Filer City Biomass Carbon Removal and Storage (BiCRS) Net-Negative Study Project Number: DE-FE0032262

Tim Gehring NorthStar Clean Energy

2023 Carbon Management Research Project Review Meeting August 28 – September 1, 2023

Project Overview

– Funding

- DOE: \$1,416,224
- Cost Share: \$903,913

– Overall Project Performance Dates

- Award Date 08/01/2023
- Basis of Design for Project Finalized 10/01/2023
- DOE Kick-off Meeting 10/30/2023
- Preliminary Process Design Review 11/20/2023
- Initial Engineering Design Package 12/29/2023
- Overall Cost Estimate and Cost of Capture Review 04/01/2024
- Final Engineering Design Package 04/15/2024
- Final DOE Report and Presentation 7/12/2024

Project Overview

- Project Participants
 - DOE/NETL Sponsor
 - NorthStar Clean Energy Prime
 - Babcock & Wilcox Bio-Energy Carbon Capture and Support Services
 - Sargent & Lundy EPC Engineering and Support Services
- Overall Project Objectives
 - Confirm availability of sustainably sourced biomass 20 years – completed January 2023.
 - Existing boilers to be retrofitted to fire 100% woody biomass.

Project Overview

- Overall Project Objectives
 - 95% CO₂ removal from flue gas at design conditions
 - Capture ~ 500,000 tonnes of CO₂/year
 - Supply 30 MWs of base load 24/7 carbon-free electricity and process stream
 - Prove viability of business case AACE Class 4 estimate
 - Create a Community Benefits Plan
 - Begin construction in 2025
 - COD in 2026

Project Background



Project Background

- The Project reached commercial operations in 1990 - A partnership between Tondu Corp/CMS Enterprises (now NorthStar Clean Energy)
- Corporate commitment to stop burning coal in 2025
- Project is located on Manistee Lake with access to Lake Michigan
- Based on our biomass studies there are over 61 million tons of unutilized sustainable biomass within trucking distance of the Filer Plant.

Project Background - Biomass Availability

The Manistee National Forest is adjacent to the Filer Plant and much of this forest needs the removal of dying and overcrowded trees for forest health management. In addition to locally source biomass, there are numerous ports within a short shipping distance of the Filer Dock with the capacity to meet the Filer City Plant requirement many times over.



Project Background

- Project is located less than ½ mile from existing pipeline infrastructure for transport of CO₂ to the highly studied Niagaran Reef trend.
- There are over 140 reefs with the potential to store between 500,000 and 2,000,000 tonnes of CO₂ each.
- Strong relationship with Core Energy – who has an CO₂ Monitoring, Reporting, and Verification (MRV) Plan approved Environmental Protection Agency (EPA) covering the entire Reef Trend.



Technical Approach

- Babcock & Wilcox SolveBright CO2 Capture System
- Amine-Based Solvent Scrubbing Process solvent agnostic
- The two major pieces of equipment:
 - Absorber: contacts solvent with incoming flue gas to absorb CO2 into solution
 - Regenerator: CO2 rich solvent from absorber routed to regenerator where heat is added to strip the CO2 from the solvent.
- CO2 lean solvent exits bottom of regenerator and can be used again for CO2 removal in the absorber

Technical Approach

- Prior to carbon capture the exhaust gas from the repowered existing boilers gas will route through:
 - Selective non-catalytic reduction (new)
 - Dust collectors (existing)
 - Spray dryer absorbers (existing)
 - Baghouse (existing)

Technical Approach

Amine-Based Solvent Scrubbing Process



Summary Slide

- 1. The Filer Plant is debt free with the capability to be converted to a BECCS facility. The existing facility and its supporting infrastructure would cost in excess of \$350 million to replicate.
- 2. A CO₂ pipeline exists 2,600 feet from the Filer Plant that can deliver the captured CO₂ to secure geologic storage for sequestration.
- 3. An EPA approved under Subpart RR sequestration MRV plan exists that provides ample locations to sequester the captured CO₂ in deep geologic formations within 10 miles of the Filer Plant.
- 4. No Title V EPA permitting required.
- 5. No electric interconnection is required.
- 6. No new property to be acquired.
- 7. Operating crews are in place.
- 8. Adjacent deep water port facilities allow for low-cost shop-built components to be delivered directly to the site.
- 9. There is ample sustainable waste wood to fuel the facility with existing supply chains to support 500,000 tonnes of captured atmospheric CO₂ per year.
- 10. Over the first 12 years of commercial operation over \$1.2 billion million of positive economic impact will accrue to Michigan supporting 220 permanent jobs in the depressed Northern Michigan economy.

