INITIAL ENGINEERING AND DESIGN FOR CO₂ CAPTURE FROM ETHANOL FACILITIES

Project Number: DE-FE0031938
U.S. Department of Energy National Energy Technology Laboratory
Carbon Management and Natural Gas & Oil Research Project
Virtual Review Meetings, August 2–31, 2021

Jason Laumb
Director of Advanced Energy Systems Initiatives
AGENDA

• Project Overview
• Red Trail Energy, LLC (RTE) CCS
• Technology and Scope
• Project Status
• Summary and Questions
PROJECT OVERVIEW

• Project Budget: $1,949,954
  – $1,559,954 DOE cash
  – $390,000 RTE in-kind match

• Period of Performance (POP): Oct 1, 2020 – March 31, 2022

• Goal: Develop an initial engineering design (IED) and estimated cost for capture and compression of CO₂ generated from an operational ethanol production facility
PROJECT OBJECTIVES

- Design a hybrid capture system using CO\textsubscript{2} emissions from both bioprocessing and heat production at the RTE facility.

- Complete a pre-front-end engineering and design (FEED) analysis of the hybrid capture system which includes environmental health and safety (EH&S), constructability report, identification of permits, and corporate approvals.

- Complete a techno-economic assessment (TEA) in accordance with DOE’s methodology, as demonstrated by the bituminous baseline study.
RTE CCS PROJECT: Partners and Progress

- The first North Dakota CO₂ Storage Facility (Class VI) Permit application submitted February 9, 2021.
Broom Creek Formation: >10 billion tonnes CO₂ storage potential

RTE CCS: ~6 million tonnes CO₂ (assuming 20-year injection period)

- CO₂ capture potential
  - ~310,000 tonnes/yr of CO₂ from bioprocessing, heat production.
  - Bioprocessing CO₂ stream is nearly pure.

- Geologic storage potential:
  - Broom Creek Formation
  - 6400 ft directly underlying RTE facility, ~300 ft thick
RTE CCS SITE
PROJECT TECHNOLOGY

Hybrid Capture System

- CO₂ from Bioprocessing
- Steam/Electricity
- CO₂ from Heat Production

Injection for Geologic Storage

Image Credit: Energy & Environmental Research Center
ETHANOL–CCS PROCESS WITH NOVEL HYBRID CAPTURE SYSTEM

- Corn Feedstock
- Ethanol
- CO₂ Stream
- Natural Gas Steam Boilers
- Heat Production CO₂ Stream
- Centrifuge Evaporators Dryers
- Steam Heat
- Bioprocessing CO₂ Stream
- Corn Slurry Fermentation Beerwell
- Distillation Dehydration
- Byproducts*
- Hybrid Capture System
- Chemical Absorption
- Liquefaction
- Energy
- Geologic Storage
- CO₂ Pipeline**

*Includes distillers grains, etc.

**Developing separately

Image Credit: Energy & Environmental Research Center
**PROJECT SCOPE**

1. Project Management and Planning
2. Project Engineering and Design
3. Determine Pre-FEED Cost Estimate

[Table showing milestones and planned completion dates]

- **POP: Oct 1, 2020 – March 31, 2022**

<table>
<thead>
<tr>
<th>Milestone Title</th>
<th>Planned Completion Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1 – Design Basis Determined</td>
<td>End of Month 4</td>
</tr>
<tr>
<td>M2 – Complete Pre-FEED Analysis</td>
<td>End of Month 12</td>
</tr>
<tr>
<td>M3 – Complete Design</td>
<td>End of Month 12</td>
</tr>
<tr>
<td>M4 – Complete TEA</td>
<td>End of Month 15</td>
</tr>
</tbody>
</table>
SUCCESS CRITERIA

✓ Completion of design basis for hybrid capture at RTE.

• Completion of TEA for design basis at RTE.
• Pre-FEED-level cost estimate for implementation of hybrid capture technology at RTE.
• Designed capture process that provides negative CO₂ emissions for RTE.
• RTE management approval of hybrid capture design such that it is considered by the RTE Board.

