cognizant of program overlap.                                                                                                                                                                              |
|                                           |                                                                                                                                                                                                                           | • Ensure mass balance data requirements are met but don’t overburden parties who aren’t seeking credit.                                                                                                       |
| Clearly identify the responsible party associated with the project | • The party responsible for CO₂ capture may be the one seeking credit for complying with the QM.                                                                                                                     | • Allow for flexibility in the definition of the “responsible party”.                                                                                                                                             |
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