



MEMBRANE
TECHNOLOGY & RESEARCH

Commercial-Scale FEED Study For MTR's Membrane CO₂ Capture Process (DE-FE0031846)

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U.S. Department of Energy

National Energy Technology Laboratory

**Carbon Management and Oil and Gas Research Project Review Meeting: Integrated CCUS
Projects and FEED Studies**

August 2, 2021

Project Overview

Award name: Commercial-Scale FEED Study for MTR's Membrane CO₂ Capture Process (DE-FE0031846; FOA-2058)

Project period: 10/1/19 to 6/30/22

Funding: \$5.12 million DOE; \$1.28 million cost share (\$6.40 million total)

NETL Federal Project Manager: Carl Laird

Participants: MTR, Sargent & Lundy, Trimeric, EPRI, Carbon Management Strategies, and Basin Electric

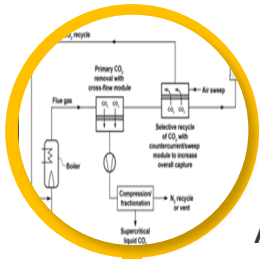
Project scope: Conduct a FEED study of MTR's capture process applied to Basin Electric's 420 MWe Dry Fork Station power plant in Gillette, WY

Project plan: The project is organized into 6 tasks with a total duration of 33 months. The end product will be a FEED report with detailed designs, a construction plan and schedule, and costs estimated with $\pm 15\%$ reliability

MTR's CO₂ Capture Development Timeline

Feasibility Study (NT43085)

- Sweep concept proposed
- Polaris membrane conceived



APS Red Hawk NGCC Demo

- First Polaris flue gas test
- 250 lb/d CO₂ for algae farm



APS Cholla Demo (NT0005312)

- First Polaris coal flue gas test
- 1TPD CO₂ captured (50 kWe)



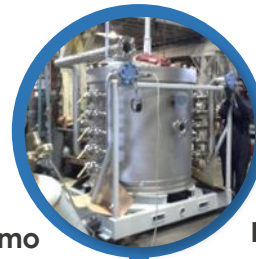
NCCC 1 MWe Demo (FE0005795)

- 11,000 hrs of 1 TPD system operation
- 1 MWe (20 TPD) system operation



Low Pressure Mega Module (FE0007553)

- Design/build 500 m² module



Hybrid Capture (FE0013118)

- Membrane solvent hybrids with UT, Austin



B&W Integrated (FE0026414)

- Integrated operation of 1 MWe system with B&W's 0.6 MWe coal-fired boiler



10 MWe Large Pilot (FE0031587)

- Phase I (feasibility)
- Phase II (design) and
- Phase III (construction/operation)



Full Scale FEED (FE0031846)

- Retrofit study for Dry Fork Station
- Partial capture conditions
- Coordination with CarbonSAFE



2006

2008

2010

2012

2014

2016

2018

2020

Site Background: Dry Fork Station



- Single unit, 422/385 MWe coal fired power plant in Gillette, WY
- Owned by Basin Electric (92.9%), and the Wyoming Municipal Power Agency (7.1%)
- Commissioned in 2011
- Low sulfur, sub-bituminous PRB coal from the nearby Dry Fork Mine
- Low NOx burners w/ OFA, SCR, dry lime fluidized bed, fabric filter
- Zero Liquid Discharge (ZLD) facility
- Cooling via an air-cooled condenser
- Home to the Wyoming Integrated CO₂ Test Center
- Home to the Dry Fork CarbonSAFE project