Photograph by Lars Plougmann
## RISKS AND MITIGATION

<table>
<thead>
<tr>
<th>Risk Category</th>
<th>Perceived Risk</th>
<th>Mitigation/Response Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Financial Risks</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insufficient Cost-Share Acquisition</td>
<td>Efficent Communication Leads to Schedule Overruns or Cost Overruns</td>
<td>Schedule regular or weekly stand-up meetings to ensure project priority is addressed and stakeholders are informed of schedule requirements and milestone dates.</td>
</tr>
<tr>
<td>Budget Insufficient to Complete Project</td>
<td>PI will work with task leads to ensure priority is given to schedule and use of allocated hours. Hours and schedule will be tracked using the EERC’s internal project cost-tracking system.</td>
<td></td>
</tr>
<tr>
<td><strong>Cost/Schedule Risks</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inadequate Plant Information</td>
<td>RTE is committed to the project as evidenced by its letter of support. The project team will communicate regularly to mitigate this risk.</td>
<td></td>
</tr>
<tr>
<td>Subcontractor Delays</td>
<td>Subcontractors for this project have worked with the project team in the past. Regular communication will be key to mitigate this risk.</td>
<td></td>
</tr>
<tr>
<td><strong>Technical/Scope Risks</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data Lost Because of Hacking or System/Human Failures</td>
<td>Maintain the EERC’s high internal standards for data management. Ensure team is trained to comply with existing internal data management plan. Ensure server data are regularly backed up.</td>
<td></td>
</tr>
<tr>
<td>Design Concept Not Feasible</td>
<td>The team has chosen commercial technologies to implement.</td>
<td></td>
</tr>
<tr>
<td>Economic Conditions Decrease Funding</td>
<td>The EERC will adjust scope items as necessitated by reduced funding.</td>
<td></td>
</tr>
</tbody>
</table>
• **Subtask 1.1 – Project Management Plan**
  ✓ Update due 30 days after award.
  ✓ Updates submitted, as needed, throughout the project POP.

• **Subtask 1.2 – Technology Maturation Plan**
  ✓ Initial due 90 days after award.
  ❑ Final due within 90 days of project completion.

• **Subtask 1.3 – TEA and Technology EH&S Risk Assessment**
  ❑ Within 90 days of project completion.

• **Subtask 1.4 – State Point Data Table**
  ❑ Updated within 90 days of project completion.

• **Subtask 1.5 – Life Cycle Assessment (LCA) Report**
  ❑ Final LCA results within 90 days of project completion.
TASK 2.0 – PROJECT ENGINEERING AND DESIGN

- Subtask 2.1 – Design Basis
- Subtask 2.2 – Utility Requirements
- Subtask 2.3 – Flow Diagrams
- Subtask 2.4 – Balance of Plant (BOP)
- Subtask 2.5 – Develop Permitting Strategy
- Subtask 2.6 – Optimization Studies

Image Credit: Willbros Engineering
TASK 2.0 – PROJECT ENGINEERING AND DESIGN

Subtask 2.1 – Design Basis

- **Completed:** Capture technology island capacity
- **Completed:** Site and operating conditions
- **Completed:** Expected fuel consumption
- **Completed:** Performance requirements

Subtask 2.2 – Utility Requirements

- **Completed:** Water, electricity, and steam needs
  - Identify locations of utilities, strategies, and other site specifics
  - Determine potential impacts to the RTE site
Subtask 2.3 – Flow Diagrams

- **Completed:** Existing diagrams updated
  - Process flow
  - Block flow
- **Completed:** Major equipment list

Subtask 2.4 – BOP

- **Completed:** Interconnection requirements
  - Electrical power sources
  - Treated water
  - Steam for process heating
  - Water for process cooling
  - Interconnecting gas flues to support the capture island requirements
- Develop designs and technology island configurations
  - PFDs and site layouts
  - Equipment lists, preliminary piping, wiring routings
  - Preliminary foundation requirements
### Subtask 2.5 – Develop Permitting Strategy

- **Completed:** Required information determined
  - Approvals, permits, concurrences, clearances, and environmental studies
  - Federal, state, and local

- Generate a permit matrix
  - Name or type of permit/approval
  - Regulatory agency issuing the permit/approval
  - Reason for permit/approval
  - Estimated agency review time
  - Potential permit application requirements
  - Permit fee (if required)

### Subtask 2.6 – Optimization Studies

- **Completed:** Process equipment, redundancy, materials of construction defined

- **Completed:** Scoping/optimization
  - Effluent identification and disposition
  - Process heat recovery
  - Process heat integration
  - Redundancy evaluation
  - Cooling system evaluation (water availability)
  - Contracting approach
TASK 3.0 – DETERMINE PRE-FEED COST ESTIMATE