Acknowledgements

- Tondu Corp
- Sargent & Lundy
- B&W
- Filer City Plant Staff
- NorthStar Staff PM, Engineering, Sales and Marketing

Appendix

Organization Chart



Gantt Chart

Northstar BECCS FEED Date Printed: Th													nted: Thu	8/24/23							
Filer	ity				Pr	oject Sc	hedule	e													
ID	Task Name	Duration	Start	Finish	Predecessors	Qtr 3, 2 Jul	023 Auc		Sep	Qtr 4, 202 Oct	23 Nov	Dec	Qtr 1, 2024 Jan	Feb M	Qtr Iar A	2, 2024 pr Mav	Jun	Qtr 3, 2024 Jul	Aug Sec	Qtr 4, 20 Oct	Nov
1	Milestone Dates	248 days	Tue 8/1/23	Fri 7/12/24																	
2	Project Award	0 days	Tue 8/1/23	Tue 8/1/23		1	•														
3	DOE Kickoff Meeting	0 days	Wed 8/30/23	Wed 8/30/23	24	1															
4	Udpated PMP	0 days	Thu 8/31/23	Thu 8/31/23	25																
5	Basis of Design for Project Finalized	0 days	Mon 10/2/23	Mon 10/2/23	32	1				•											
6	Preliminary Process Design Review	0 days	Mon 11/20/23	Mon 11/20/23	50	1					٠										
7	Initial Engineering Design Package	0 days	Mon 11/20/23	Mon 11/20/23	43	1															
8	HAZOP / HAZID Review	0 days	Mon 1/15/24	Mon 1/15/24	70	1							•								
9	Overall Cost Estimate and Cost of Capture	0 days	Mon 4/1/24	Mon 4/1/24	81										٠						
10	Final Engineering Design Package	0 days	Mon 4/15/24	Mon 4/15/24	97	1										•					
11	Final DOE Report & Presentation	0 days	Fri 7/12/24	Fri 7/12/24	98													•			
12	Task 1.0 Project Management and Planning	328 days	Tue 8/1/23	Thu 10/31/24			<u> </u>	-													1
13	Project Management and Reporting	327 days	Wed 8/2/23	Thu 10/31/24				-													-
14	Project Management and Reporting	1 day	Wed 8/2/23	Wed 8/2/23	255	1	1														
15	Project Reporting	282 days	Wed 10/4/23	Thu 10/31/24						—											-
16	Quarterly Reporting	282 days	Wed 10/4/23	Thu 10/31/24						—											1
17	Quarterly Report - Q3, 2023	20 days	Wed 10/4/23	Tue 10/31/23	2SS+45 days																
18	Quarterly Report - Q4, 2023	20 days	Thu 1/4/24	Wed 1/31/24	17SS+66 days																
19	Quarterly Report - Q1, 2024	20 days	Thu 4/4/24	Wed 5/1/24	18SS+65 days																
20	Quarterly Report - Q2, 2024	20 days	Thu 7/4/24	Wed 7/31/24	19SS+65 days																
21	Quarterly Report - Q3, 2024	20 days	Fri 10/4/24	Thu 10/31/24	20SS+66 days																
22	Final Report / Final Presentation	0 days	Fri 7/12/24	Fri 7/12/24	11FF													٠			
23	x	5 days	Wed 8/2/23	Tue 8/8/23	2		-														
24	Project Kickoff Meeting	0 days	Wed 8/30/23	Wed 8/30/23	2FS+21 days																
25	Subtask 1.1 Project Management Plan	23 days	Tue 8/1/23	Thu 8/31/23	2																
26	Subtask 1.2 Technology Maturation Plan	184 days	Wed 8/2/23	Mon 4/15/24			—	-								I					
27	Initial TMP	60 days	Wed 8/2/23	Tue 10/24/23	2																
28	Final TMP	40 days	Tue 2/20/24	Mon 4/15/24	97FF																
29	Subtask 1.3 Workforce Readiness Plan	45 days	Tue 2/13/24	Mon 4/15/24												I					
30	Workforce Readiness Plan	45 days	Tue 2/13/24	Mon 4/15/24	97FF	1															
31	Task 2.0 Study Planning and Definition	95 days	Tue 8/1/23	Mon 12/11/23				-													
32	Subtask 2.1 Project Design Basis / Design Criteria	45 days	Tue 8/1/23	Mon 10/2/23	2					1.1											
33	Subtask 2.2 Initial Scope Definition Studies	89 days	Wed 8/9/23	Mon 12/11/23				-													
34	Biomass Supply Study	20 days	Wed 8/9/23	Tue 9/5/23	23																
35	Material Handling Study	20 days	Wed 8/23/23	Tue 9/19/23	34SS+2 wks	1		-													
36	Boiler Modification Review	30 days	Wed 8/9/23	Tue 9/19/23	23	1															
37	AQCS Operations Review	15 days	Wed 9/20/23	Tue 10/10/23	36	1															
38	Steam and Electricity Sourcing Study	30 days	Tue 10/31/23	Mon 12/11/23	48	1															
39	Cooling Water Options Study	20 days	Tue 10/31/23	Mon 11/27/23	48	1															

