Project Delta (DE-FE0032149)

Front-End Engineering and Design for a CO2 Capture System at Calpine's Delta Energy Center

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Project Objective

Project Period of Performance:

*February 1, 2022 – August 31, 2023**

Funding:

Federal: $5,811,210

Cost Share: $1,452,803

Objective:

Complete a FEED for a commercial-scale carbon dioxide (CO_2) capture facility retrofitted onto an existing natural gas combined cycle (NGCC) power station. The project team will design and cost a CO_2 capture facility for retrofit onto Delta Energy Center (DEC), an 857 MW facility in Calpine's fleet.

** NCE Requested*

Project Team Members

ION Clean Energy
- Award Recipient
- Technology Developer
- Process Design and Project Management

Calpine
- Host Site & Subrecipient
- Power Generation Engineering, Operational and Financial Expertise

Sargent and Lundy
- Capture Island Process Oversight, Engineering & Costing
- Balance of Plant Engineering & Costing
- Overall Cost Estimate Development
- Engineering Studies Lead

Koch Engineered Solutions (KES)
- Gas/Liquid Contactor Vendor
- Contactor Design & Costing Support

Siemens Energy
- Compressor Technology Provider
- CO_2 Compressor Design & Costing – Including Heat Integration

Kiewit
- Owners Engineer
- Document Review

Toshiba America Energy System (TAES)
- Steam Turbine OEM
- Evaluation of Steam Extraction

Deltak
- HRSG OEM
- Evaluation of Flue Gas Duct Tie-in

Statement of Project Objectives

Task 1 – Project Management

Task 2 – Overall Project Design Basis

- Subtask 2.1 – Overall Project Design Basis
  - Overall Design Basis/Design Criteria
  - Carbon Capture System Requirements Document
- Subtask 2.2 – System Design Description
  - System Design Description including BOP

Task 3 – Process Design – CO_2 Capture Island

- Subtask 3.1 – Preliminary Design of the Carbon Capture Island
  - Process Flow Diagrams, Heat and Material Balance, Utility Summary, Preliminary Equipment List, a Theory of Operation, and a refined set of requirements with support from performance models and system analyses.
- Subtask 3.2 – Detailed Design of the Carbon Capture Island
  - Detailed Equipment List supported by vendor data sheets, Controls Description, Emissions and Effluent List, Capture System P&IDs and an Equipment Layout Plan

Statement of Project Objectives

Task 4 – Engineering and Design

- Subtask 4.1 – BOP Systems Design
  - Design work supporting Site Plan, Foundation, Ductwork, Structural Steel, Steam Turbine Tie-In, Heat Rejection System, Pipe Racks, Building/Architecture, Electrical Systems, General Arrangement Drawings and a Preliminary 3D Model
- Subtask 4.2 – System Level Engineering
  - System level engineering packages including the system level Heat and Water Balances, P&ID's and resulting Equipment, Piping, Instrument and Electrical Load Lists

Task 5 – Supplemental Studies and Investigations

- Including
  - Steam and Power Sourcing Study
  - Cooling Water and Optimization Study
  - Reliability, Availability and Maintainability (RAM) Analysis
  - Hazard and Operability Review (HAZOP)
  - Constructability Review

Statement of Project Objectives

Task 6 – Cost Estimating

- Subtask 6.1 – CO_2 Capture Island and BOP Capital Costs
- Subtask 6.2 – Operating & Maintenance Costs
- Subtask 6.3 – Overall Cost Estimate and Cost of Capture

Task 7 – Final Reporting & DOE Deliverables

- Subtask 7.1 – FEED Study
- Subtask 7.2 – Additional Required DOE Deliverables:
  - Life Cycle Analysis
  - Business Case Analysis
  - Techno-Economic Analysis
  - Economic Revitalization and Job Creation Outcomes Analysis
  - Environmental Justice Analysis

Key Milestones

#	Corresponding Task	Title/Description	Target/Actual Completion Date	Verification Method
M1	1.0	DOE Kickoff Meeting	**06/13/2022**	Presentation Slides
M2	1.0	Updated PMP	**02/28/2022**	PMP Transmitted to DOE FPM
M3	2.0	Basis of Design for Project Finalized	**05/31/2022**	Meeting Held w/ Results Project SharePoint Site; Completion Memo to DOE
M4	3.0	Preliminary Design Review Complete	**05/10/2022**	Meeting Held w/ Results Project SharePoint Site; Completion Memo to DOE
M5	4.0	Critical Design Review Complete	**09/13/2022**	Meeting Held w/ Results Project SharePoint Site; Completion Memo to DOE
M7	5.4	HAZOP Complete	**11/29/2022**	HAZOP Report Completed
M8	6.0	Overall Cost Estimate and Cost of Capture	08/31/2023	Meeting Held w/ Results Project SharePoint Site; Completion Memo to DOE
M9	7.0	Front-End Engineering Design (FEED) Report	10/31/2023	Report Delivered to DOE/NETL
M10	7.0	Final DOE Report & Presentation	11/30/2023	Report Delivered to DOE/NETL