Subtask 3.1 – Develop Capture Island Cost Estimate

- Determine pre-FEED-level costs
- Estimate postcombustion capture costs
- Integrate with compression and liquefaction subsystems

Subtask 3.2 – Develop BOP Cost Estimate

- Complete integration of the hybrid capture system with the remainder of the plant

Image Credit: Energy & Environmental Research Center
PROJECT SUMMARY

Tentative Takeaways

• **Completed Milestone:** Design Basis Determined

• **Completed Deliverables**
  – TMP (initial)
  – HAZOP Report
  – Updated PMP

Remaining Products

• Milestones
  – Pre-FEED Analysis
  – Design
  – TEA

• Deliverables
  – Pre-FEED Report
  – TEA and Technology EH&S Risk Assessment
  – TMP (final)
  – State Point Data Table
  – LCA Report
Questions?
PROJECT ORGANIZATION

Project Partners
- DOE
- Red Trail Energy
- Energy & Environmental Research Center
- Trimeric
- KLJ

Lead Organization
- EERC
- Project Manager
  - Jason Laumb

Task 1: Project Management and Planning
- Lead
  - J. Laumb
- Task Assist
  - J. Kay

Task 2: Project Engineering and Design
- Lead
  - K. Leroux
- Task Assist
  - Trimeric
  - KLJ
  - Red Trail Energy

Task 3: Determine Pre-FEED Cost Estimate
- Lead
  - J. Kay
- Task Assist
  - Trimeric
  - KLJ
  - Red Trail Energy
<table>
<thead>
<tr>
<th>Task</th>
<th>Deliverables (D)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task 1.0 – Project Management and Planning</td>
<td>D1 – Updated Project Management Plan</td>
</tr>
<tr>
<td>Subtask 1.1 – Project Management Plan</td>
<td>D2A – Technology Maturation Plan (TMP)</td>
</tr>
<tr>
<td>Subtask 1.2 – Technology Maturation Plan</td>
<td>D2B – TMP Final</td>
</tr>
<tr>
<td>Subtask 1.3 – Techno-Economic Analysis (TEA) and Technology EH&amp;S Risk Assessment</td>
<td>D3 – TEA and Technology EH&amp;S Risk Assessment</td>
</tr>
<tr>
<td>Subtask 1.4 – State Point Data Table</td>
<td>D4 – State Point Data Table</td>
</tr>
<tr>
<td>Subtask 1.5 – Life-Cycle Assessment (LCA) Report</td>
<td>D5 – HAZOP Review</td>
</tr>
<tr>
<td>Task 2.0 – Project Engineering and Design</td>
<td>D6 – Pre-FEED Report</td>
</tr>
<tr>
<td>Subtask 2.1 – Design Basis</td>
<td>D7 – LCA Report</td>
</tr>
<tr>
<td>Subtask 2.2 – Utility Requirements</td>
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<tr>
<td>Subtask 2.3 – Flow Diagrams</td>
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<td>Subtask 2.6 – Optimization Studies</td>
<td></td>
</tr>
<tr>
<td>Task 2.0 – Determine Pre-FEED Cost Estimate</td>
<td></td>
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<tr>
<td>Subtask 3.1 – Develop Capture Island Cost Estimate</td>
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<tr>
<td>Subtask 3.2 – Develop BOP Cost Estimate</td>
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</tbody>
</table>

**Milestone (M)**

- M1 – Design basis determined.
- M2 – Complete pre-FEED analysis.
- M3 – Complete design.
- M4 – Complete TEA.
## Milestones

<table>
<thead>
<tr>
<th>Milestone Title</th>
<th>Task/ Subtask</th>
<th>Planned Completion Date</th>
<th>Verification Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1 – Design Basis Determined</td>
<td>2.1</td>
<td>End of Month 4 Jan 31, 2021</td>
<td>Completed: Reported in subsequent quarterly report.</td>
</tr>
<tr>
<td>M2 – Complete Pre-FEED Analysis</td>
<td>3.0</td>
<td>End of Month 12 Sep 30, 2021</td>
<td>Reported in subsequent quarterly report.</td>
</tr>
<tr>
<td>M3 – Complete Design</td>
<td>2.0</td>
<td>End of Month 12 Sep 30, 2021</td>
<td>Reported in subsequent quarterly report.</td>
</tr>
<tr>
<td>M4 – Complete TEA</td>
<td>1.3</td>
<td>End of Month 15 Dec 31, 2021</td>
<td>Reported in subsequent quarterly report.</td>
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</table>
## DELIVERABLES