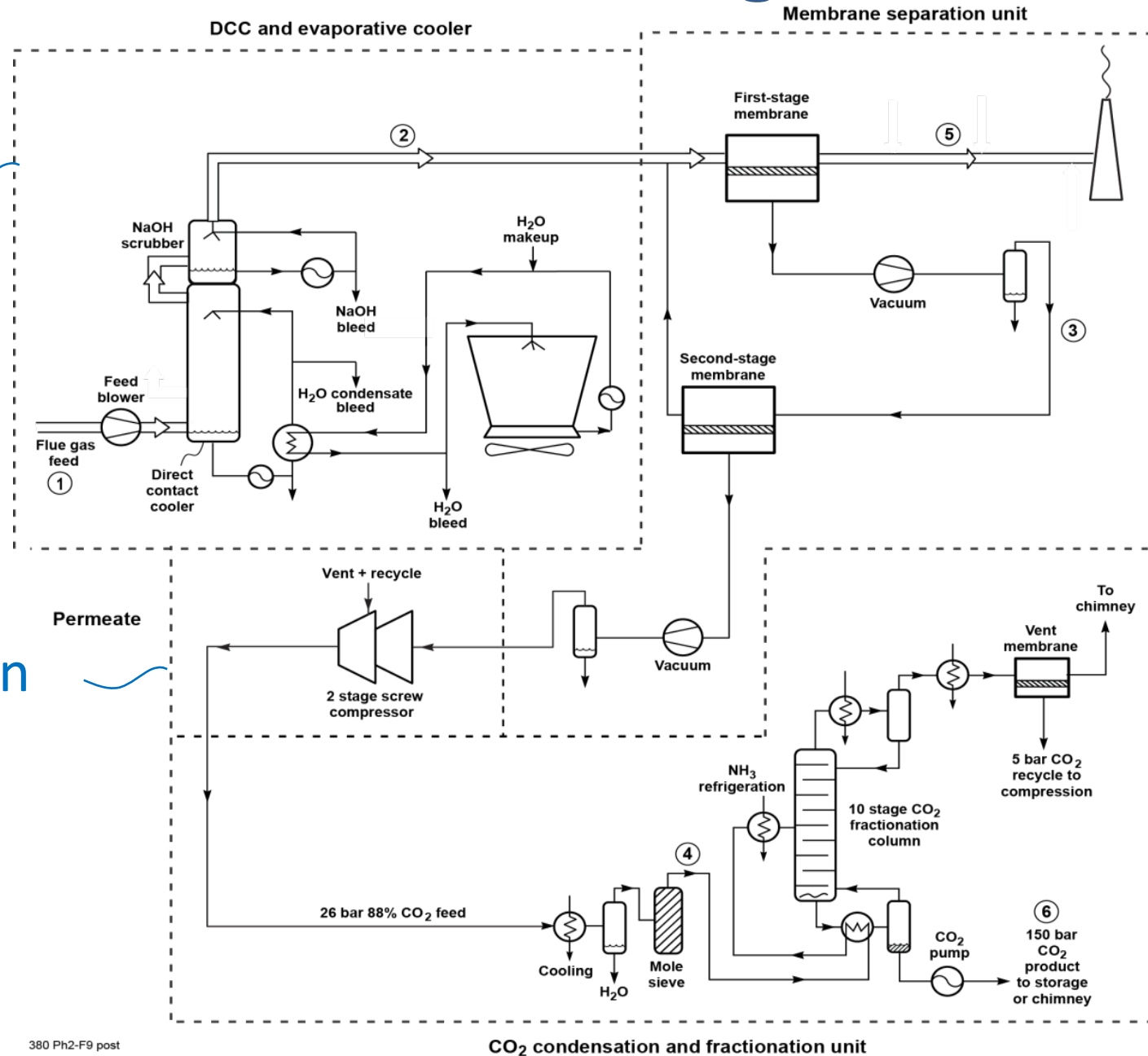
Process Diagram

1
Flue gas
cooling and
pre-treatment

3
CO₂ compression

2
First and
second stage
membrane
equipment

4
Refrigeration
and final CO₂
product pump



Containerized Membrane Product



Full-Scale FEED of MTR's Capture Process at Dry Fork Station

Jan 2020

Set Design Basis / RFI

Capture Plant Process Design

Water Management and Balance

Vendor Equipment Selection

