Front-End Engineering & Design: Project Tundra Carbon Capture System

Project Number FE0031845

Gerry Pfau
Minnkota Power Cooperative

U.S. Department of Energy
National Energy Technology Laboratory
Carbon Capture Front End Engineering Design Studies and CarbonSafe
2020 Integrated Review Webinar
August-17-19 2020
Agenda

- Program Overview
- Technology & Site Selection
- Technical Approach & Project Scope
- Progress & Current Status
- Summary
PROGRAM OVERVIEW
### Funding and Cost Profile

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**NOTE:** Minnkota is planning to request a no-cost extension.
Performance Dates, Project Team and Objective

Project Performance Dates
12/19/19 – 12/31/20*

Objective
Complete a FEED study on the addition of post-combustion CO₂ capture for the Milton R. Young Station’s Unit 2 (MRY2)

* A no-cost extension will be requested
Project Tundra Overview

Milton R. Young Station

Electric Generating Station

CO₂ capture system

Flue gas with CO₂

CO₂ to Sequestration

Future Energy Corridor

100+ mile CO₂ pipeline

CO₂ return

Williston Basin Oil & Gas Fields

CO₂ oil separator

Oil combined with EOR CO₂

Naturally sealed formation (Reservoir)

Coal Mine

Oil sales

BNI energy

AN ALLETE COMPANY

Square Butte Electric Cooperative

Minn Kota Power Cooperative

Coal Mine

Electric Generating Station

CO₂ capture system

Flue gas with CO₂

CO₂ to Sequestration
TECHNOLOGY & SITE SELECTION
Technology & Site Selection

- **Capture Technology**: Fluor’s Econamine FG Plus℠
- **Site**: Milton R. Young Station Unit 2, 455 MW, lignite
- MRYS is uniquely suited:
  - Very high historical and projected capacity factor
  - State of ND is extremely supportive and has been a leader in development of policy to incentivize carbon capture, utilization & storage
  - Unique Williston Basin geology: EOR and saline storage both opportunities
Integration and Economics

• **Integration:** Both steam cycle integration and natural gas boilers were considered in this project. Economics were comparable, but gas boilers offered more flexibility and lower risk to overall project.

• **Storage:** Saline formation geologic storage directly beneath MRYS and adjacent lignite mine

• **Economics:** Targets set based on $50/ton 45Q tax credit
  
  – Economy of scale: ~2.5X size of Petra Nova in a single train design
  
  – Preliminary financial modeling shows 45Q can be sufficient to finance the project without increasing member electricity rates
  
  – FEED cost estimate to be converted to lump sum EPC price
TECHNICAL APPROACH & PROJECT SCOPE
## Milestones & Success Criteria

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<th>Description</th>
<th>Planned Completion Date</th>
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### Success Criteria

- Sufficient detail for a decision on the commercial project
- Sufficient detail to provide all technical information necessary for permitting
- Completion of design basis for post-combustion capture at MRY2
- Accurate FEED-level cost estimate for simple transition to lump sum EPC
- Support a pathway to achieve DOE cost of capture goals of $30/tonne by 2030
## Significant Project Risks and Mitigation Strategies*

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<th>Perceived Risk</th>
<th>Risk Rating (Low, Med, High)</th>
<th>Mitigation Strategy</th>
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<td>Personnel availability</td>
<td>Probability: Low, Impact: High, Overall: Low</td>
<td>Capitalize on internal Minnkota expertise to support project objectives.</td>
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<td>Insufficient budget to meet objectives</td>
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<td>The scope of work has been scaled to fit the existing budget.</td>
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<td>Site accessibility</td>
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<td>Minnkota personnel are available to provide site and data access.</td>
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<td>Unforeseen Risks, e.g. natural disasters; social, legal, or technical challenges</td>
<td>Probability: Low, Impact: Medium, Overall: Low</td>
<td>Regular updates with DOE and project partners will help solve issues as they arise.</td>
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* Note: This is a paper/desktop study, and therefore all risks identified have low overall risk rating
Project Tasks

• Task 1 – Project Management and Planning

• Task 2 – Engineering and Design
  – Subtask 2.1 – Project Design Basis
  – Subtask 2.2 – Carbon Capture System (CCS) Design
  – Subtask 2.3 – Steam Source Selection & Design
  – Subtask 2.4 – BOP Integration and Design

• Task 3 – Development of Permitting Strategies
  – Subtask 3.1 – Air Emissions
  – Subtask 3.2 – Water Discharge
  – Subtask 3.3 – Waste Disposal Planning

• Task 4 – Project Tundra Cost Estimating
PROGRESS & CURRENT STATUS
Task 1 – Project Management and Planning

- Kickoff meeting held at NETL offices in Morgantown on November 12, 2019
- Subcontracts/subrecipient contracts executed by April 2020
- New vendor, RMB Consulting, added to assist in preparing an emissions monitoring plan under Task 3
- Special report detailing steam source selection (work completed under Subtask 2.3) submitted to FPM
Task 2 – Engineering and Design

- Key decisions prior to commencing FEED
  - Water source selection & discharge
  - Steam source selection
  - Oxygen levels in the CO$_2$ product specification

