“Project Delta”

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

DE-FE0032149

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U.S. Department of Energy
National Energy Technology Laboratory
Carbon Management Project Review Meeting
August 15 through August 19, 2022

DE-FE0032149: “FEED for a CO2 Capture System at Calpine’s Delta Energy Center” (Project Delta)

Project Overview

- 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.

Project Delta

Project Team and Roles

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

Project Overview

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	03/20/2023	Meeting Held w/ Results Project SharePoint Site; Completion Memo to DOE
M9	7.0	Front-End Engineering Design (FEED) Report	06/30/2023	Report Delivered to DOE/NETL
M10	7.0	Final DOE Report & Presentation	08/31/2023	Report Delivered to DOE/NETL

ION'S SOLVENT TECHNOLOGY

ION Technology

Proprietary Solvent-based Technology

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

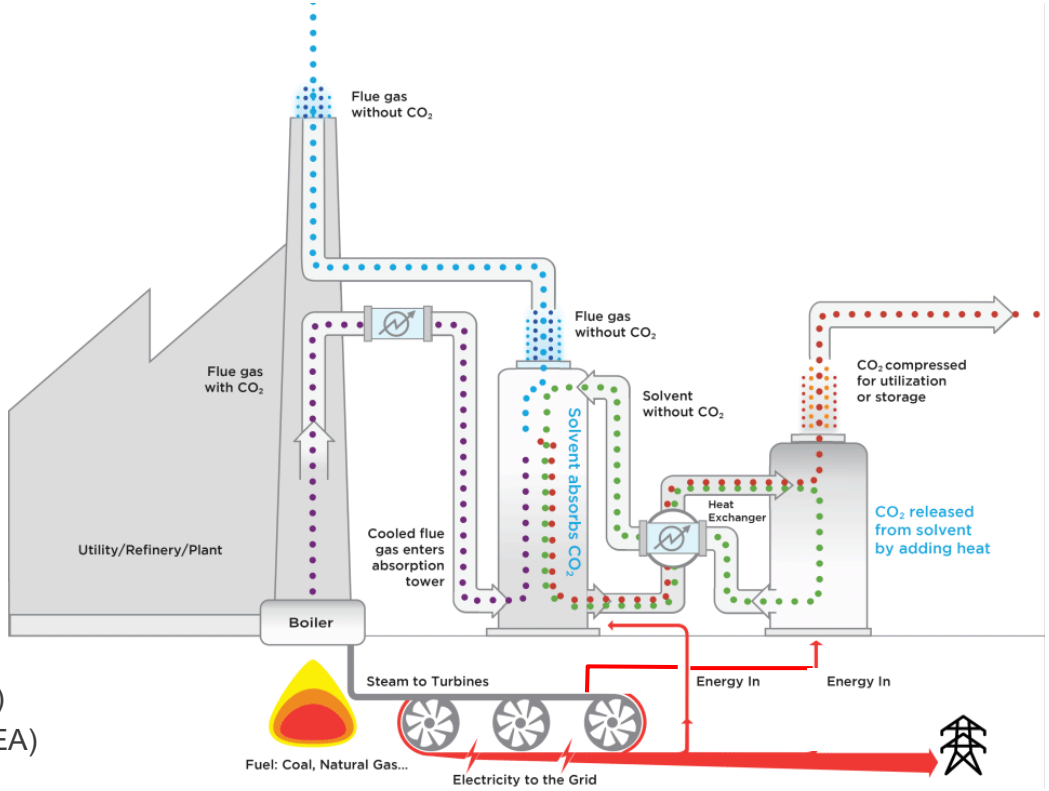
Reduced CAPEX & OPEX

- 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)



ION's CO_2 Capture Technology Development

Accelerated development path leveraging existing research facilities

ION CLEAN ENERGY

2010

ION-CE Lab-pilot
Simulated Flue Gas
3 kWe
Boulder, CO, USA

2012

EERC
Coal
0.05 MWe
Grand Forks, ND, USA

2015

NCCC
Coal & Natural Gas
0.5 MWe
Wilsonville, AL, USA

2016 - 2017

TCM
Refinery & NGCC
30 – 60 ktpa
Mongstad, Norway

2018 - Present

Commercial FEED
Coal & NGCC
2 – 5 Mtpa
USA

PROJECT DELTA – CURRENT PROJECT PROGRESS

Delta Energy Center Background

- **Location:**
  - Pittsburg, CA
- **Facility Type:**
  - 3 x 1 NGCC
  - Siemens W501F CTs
  - Deltak HRSGs
  - Toshiba ST
- **Additional Site Information**
  - Original proposed location of CCUS is immediately South of base plant
  - DDSD provides makeup water to base plant

