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

Project Number FE0031845

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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

	2019	2020			
	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec
Baseline Cost Plan					
Federal Share	20,000	1,964,315	3,437,552	3,437,552	962,159
Nonfederal Share	5,000	491,079	1,201,978	1,201,978	336,429
Total	25,000	2,455,394	4,639,530	4,639,530	1,298,588
Cumulative Federal	20,000	1,984,315	5,421,868	8,859,419	**9,821,578**
Cumulative Nonfederal	5,000	496,079	1,698,057	2,900,035	**3,236,464**
Cumulative Total	25,000	2,480,394	7,119,924	11,119,924	**13,058,042**
Actual Incurred Cost					
Federal Share	21,650	106,401	444,003		
Nonfederal Share	5,413	26,600	111,001		
Total	27,063	133,001	555,004		
Cumulative Federal	21,650	128,051	572,054		
Cumulative Nonfederal	5,413	32,013	143,014		
Cumulative Total	27,063	160,064	715,068		

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 CO_2 capture for the Milton R. Young Station's Unit 2 (MRY2)

* A no-cost extension will be requested

Project Team

Minnkota Power Cooperative

A Touchstone Energy® Cooperative

FLUOR®

BURNS McDONNELL

AECOM

EERC

UND University of North Dakota

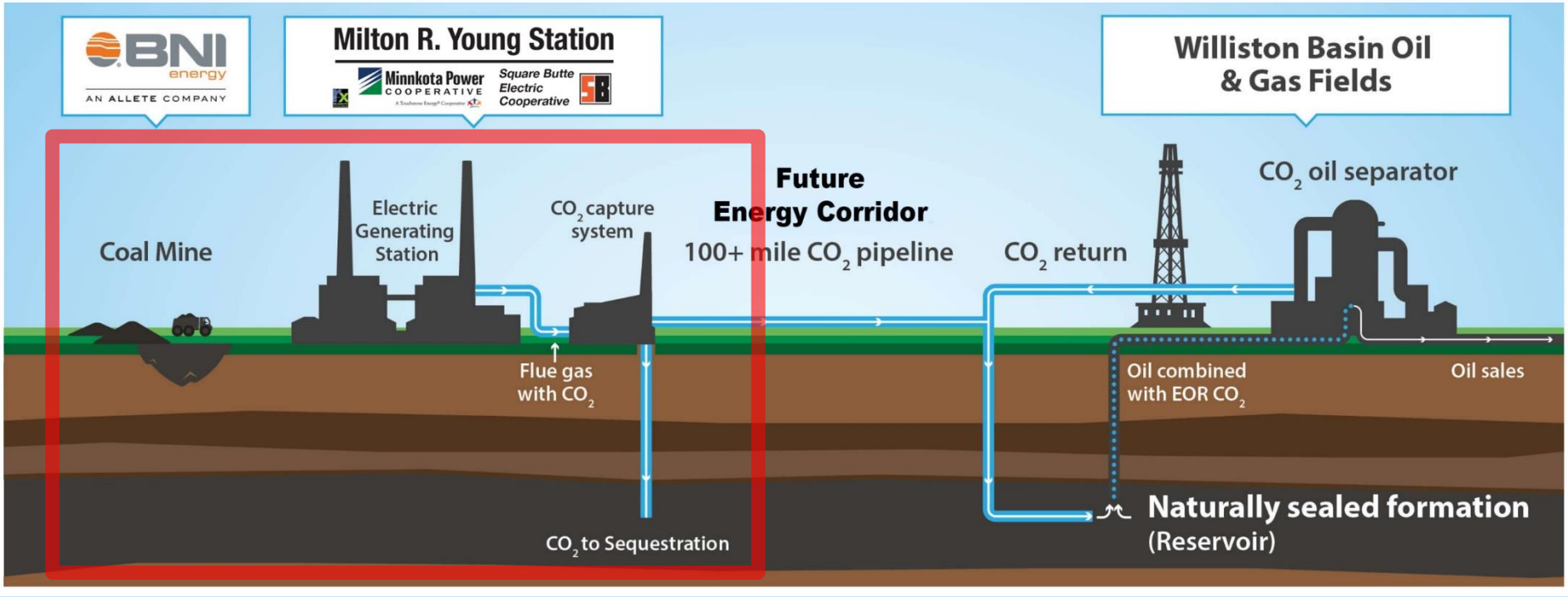
Square Butte Electric Cooperative

GOLDER

David Greeson Consulting

Hunt International Energy Services

Project Tundra Overview



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 sump EPC price

TECHNICAL APPROACH & PROJECT SCOPE

Milestones & Success Criteria

Task No.	Description	Planned Completion Date	Actual Completion Date
1	Cooperative Agreement Signed	12/19/2019	12/19/2019
2	Design Manual Completed	02/28/2020	02/10/2020
3	Permitting Meeting with NDDEQ*	07/31/2020	07/29/2020
3	Permitting Strategy Finalized	11/30/2020	
4	FEED Report Submitted	11/30/2020	

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

* ND Department of Environmental Quality

Significant Project Risks and Mitigation Strategies*

Perceived Risk	Risk Rating (Low, Med, High)			Mitigation Strategy
	Probability	Impact	Overall	
Personnel availability	Low	High	Low	Capitalize on internal Minnkota expertise to support project objectives.
Insufficient budget to meet objectives	Low	Medium	Low	The scope of work has been scaled to fit the existing budget.
Site accessibility	Low	Low	Low	Minnkota personnel are available to provide site and data access.
Unforeseen Risks, e.g. natural disasters; social, legal, or technical challenges	Low	Medium	Low	Regular updates with DOE and project partners will help solve issues as they arise.

* 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

Task 2 – Engineering and Design (continued)

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

Task 2 – Engineering and Design (continued)

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

Task 2 – Engineering and Design (continued)

Oxygen specification for CO_2 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

Task 2 – Engineering and Design (continued)

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

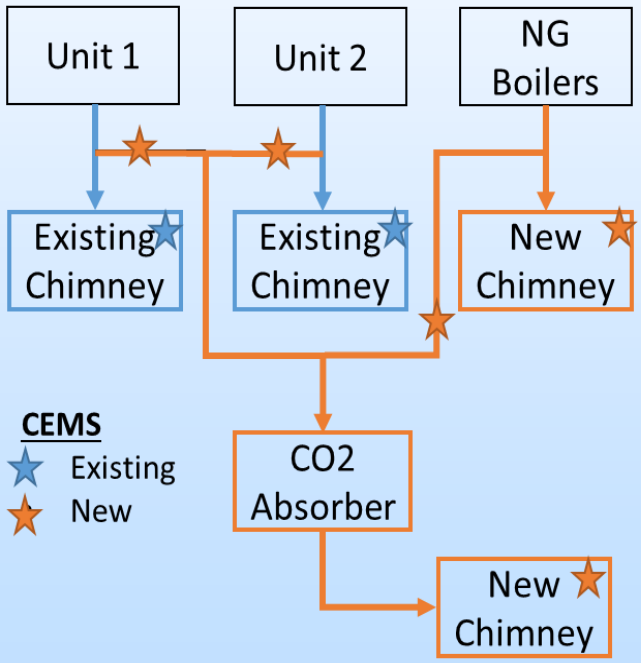
Task 3 – Development of Permitting Strategies (continued)