- A design manual was developed in conjunction with Hunt International and Burns & McDonnell
  - Includes specific requirements for cold weather
  - Being used by Fluor and Burns & McDonnell for capture system design, water treatment, and balance of plant design
Water source selection

- The water source for the CCS was chosen as Nelson Lake adjacent to the plant
  - Sufficient water retention and short pipeline requirement
- Pre-treatment was selected as cold lime softening
  - Ability to lower amount of cooling tower make-up and eventual cooling tower blowdown rates
- Cooling tower blowdown was selected to be deep well injection (Class I), which is anticipated to be the lowest cost
Steam source selection

• Direct extraction from MRY2 steam turbine and auxiliary natural gas package boilers considered

• Natural gas boilers selected as best option
  – Significantly lower technical risk
  – Improved CCS and MRY operational flexibility
  – Potentially improved economics
Oxygen specification for CO₂ product

- Level will impact the need for deoxygenation
- After reviewing literature it was determined that catalytic deoxygenation is not required for geologic storage
  - Short pipeline
  - No oil miscibility concerns in this scenario
- Flexibility will be built into the design to add catalytic deoxygenation in the future for an EOR scenario
Capture island design status

• PFD, HMB, & UFD initial review completed
• Fluor doing internal review of P&IDs
• Initial plot plan work in progress
• Modular design review in progress
• Equipment specification development in progress

BOP design status

• Water treatment system in initial design
• Water balance of facility being finalized
• Work underway for deep well injection of final waste water produced
Task 3 – Development of Permitting Strategies (continued)

Air emissions

• One key benefit of using NG boilers for steam source is that Unit 1 can be tied into CCS for times when Unit 2 is in outage

• However, this makes the air emissions monitoring more complex

• Meetings held with NDDEQ to discuss monitoring requirements and general permitting questions and overview

• Minnkota contracted with RMB Consulting to assist with developing the monitoring strategy/plan
Task 3 – Development of Permitting Strategies (continued)

Flue Gas Path Diagram

- **Normal Operation (Unit 2 at or near full load):**
  - 100% of Unit 2 flue gas to CO2 absorber
  - 100% of NG boilers flue gas to CO2 absorber
  - 100% of Unit 1 flue gas to existing chimney

- **Alternate Operation (Unit 2 in outage):**
  - 100% of NG boilers flue gas to CO2 absorber
  - 100% of Unit 1 flue gas to CO2 absorber

- **Alternate Operation (Unit 2 at partial load):**
  - Variable % of Unit 2 flue gas to CO2 absorber, remainder to existing chimney
  - Variable % of Unit 1 flue gas to CO2 absorber, remainder to existing chimney
  - 100% of NG boilers flue gas to CO2 absorber
Task 3 – Development of Permitting Strategies

Water discharge (zero discharge target)

- Information was finalized for water appropriation permit to increase the allocation of Missouri River water
  - A Sovereign Lands permit was identified as being required

- Work on the Class I wastewater injection well has been initiated with Golder Associates
  - Cooling tower blowdown
  - Targeting the Inyan Kara formation (~3600-3800 ft. depth) for injection
  - Feasibility report complete that identifies range of potential injection flows and pressures

- Identifying opportunities to integrate MRYS CCR ponds
  - i.e., sulfur polishing scrubber blowdown
Next Steps

- Joint P&ID review starting the end of August or early September
- Plot plan work continues
- Finish modular construction study
- Duct constructability
- Site survey & geotechnical work
- Complete firewater design basis and supply options
- Mechanical equipment design sheets
- Water treatment & water balance work
Summary

• Project Tundra is a bold initiative to build the world’s largest carbon capture and storage facility in North Dakota
• Design specifics are now being generated on the carbon capture system, water treatment, and balance of plan.
• Cost estimating will begin soon

Contact Information:
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701-794-7234
gpfau@minnkota.com
APPENDIX
Project Organizational Chart

Lead Organization
Minnkota Power Cooperative (MPC)
Principal Investigator
Gerry Pfau

Project Participants/Sponsors
Fluor Enterprises, Inc. (Fluor)
Energy & Environmental Research Center (EERC)
Golder Associates
AECOM
RMB Consulting
North Dakota Industrial Commission
U.S. Department of Energy

Project Consultants
David Greeson Consulting (DGC)
Hunt International Energy Services (Hunt)

Owner's Engineer
Burns & McDonnell (BMcD)

Task 1: Project Management and Planning
Lead: G. Pfau (MPC)
Assist: J. Laumb (EERC), D. Greeson (DGC)

Task 2: Project Engineering and Design
Lead: R. Graebe (Fluor)
Assist: G. Pfau (MPC), R. Bryant (BMcD), S. Reddy (Fluor)

Task 3: Permitting Strategy
Lead: G. Pfau (MPC)
Assist: D. Laudal (MPC)

Task 4: Project Cost Estimation
Lead: R. Graebe (Fluor)
Assist: G. Pfau (MPC), R. Bryant (BMcD)
### Project Gantt Chart

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**NOTE:** Minnkota is planning on requesting a no-cost extension.