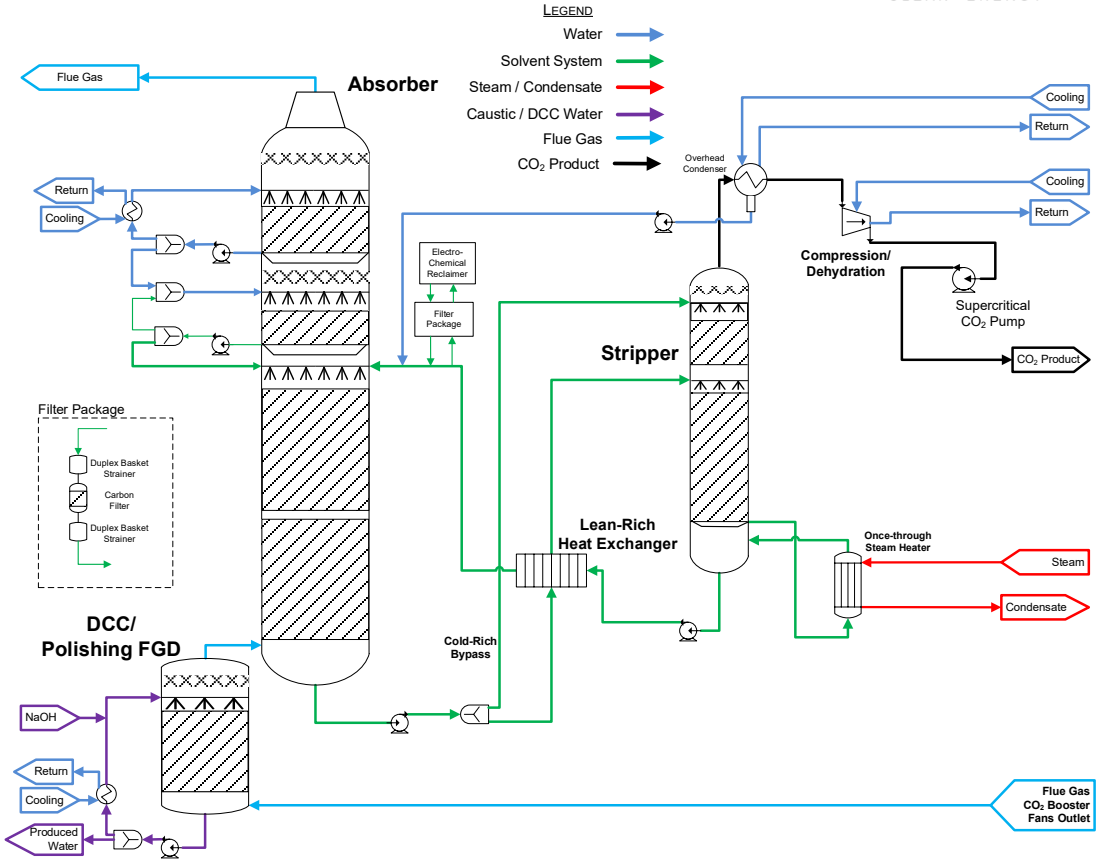
ProTreat® Process Model

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
- Caustic addition to DCC to act as a Polishing Scrubber
- Compressor Selection

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: 2.36M tonnes of CO_2/yr

System Design

CO_2 Capture Plant

- BOP Design
  - Steam Sourcing
    - Working 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
    - Working with vendor to design tie-in point and consolidate HRSG stack flows