Gantt Chart

North	star					BECCS F	EED										Date Prin	ted: Thu 8	8/24/23
Filer C	ity				Pi	oject Scl	nedule												
ID	Task Name	Duration	Start	Finish	Predecessors	Qtr 3, 20 Jul	23 Aug	Sep	Qtr 4, 20 Oct	Nov	Qt Dec	r 1, 2024 Jan Feb	Mar	Qtr 2, 2024 Apr May	Jun	Qtr 3, 2024 Jul /	ug Sep	Qtr 4, 202 Oct	24 Nov
40	Water and Wastewater Treatment Study	20 days	Tue 10/31/23	Mon 11/27/23	48												-		
41	Staffing Plan	20 days	Tue 11/7/23	Mon 12/4/23	49														
42	Task 3.0 FEED Study Engineering and Design	145 days	Tue 8/29/23	Mon 3/18/24				· – –											
43	Subtask 3.1 Initial Engineering and Design	60 days	Tue 8/29/23	Mon 11/20/23				<u> </u>											
44	Process Modeling	20 days	Tue 8/29/23	Mon 9/25/23	32SS+20 days														
45	Preliminary Deliverables	30 days	Tue 9/26/23	Mon 11/6/23					<u> </u>	-									
46	Process Flow Diagrams	15 days	Tue 9/26/23	Mon 10/16/23	44														
47	Heat & Material Balances	10 days	Tue 10/3/23	Mon 10/16/23	46FF														
48	Utility Flow Diagrams	10 days	Tue 10/17/23	Mon 10/30/23	47														
49	System Description	15 days	Tue 10/17/23	Mon 11/6/23	47														
50	Preliminary Design Review	10 days	Tue 11/7/23	Mon 11/20/23	45														
51	Subtask 3.2 - Process Engineering and Design	30 days	Tue 11/21/23	Mon 1/1/24															
52	Process Engineering and Design	30 days	Tue 11/21/23	Mon 1/1/24	43														
53	Process Deliverables	30 days	Tue 11/21/23	Mon 1/1/24															
54	Process & Instrumentation Diagrams	30 days	Tue 11/21/23	Mon 1/1/24	43														
55	Process Equipment List	15 days	Tue 11/21/23	Mon 12/11/23	43														
56	Process Equipment Electrical Load List	15 days	Tue 12/12/23	Mon 1/1/24	55														
57	Subtask 3.3 - Overall Project Engineering and	135 days	Tue 9/12/23	Mon 3/18/24															
	Design																		
58	Overall Project Engineering and Design	120 days	Tue 10/3/23	Mon 3/18/24	32														
59	Overall Project Deliverables	105 days	Tue 9/12/23	Mon 2/5/24															
60	Project Site Plan	20 days	Tue 12/12/23	Mon 1/8/24	55														
61	Project Process Flow Diagrams	15 days	Tue 9/12/23	Mon 10/2/23	32FF	-													
62	Project Heat and Material Balances	10 days	Tue 9/19/23	Mon 10/2/23	61FF			I											
63	Project Water Balance	10 days	Tue 11/28/23	Mon 12/11/23	39,40,62FF														
64	BOP Process & Instrumentation Diagrams (P&IDs)	45 days	Tue 10/3/23	Mon 12/4/23	61														
65	Project Equipment List	15 days	Tue 10/3/23	Mon 10/23/23	61														
66	Project Electrical Load List	15 days	Tue 11/7/23	Mon 11/27/23	65FS+2 wks														
67	General Arrangement Drawings	40 days	Tue 12/12/23	Mon 2/5/24	60SS														
68	Terminal Point List	15 days	Tue 11/21/23	Mon 12/11/23	43,61														
69	Single Line Diagram	20 days	Tue 1/2/24	Mon 1/29/24	56,65,66														
70	HAZOP / HAZID Review Meeting	10 days	Tue 1/2/24	Mon 1/15/24	54,64FS+2 wks														
71	Permitting Matrix	15 days	Tue 12/12/23	Mon 1/1/24	62,63														
72	Constructability Review Meeting	2 days	Fri 1/19/24	Mon 1/22/24	67FF-2 wks							- 1							
73	Project Execution Plan	30 days	Fri 1/19/24	Thu 2/29/24	72SS														
74	Task 4.0 FEED Study Project Cost Estimate	107 days	Tue 11/7/23	Wed 4/3/24															
75	Capital Cost Estimate Input	105 days	Tue 11/7/23	Mon 4/1/24		_													
76	CO2 Capture Equipment Pricing Input	40 days	Tue 12/12/23	Mon 2/5/24	55	_													
77	BOP Equipment Pricing Input	40 days	Tue 11/7/23	Mon 1/1/24	65FS+10 days														