Delta Energy Center

Information

- **Location:**
  - Pittsburg, CA
- **Facility Type:**
  - 3 x 1 NGCC
  - Siemens W501F CTs
  - Deltak HRSGs
  - Toshiba ST
- **Additional Site Information**
  - Adjacent to a wetland
  - Land south of the facility is not available for Carbon Capture System
  - DDSD provides makeup water to base plant

ION Technology

Proprietary Solvent-based Technology

- Liquid absorbent-based capture
- Low aqueous
- WW Patents

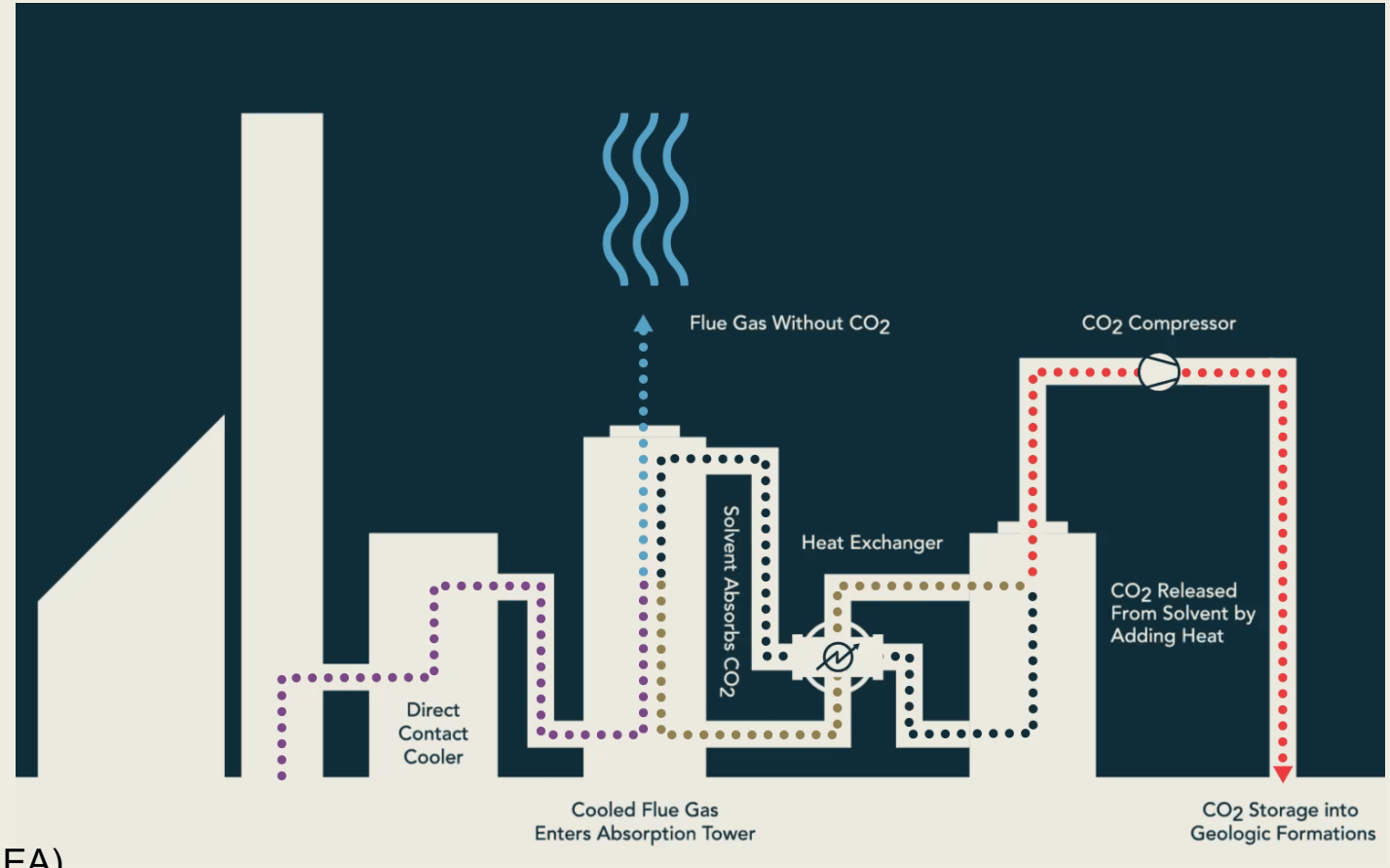
Reduced CAPEX & OPEX

- Smaller columns, HXs and footprint
- Lower energy requirements