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

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

PROJECT TUNDRA

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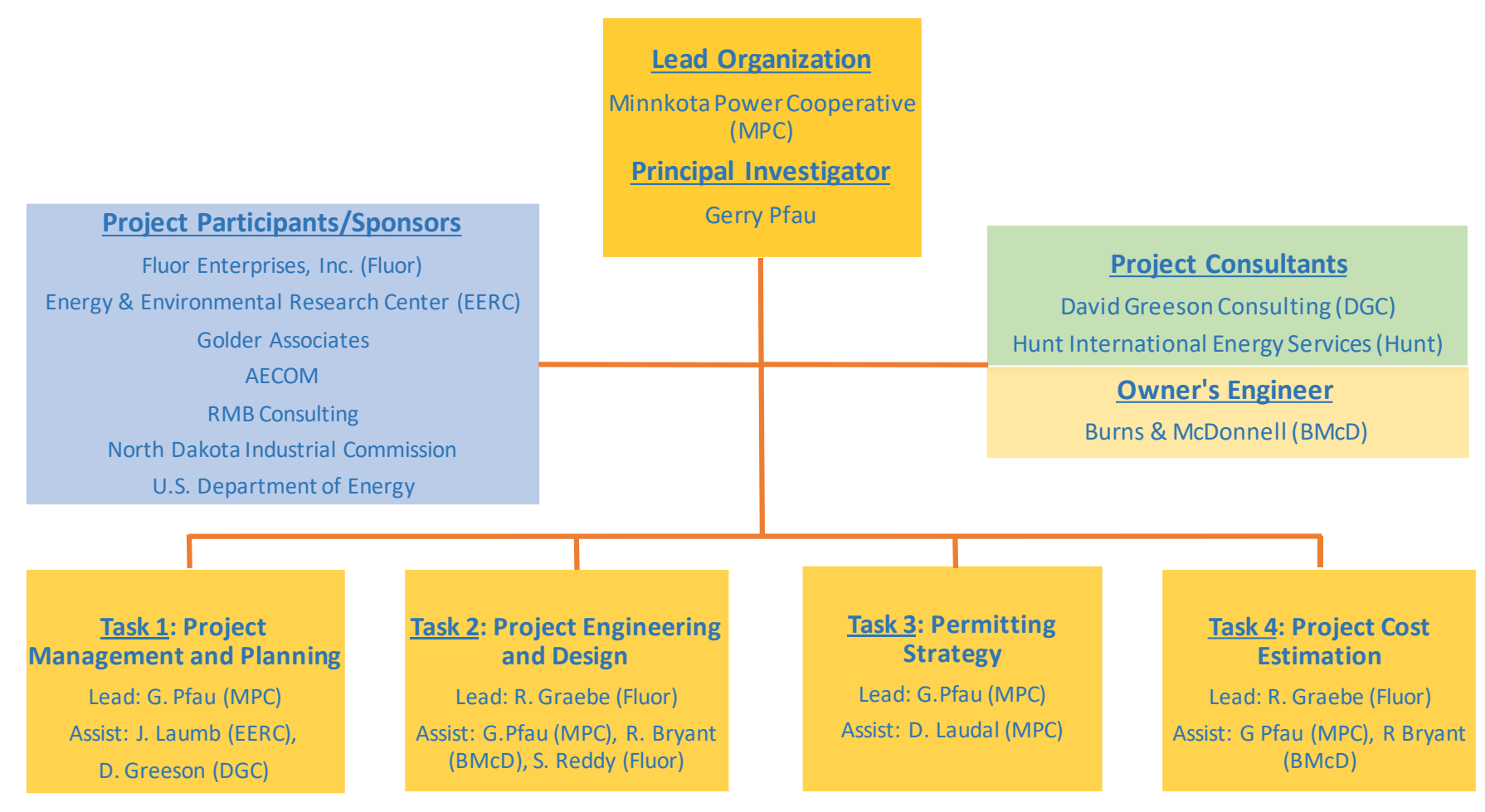
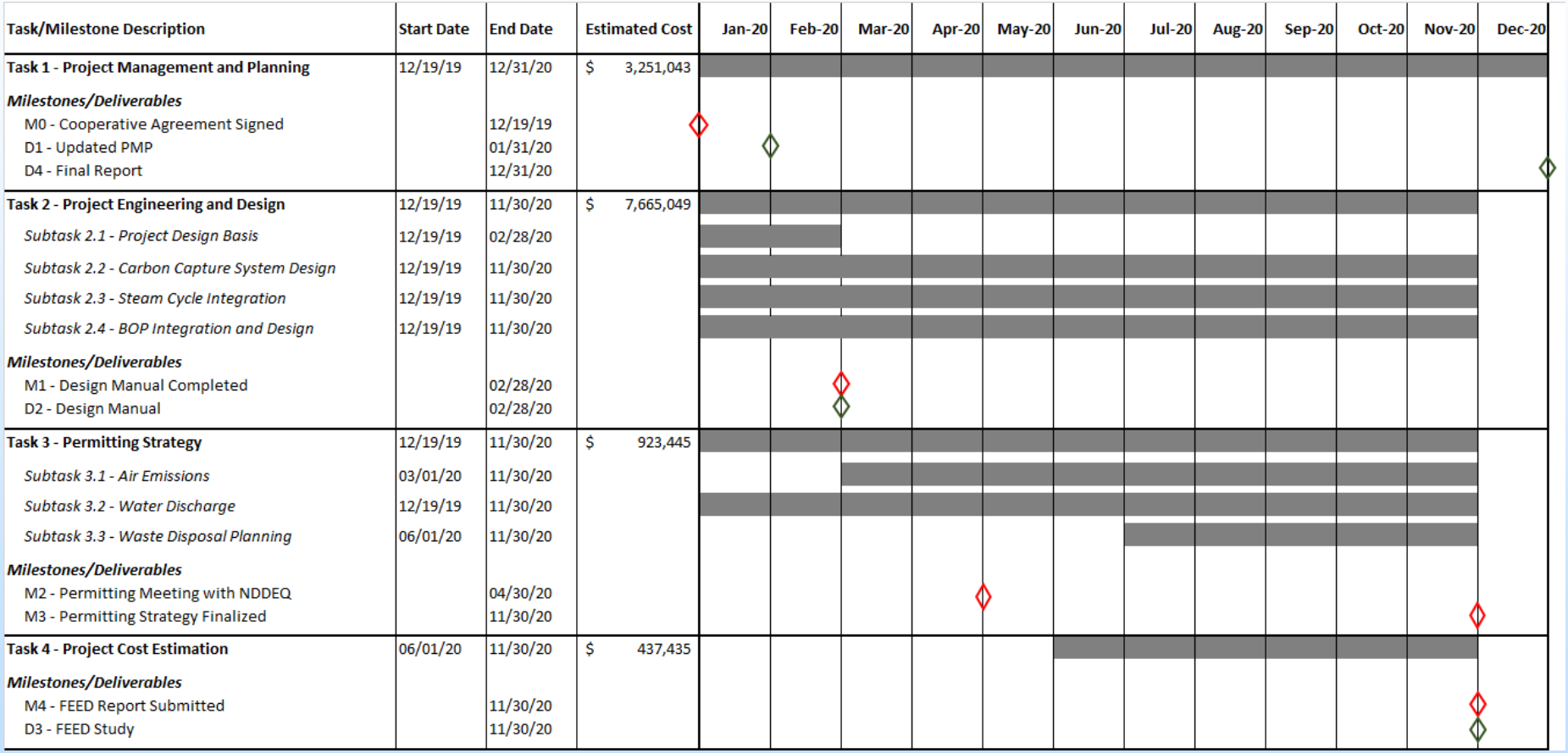
APPENDIX