General Arrangement

Construction Cost Estimate

Permit Review

Cost Estimates and Reporting

March 2022



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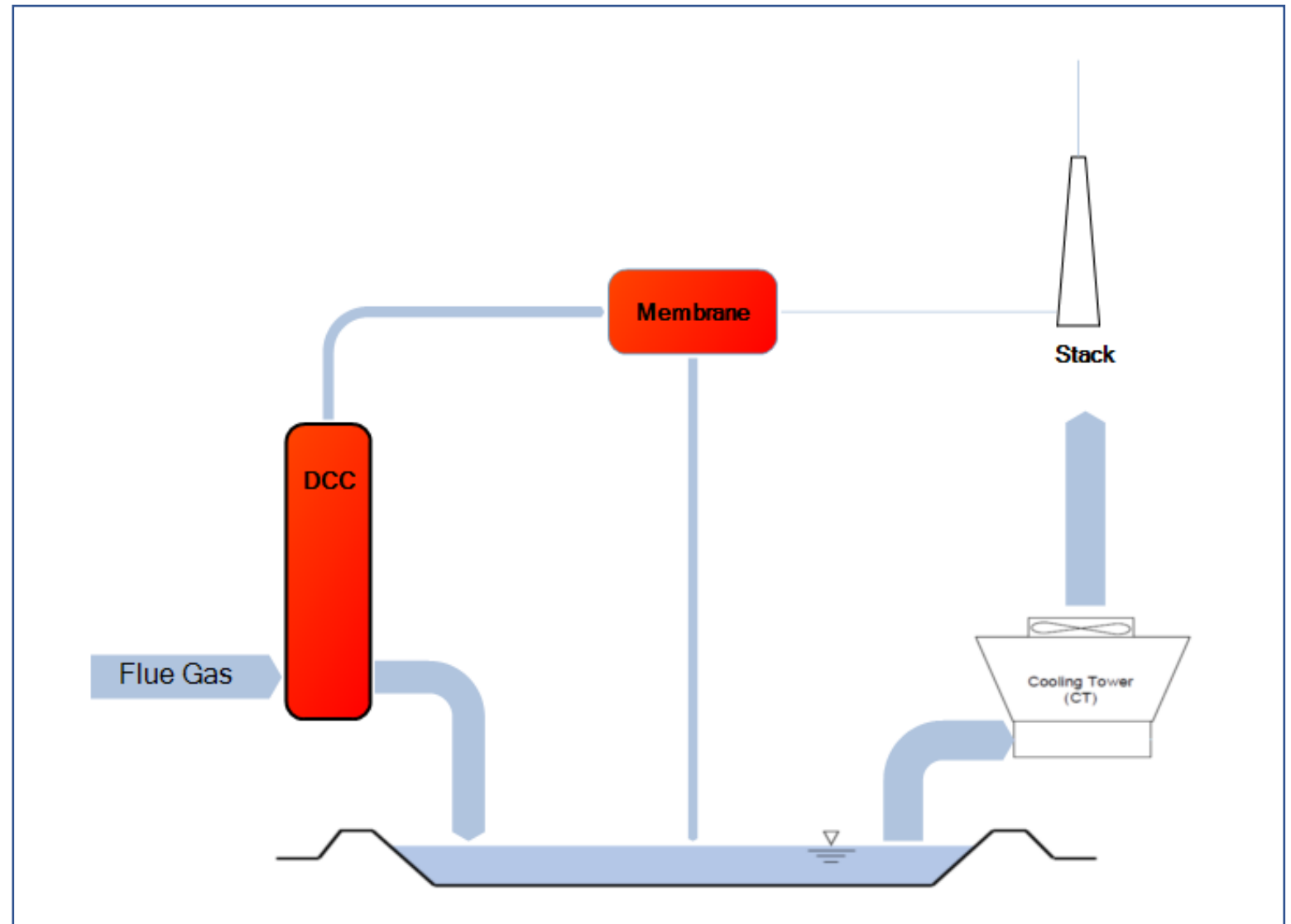
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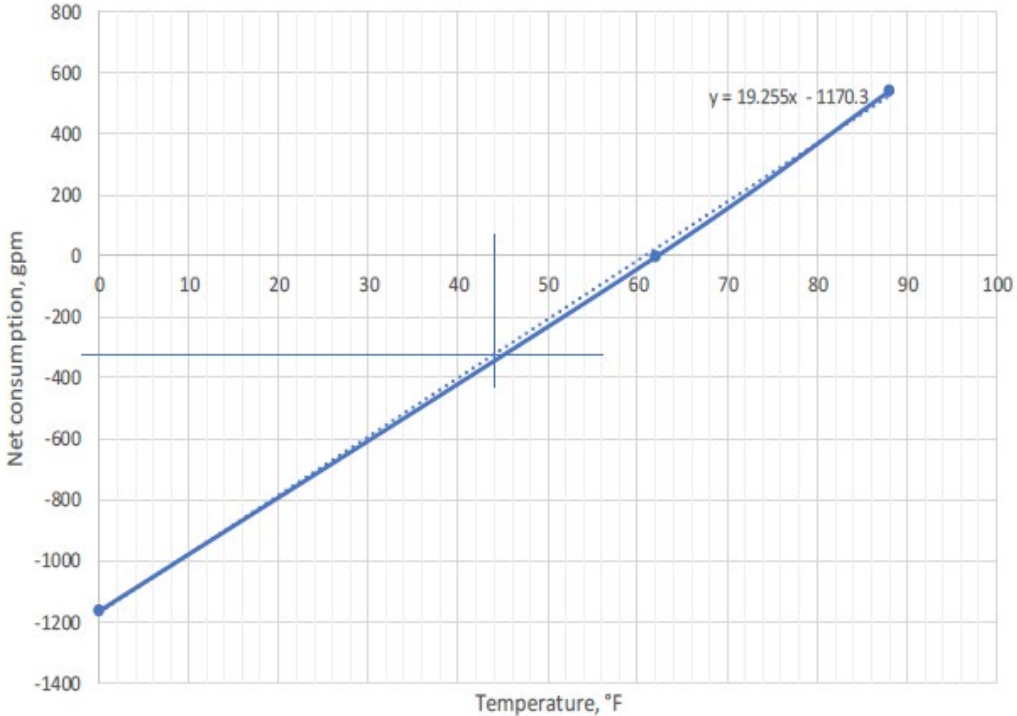
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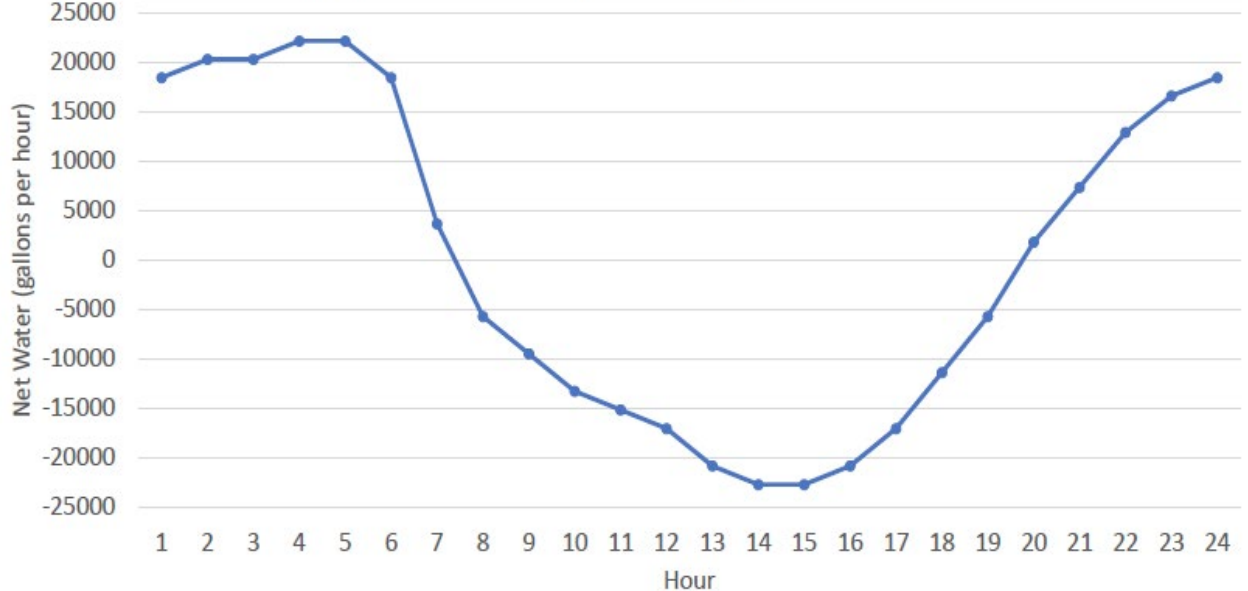
March 2022