Established Engineering Process

Basis of Performance

- < 1,050 Btu/lb CO_2 (2.4 MJ/kg CO_2)
  - Fast kinetics (on par or faster than MEA)
  - Working capacity (higher than MEA)
  - Low heat capacity (much lower than MEA)
- Low tendency for corrosion (much lower than MEA)



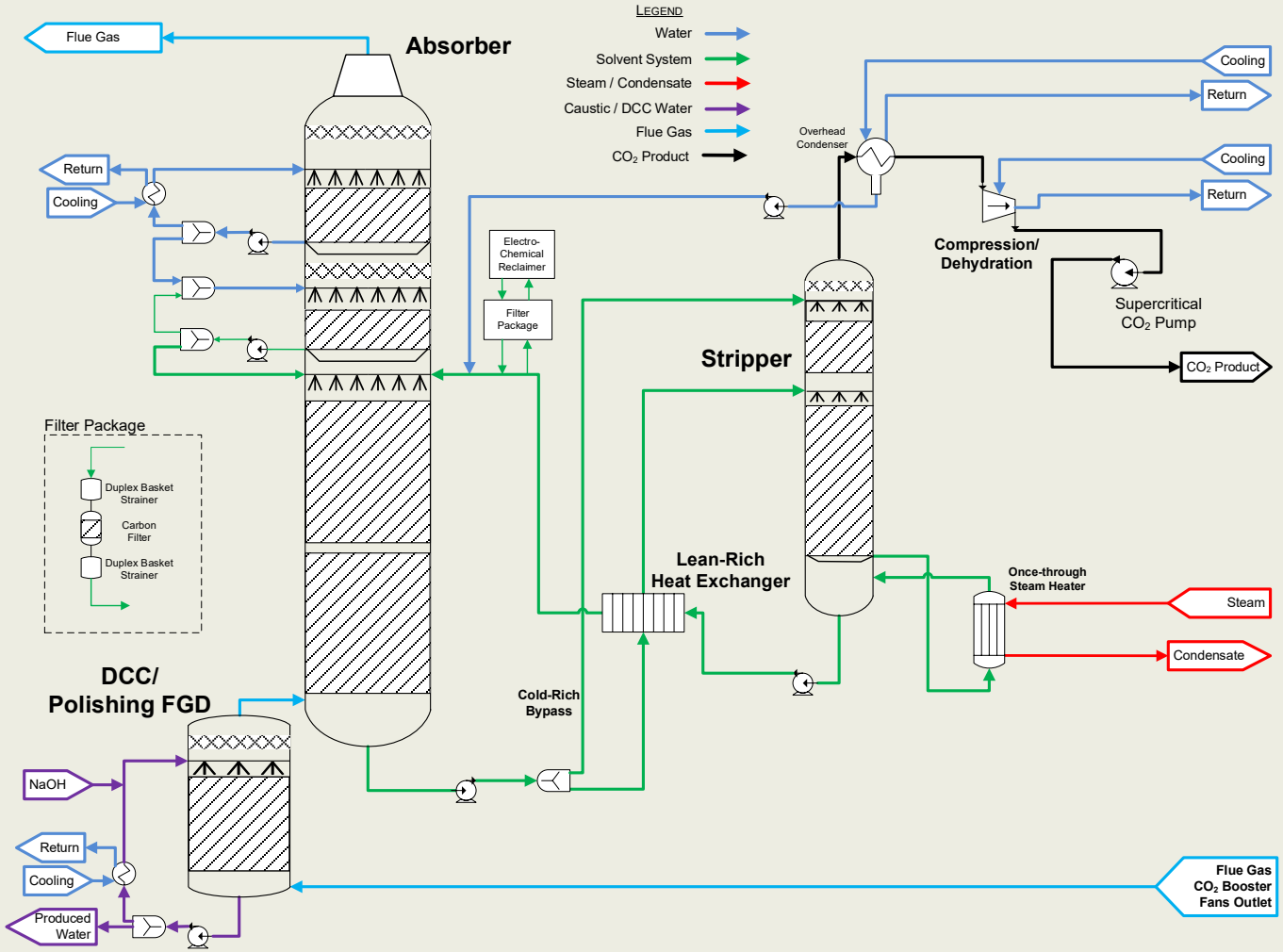
ProTreat Process Model

ION CO_2 Capture Process

Key features of ION process compared to 'common' MEA-designed plant

- Cold-Rich By-pass
- Optimized lean rich cross exchanger (LRXC) design
- Compressor Selection for heat integration