<table>
<thead>
<tr>
<th>Task/Subtask Number</th>
<th>Deliverable Title</th>
<th>Due Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>D1 – Updated Project Management Plan</td>
<td>Completed: End of Month 1 <em>(Oct 31, 2020)</em></td>
</tr>
<tr>
<td>1.2</td>
<td>D2 – Technology Maturation Plan (TMP)</td>
<td>Completed: The initial TMP is due 90 days after award <em>(Dec 30, 2020)</em>. Updates to the TMP shall be submitted, as needed, throughout the project period of performance. A final TMP is due within 90 days of project completion <em>(June 30, 2022)</em>.</td>
</tr>
<tr>
<td>1.3</td>
<td>D3 – TEA and Technology EH&amp;S Risk Assessment</td>
<td>Within 90 days of project completion <em>(June 30, 2022)</em></td>
</tr>
<tr>
<td>1.4</td>
<td>D4 – State Point Data Table</td>
<td>Updated state point data are due within 90 days of project completion <em>(June 30, 2022)</em>.</td>
</tr>
<tr>
<td>1.5</td>
<td>D7 – Life Cycle Assessment (LCA) Report</td>
<td>The final LCA results are due within 90 days of project completion <em>(June 30, 2022)</em>.</td>
</tr>
<tr>
<td>2.0</td>
<td>D5 – HAZOP Review</td>
<td>Completed: End of Month 10 <em>(July 31, 2021)</em></td>
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<tr>
<td>3.0</td>
<td>D6 – Pre-FEED Report</td>
<td>End of Month 14 <em>(Nov 30, 2021)</em></td>
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</table>
BUDGET: $1,949,954

<table>
<thead>
<tr>
<th></th>
<th>FY 2021</th>
<th></th>
<th>FY 2022</th>
<th></th>
<th>Total</th>
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<tbody>
<tr>
<td></td>
<td>DOE Funds</td>
<td>Cost Share</td>
<td>DOE Funds</td>
<td>Cost Share</td>
<td>DOE Funds</td>
<td>Cost Share</td>
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<tr>
<td>EERC – Prime</td>
<td>$810,518</td>
<td>$8,000</td>
<td>$352,870</td>
<td>$7,000</td>
<td>$1,163,388</td>
<td>$15,000</td>
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<tr>
<td>Trimeric Corp. – Subrecipient</td>
<td>$276,566</td>
<td>$ –</td>
<td>$120,000</td>
<td>$ –</td>
<td>$396,566</td>
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<tr>
<td>Red Trail Energy, LLC</td>
<td>$ –</td>
<td>$243,000</td>
<td>$ –</td>
<td>$132,000</td>
<td>$ –</td>
<td>$375,000</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>$1,087,084</strong></td>
<td><strong>$251,000</strong></td>
<td><strong>$472,870</strong></td>
<td><strong>$139,000</strong></td>
<td><strong>$1,559,954</strong></td>
<td><strong>$390,000</strong></td>
</tr>
<tr>
<td><strong>Total Cost Share %</strong></td>
<td>81.2%</td>
<td>18.8%</td>
<td>77.3%</td>
<td>22.7%</td>
<td>80.0%</td>
<td>20.0%</td>
</tr>
</tbody>
</table>
PROJECT MANAGEMENT

Jason Laumb
Principal Investigator (PI)
Task 1.0 – Project Management and Planning

Kerrynanne Leroux
Task 2.0 – Project Engineering and Design

John Kay
Task 3.0 – Determine Pre-FEED Cost Estimate
ROLES OF PARTICIPANTS

• EERC, *Lead Organization* – Oversee all tasks and management activities.

• RTE, *Project Partner*  
  – Allow access to facilities, drawings, etc., to facilitate design and pre-FEED objectives.  
  – Participate in the IED and information gathering to determine the pre-FEED-level cost estimate.  
  – Provide valuable insight into commercial application of the CO₂ capture technologies investigated that support the viability of the project design and costing support.

• Trimeric Corporation, *Project Partner* – Design and costing of both components of the hybrid CO₂ capture system as well as compression.

• KLJ, *Project Partner* – BOP, civil engineering design, and costing support.