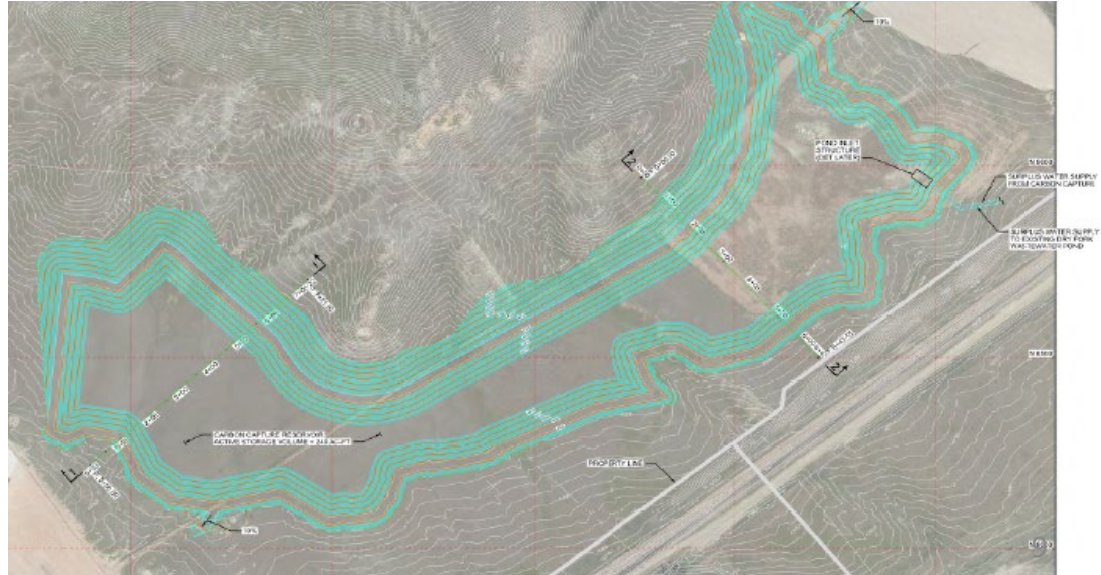
Net Consumption vs. Temperature



Water Produced Over 24 Hour Period
62F Dry Bulb Day
(0 gpm of well water consumed, 0 gallons net water)