Project Organizational Chart



Project Gantt Chart



Task/Milestone Description	Start Date	End Date	Estimated Cost
Task 1 - Project Management and Planning	12/19/19	12/31/20	$ 3,251,043
Milestones/Deliverables			
M0 - Cooperative Agreement Signed		12/19/19	
D1 - Updated PMP		01/31/20	
D4 - Final Report		12/31/20	
Task 2 - Project Engineering and Design	12/19/19	11/30/20	$ 7,665,049
Subtask 2.1 - Project Design Basis	12/19/19	02/28/20	
Subtask 2.2 - Carbon Capture System Design	12/19/19	11/30/20	
Subtask 2.3 - Steam Cycle Integration	12/19/19	11/30/20	
Subtask 2.4 - BOP Integration and Design	12/19/19	11/30/20	
Milestones/Deliverables			
M1 - Design Manual Completed		02/28/20	
D2 - Design Manual		02/28/20	
Task 3 - Permitting Strategy	12/19/19	11/30/20	$ 923,445
Subtask 3.1 - Air Emissions	03/01/20	11/30/20	
Subtask 3.2 - Water Discharge	12/19/19	11/30/20	
Subtask 3.3 - Waste Disposal Planning	06/01/20	11/30/20	
Milestones/Deliverables			
M2 - Permitting Meeting with NDDEQ		04/30/20	
M3 - Permitting Strategy Finalized		11/30/20	
Task 4 - Project Cost Estimation	06/01/20	11/30/20	$ 437,435
Milestones/Deliverables			
M4 - FEED Report Submitted		11/30/20	
D3 - FEED Study		11/30/20	

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