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Gantt Chart

Northstar BECCS FEED																					Dat	e Prin	ed: Thu	8/24	/23
ID	Task Name	Duration	Start	Finish	Predecessors	Qtr 3, 20	023		Qtr 4, 2	2023		Qt	r 1, 2024		0	tr 2, 202	4		Qtr 3	3, 2024		C	Qtr 4, 2	024	
78	Overall Project Commodity Input	15 days	Tue 2/6/24	Mon 2/26/24	59	Ju	Aug	Sep	Oct	NO	v i Dec	c .	Jan F	D N	nar i	Apr	May	Jun			Aug	Sep	UC		<u>×</u>
79	Construction Costs	15 days	Tue 3/12/24	Mon 4/1/24	80FF	-																			
80	Overall Cost Estimate (AACE Class 4)	40 days	Tue 2/6/24	Mon 4/1/24	76,77FF,78FF																				
81	O&M Cost Estimate	10 days	Tue 3/19/24	Mon 4/1/24	80FF																				
82	Cost of Capture & LCOE Impact	2 days	Tue 4/2/24	Wed 4/3/24	80										1.1										
83	Task 5.0 Project Planning Deliverables	203 days	Wed 10/4/23	Fri 7/12/24															-						
84	Business Case Analysis	20 days	Tue 3/19/24	Mon 4/15/24	97FF																				
85	Life Cycle Analysis	139 days	Wed 10/4/23	Mon 4/15/24																					
86	Initial LCA	40 days	Wed 10/4/23	Tue 11/28/23	2FS+45 days																				
87	Final LCA	40 days	Tue 2/20/24	Mon 4/15/24	97FF																				
88	Environmental Health and Safety Analysis	60 days	Tue 1/23/24	Mon 4/15/24	97FF																				
89	Environmental Justice Questionnaire	30 days	Tue 3/5/24	Mon 4/15/24	97FF																				
90	Economic Revitalization and Job Creation Outcomes Questionnaire	60 days	Tue 1/23/24	Mon 4/15/24	97FF																				
91	Justice 40 Initiative Plan	139 days	Wed 10/4/23	Mon 4/15/24																					
92	Initial J40	40 days	Wed 10/4/23	Tue 11/28/23	2FS+45 days																				
93	Final J40	40 days	Tue 2/20/24	Mon 4/15/24	97FF																				
94	Community and Stakeholder Engagement Plan	139 days	Wed 10/4/23	Mon 4/15/24					_																
95	Initial CSEP	40 days	Wed 10/4/23	Tue 11/28/23	2FS+45 days																				
96	Final CSEP	40 days	Tue 2/20/24	Mon 4/15/24	97FF																				
97	Final Engineering Design Package	20 days	Tue 3/19/24	Mon 4/15/24	81FF+2 wks																				
98	Final Report / Final Presentation	64 days	Tue 4/16/24	Fri 7/12/24	97																				