ProTreat output provides stream tables, key performance indices, and steam, cooling and electrical duties



System Design

CO_2 Capture Plant

- Capture System Design
  - 2x 50% trains for the Capture Island
  - 2x 50% on major pieces of equipment to assist in turndown and provide some risk mitigation
  - Designed for operation at full load, and track plant load to maximum turndown
  - Designed for 95% capture of CO_2; resulting in upto 98% capture at turndown
  - CO_2 product at expected Capacity Factor: 2.4M tonnes of CO_2/yr

System Design

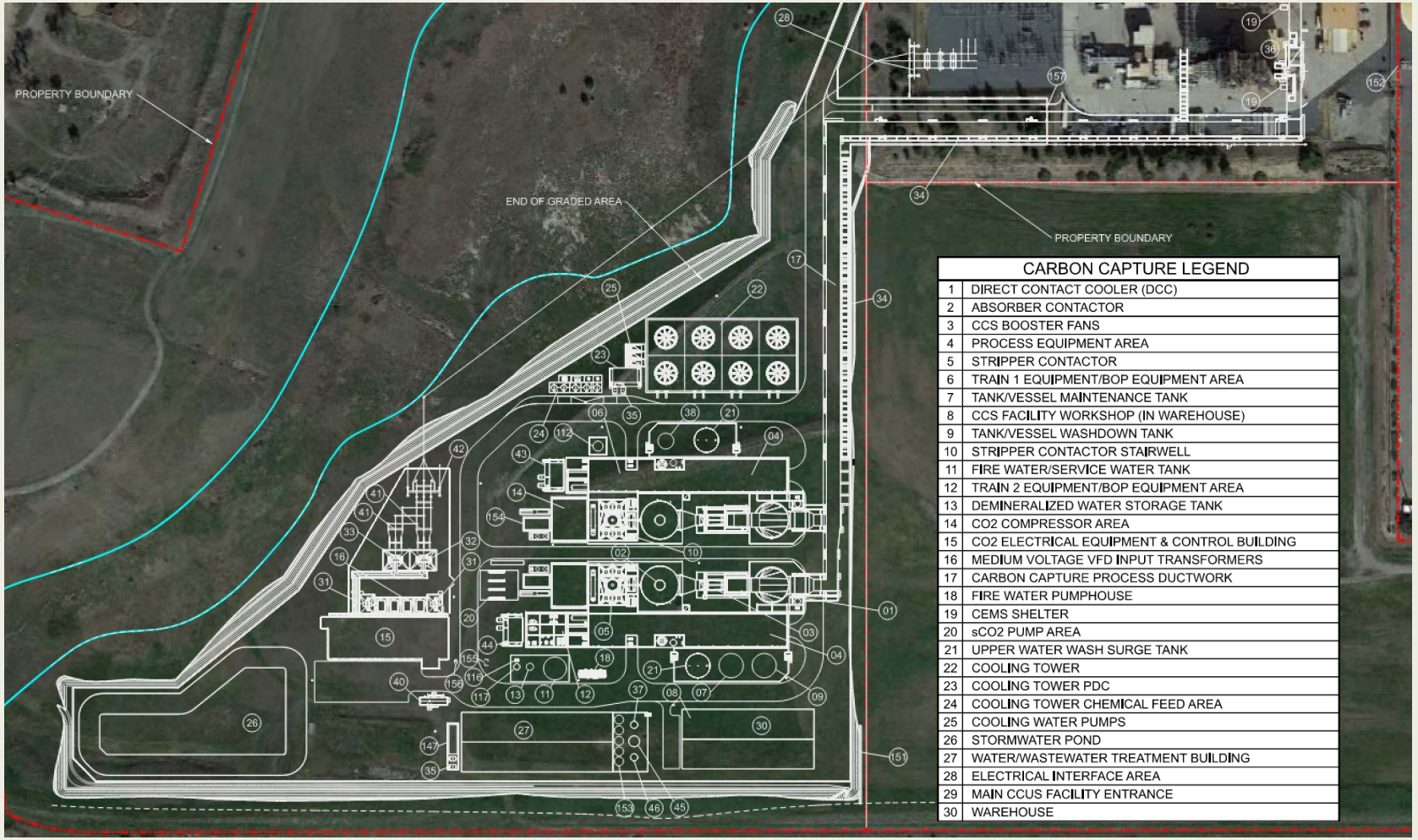
CO_2 Capture Plant

BOP Design

- Steam Sourcing
  - Worked with the Steam Turbine vendor to optimize and evaluate consequences of extraction at various locations
- Heat Rejection System
  - Utilize consumptive water available from DDSD and DCC blowdown
  - Sufficient water available for fully evaporative cooling system
  - 2% Summer occurrence temperature was used for the basis for design
- Flue Gas Tie-in
  - Worked with vendor (Deltak) to design tie-in point and consolidate HRSG stack flows