Compressor Initially Sized

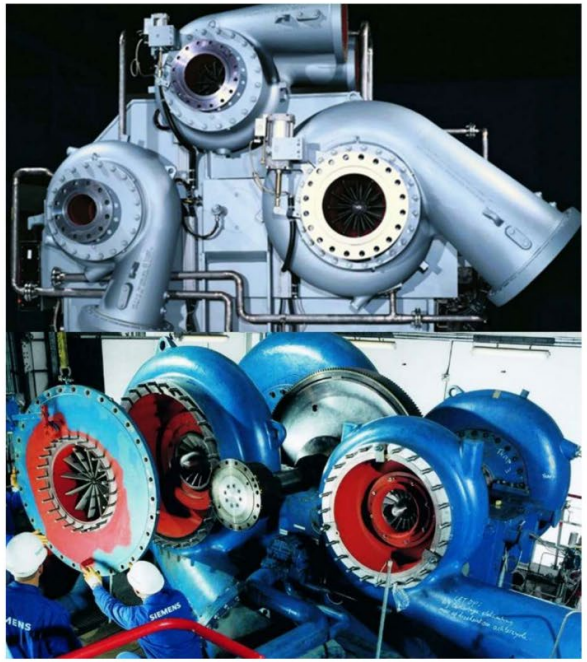
ION CLEAN ENERGY

Integrally-Geared Compressor

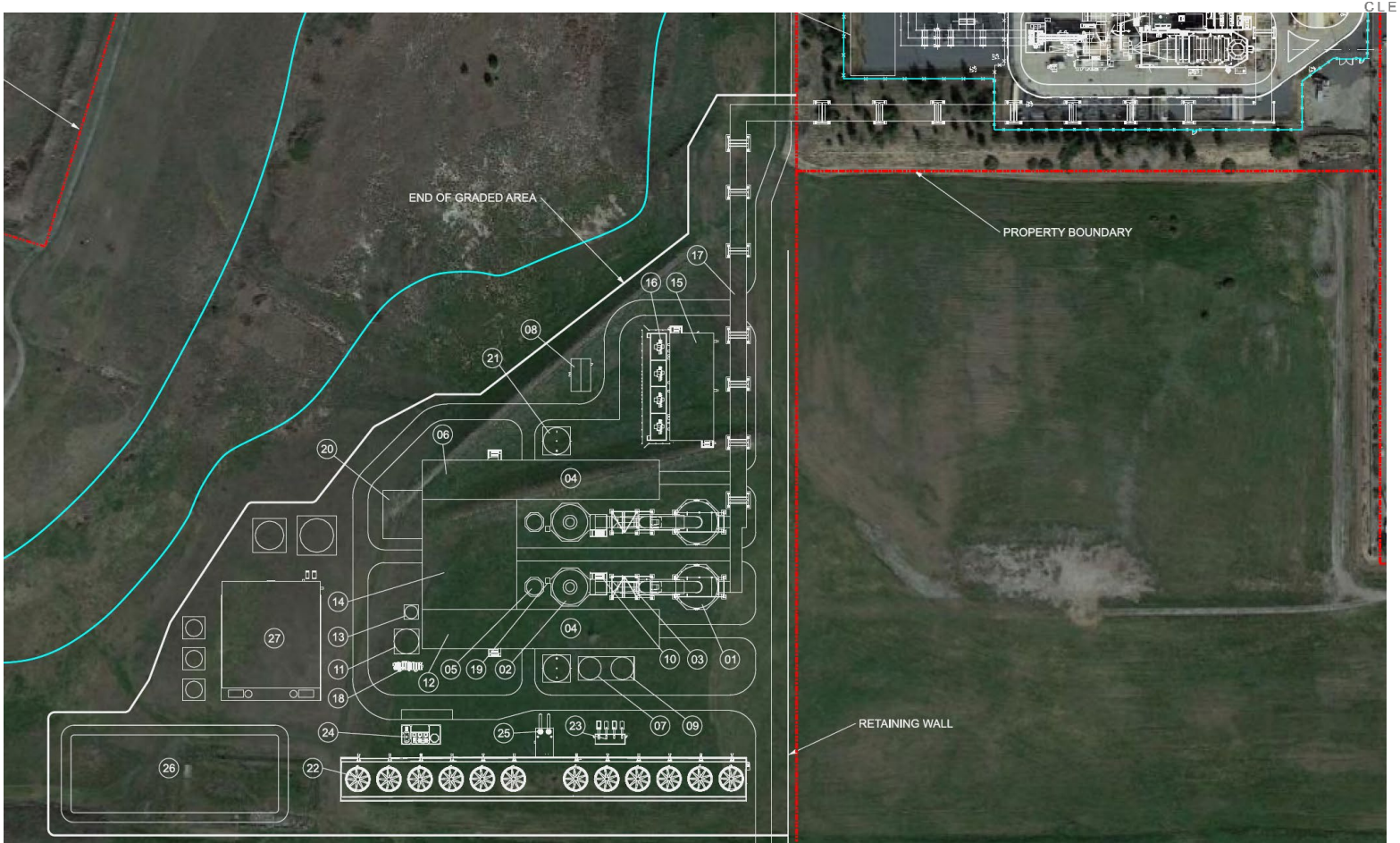
SIEMENS energy

STC-GV
(Siemens Turbo Compressor, Geared, Vertical Split

Characteristic	Range	DEC
Frame sizes	10-200	20
Volume flow (m^3/hr)	10,000 – 800,000	51,700
Discharge pressure (bara)	Up to 200	80
Power (MW)	Up to 65 MW	14.6
Impeller size (mm)	110 – 2,000	559 - 226
Pinion speed (rpm)	Up to 35,000	11,451 - 19,220
Bull gear diameter (mm)	Up to 3,300	1,554
Number of stages	2-8	6



Preliminary General Arrangement



Current Project Status

Accomplishments

- Substantial complete of Design Basis (Tracking Decision Log)
- Produced Design Criteria
- Completed the Process Design Package (PFD, HMB, Equipment List, Utility Summary)
- Completed Initial Compression Selection and Preliminary Compression Design
- Conducted Preliminary Design Review
- Generated Initial Plot Plan & performed Geotechnical Assessment
- Generated Capture system P&IDs
- Generated Overall Balances
- Laser Scan of site and initiation of 3D Model
- Kickoff of critical flaw analysis with Toshiba on Steam Extraction
- Draft reports out on the Technology Selection for the Heat Rejection system and on the Water/Wastewater Treatment Study

Current Project Status

Next Steps (Q3 2022)

- Complete the Theory of Operations Document
- Finalize Design Criteria
- Issue for use:
  - Process Equipment Drawings
  - P&IDs with associated lists
  - Overall Heat and Mass Balance
  - General Arrangement Drawings
- Finalize Compression Design
- Substantial Complete of 3D model
- Civil work for site: regrading review, site work, foundations
- Complete HRSG Tie-In work with vendor
- Complete Steam Tie-in evaluation with vendor

ION
CLEAN ENERGY

THANKS

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