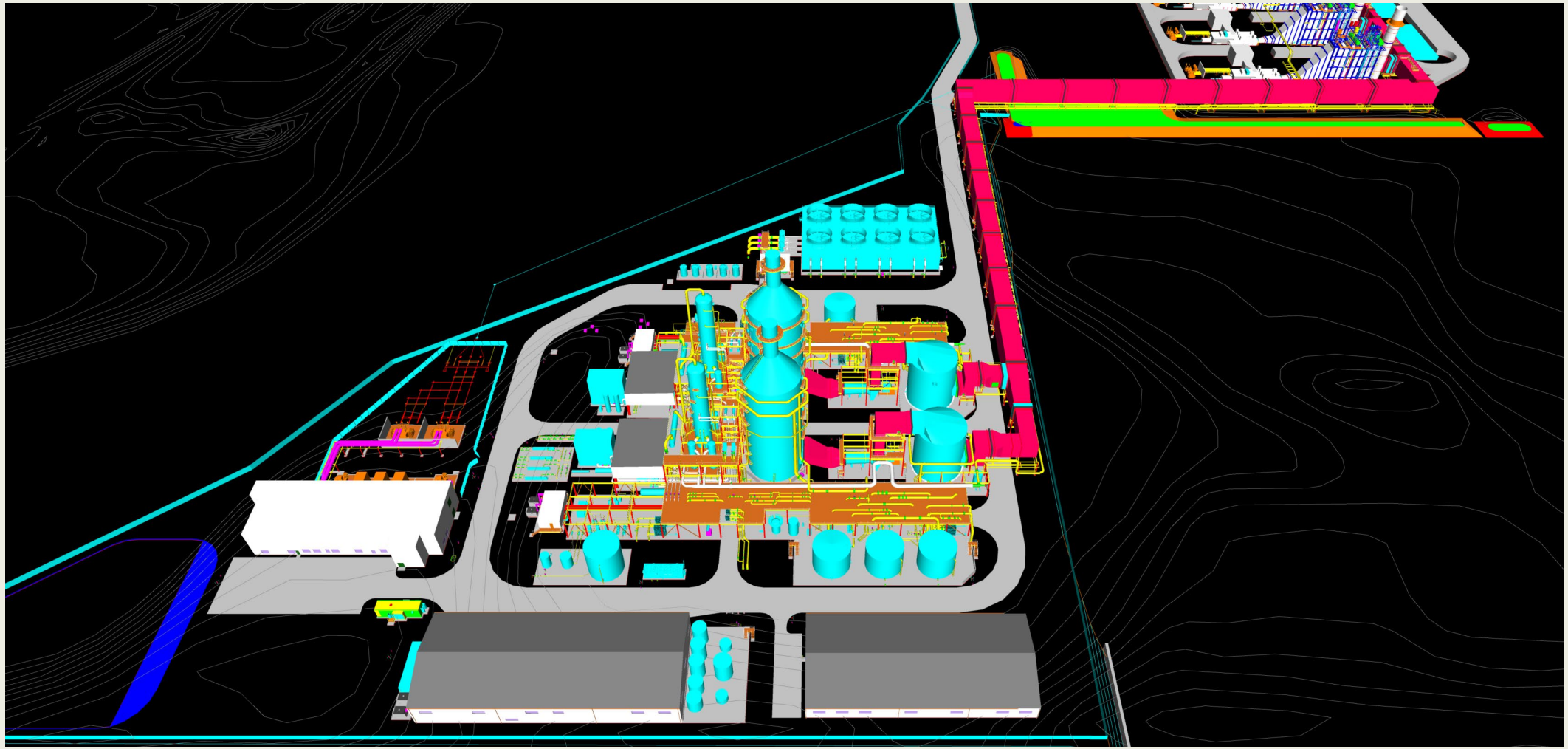
Carbon Capture System

Plot Plan – General Arrangement

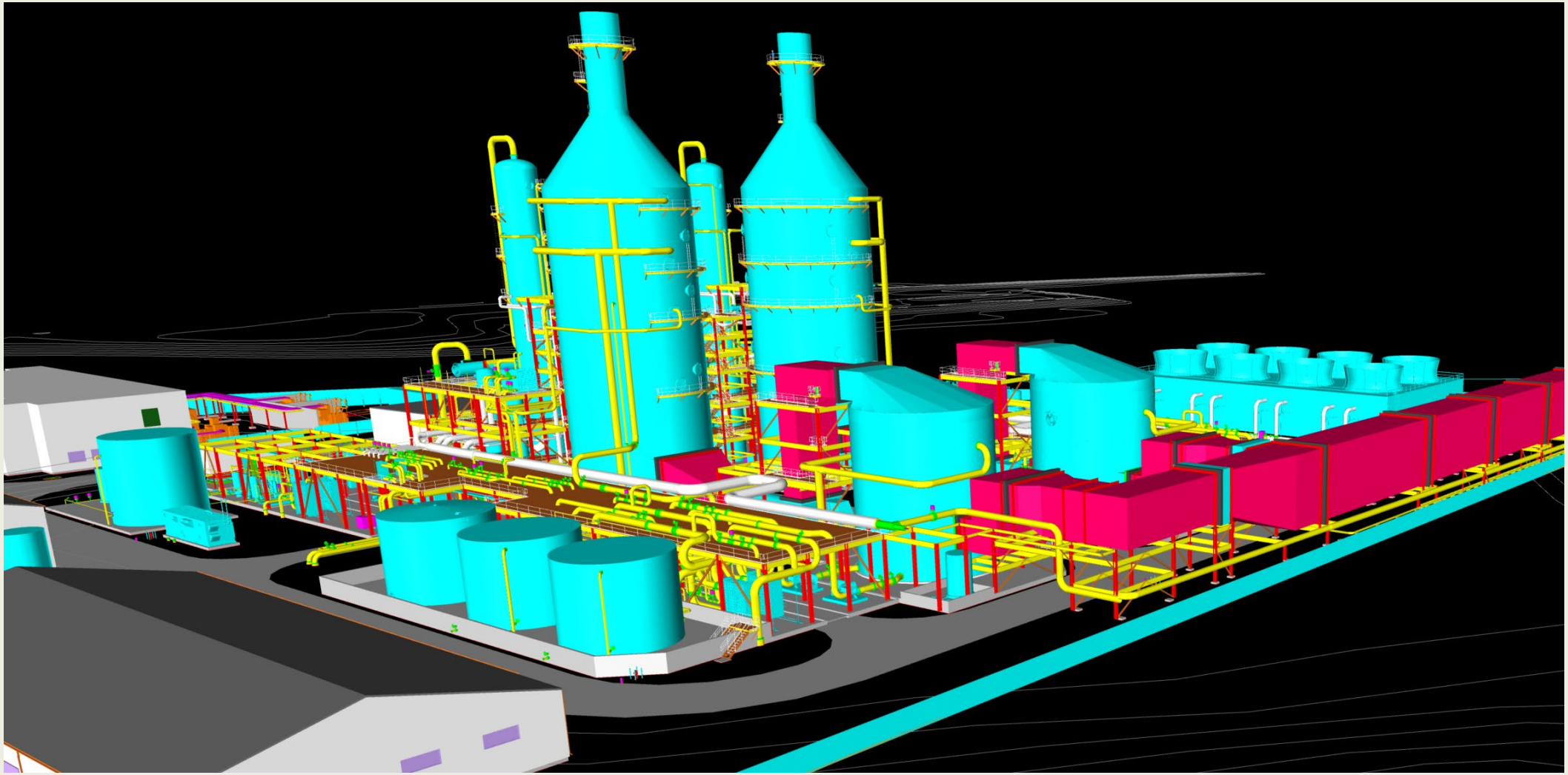


CARBON CAPTURE LEGEND	
1	DIRECT CONTACT COOLER (DCC)
2	ABSORBER CONTACTOR
3	CCS BOOSTER FANS
4	PROCESS EQUIPMENT AREA
5	STRIPPER CONTACTOR
6	TRAIN 1 EQUIPMENT/BOP EQUIPMENT AREA
7	TANK/VESSEL MAINTENANCE TANK
8	CCS FACILITY WORKSHOP (IN WAREHOUSE)
9	TANK/VESSEL WASHDOWN TANK
10	STRIPPER CONTACTOR STAIRWELL
11	FIRE WATER/SERVICE WATER TANK
12	TRAIN 2 EQUIPMENT/BOP EQUIPMENT AREA
13	DEMINERALIZED WATER STORAGE TANK
14	CO2 COMPRESSOR AREA
15	CO2 ELECTRICAL EQUIPMENT & CONTROL BUILDING
16	MEDIUM VOLTAGE VFD INPUT TRANSFORMERS
17	CARBON CAPTURE PROCESS DUCTWORK
18	FIRE WATER PUMPHOUSE
19	CEMS SHELTER
20	sCO2 PUMP AREA
21	UPPER WATER WASH SURGE TANK
22	COOLING TOWER
23	COOLING TOWER PDC
24	COOLING TOWER CHEMICAL FEED AREA
25	COOLING WATER PUMPS
26	STORMWATER POND
27	WATER/WASTEWATER TREATMENT BUILDING
28	ELECTRICAL INTERFACE AREA
29	MAIN CCUS FACILITY ENTRANCE
30	WAREHOUSE

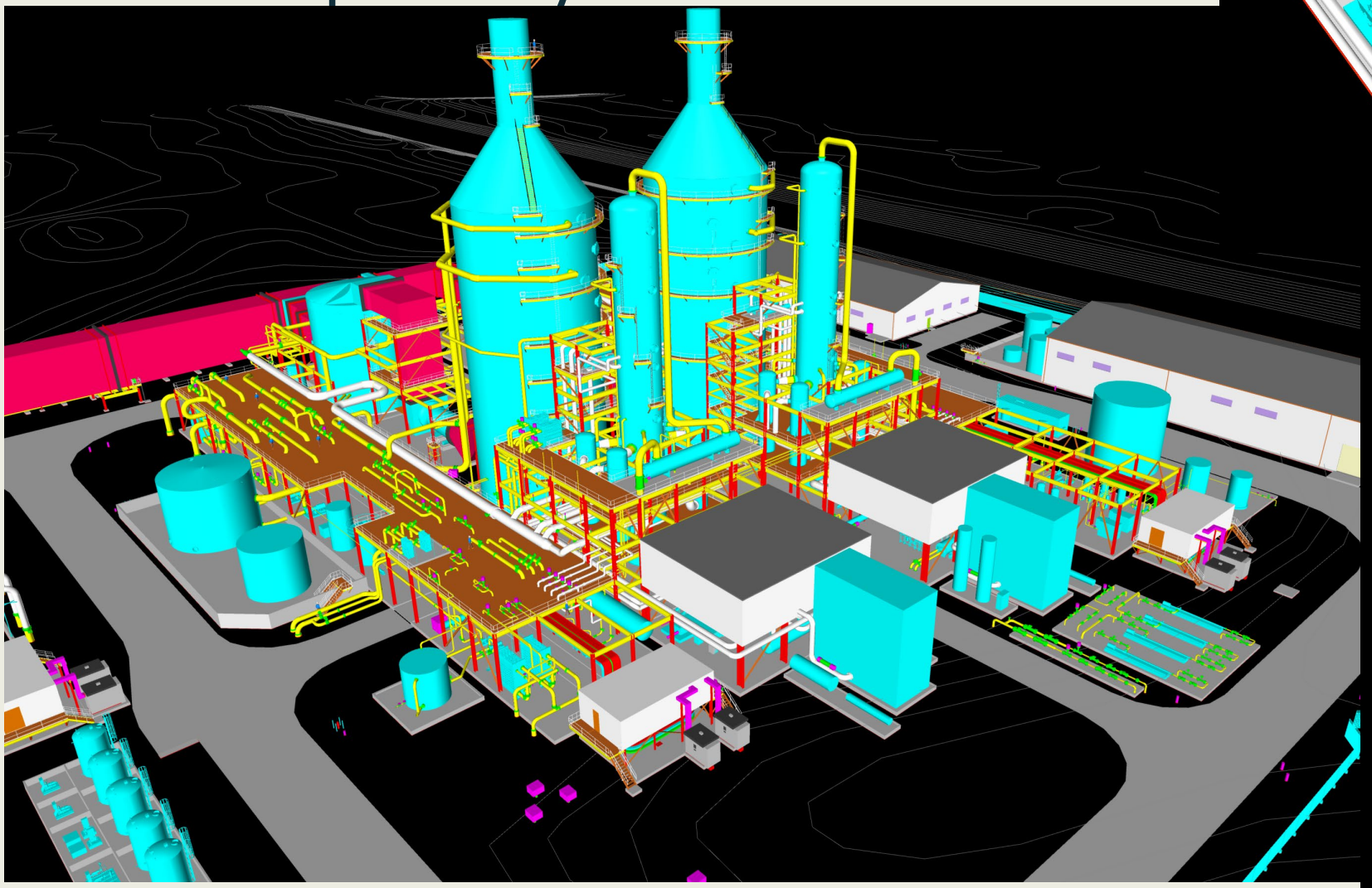
Carbon Capture System

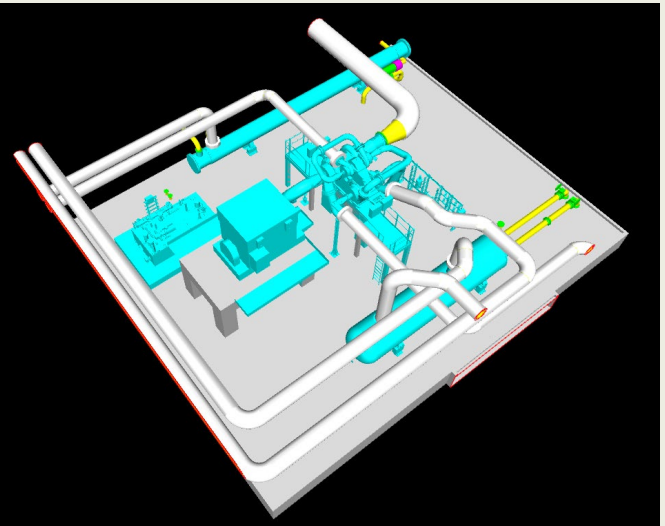


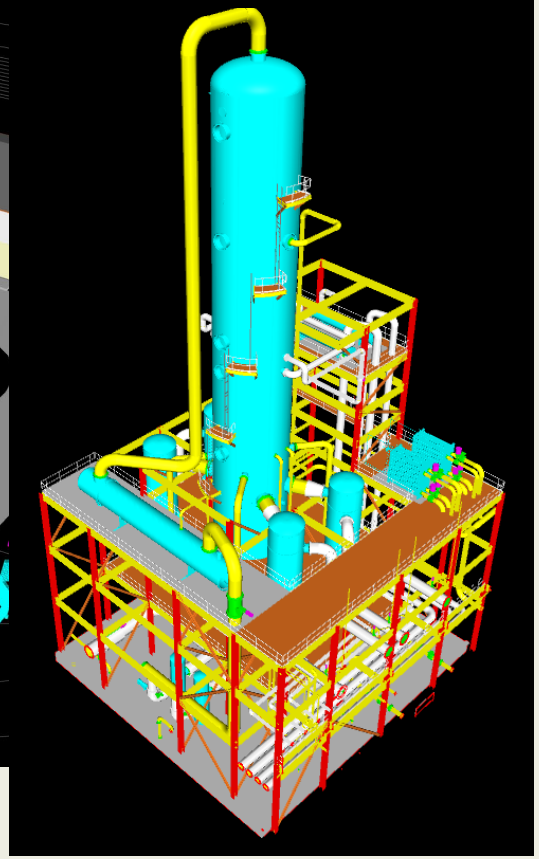
Carbon Capture System



Carbon Capture System







Project Status

Work Completed Since Q4 2022

- Conducted Critical Design Review with the Project Team (Nov 2022)
- Conducted HAZOP (Dec 2022); HAZOP Report completed (April 2023)
- Finalized BOP and Carbon Capture Island P&IDs (Feb 2023)
- Finalized Instrument List (Feb 2023)
- Generated Steel Layout, Ductwork Sketches, Foundation List, and Sitework Drawings (Feb-April 2023)
- Finalized Operational Philosophy (Mar 2023)
- Finalized Vendor's Vessel Drawings (April 2023)
- Finalized the General Arrangement (May 2023)
- Achieved Substantial Complete of 3D model (May 2023)
- Developed Permitting Matrix (June 2023)
- Terminal Points List, Piping List, Valve List (July 2023)
- Began Cost Estimate (CAPEX w/ Vendor Quotes; OPEX)
- Conducted Reliability, Availability and Maintenance (RAM) Analysis (Aug 2023)

Project Status

Work Ongoing

- Finalize Life Cycle Analysis (Aug 2023)
- Finalize Business Case Analysis (Aug 2023)
- Finalize Revitalization and Job Creation Outcomes Analysis (Aug 2023)
- Finalize Environmental Justice Analysis (Aug 2023)
- Cost Estimate – CAPEX, OPEX, Cost of Capture (Sept 2023)
- Techno-Economic Analysis (Sept 2023)
- Compile the FEED Report (Oct-Nov 2023)
- Complete Final Report (Jan 2023)

Acknowledgement & Disclaimer

Acknowledgement

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Disclaimer

Thank you


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