A new water storage pond allows the capture plant to achieve water balance throughout the year



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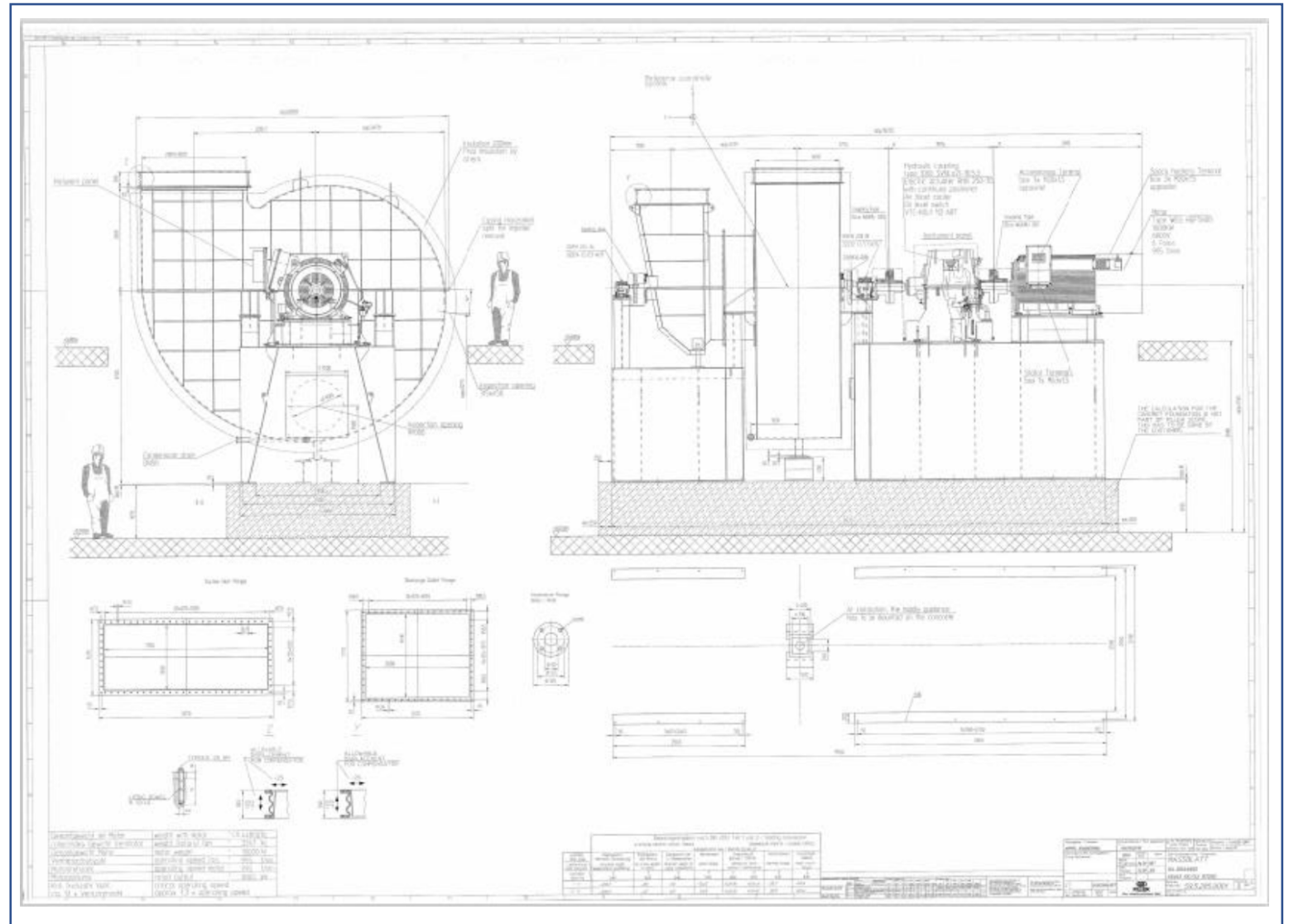
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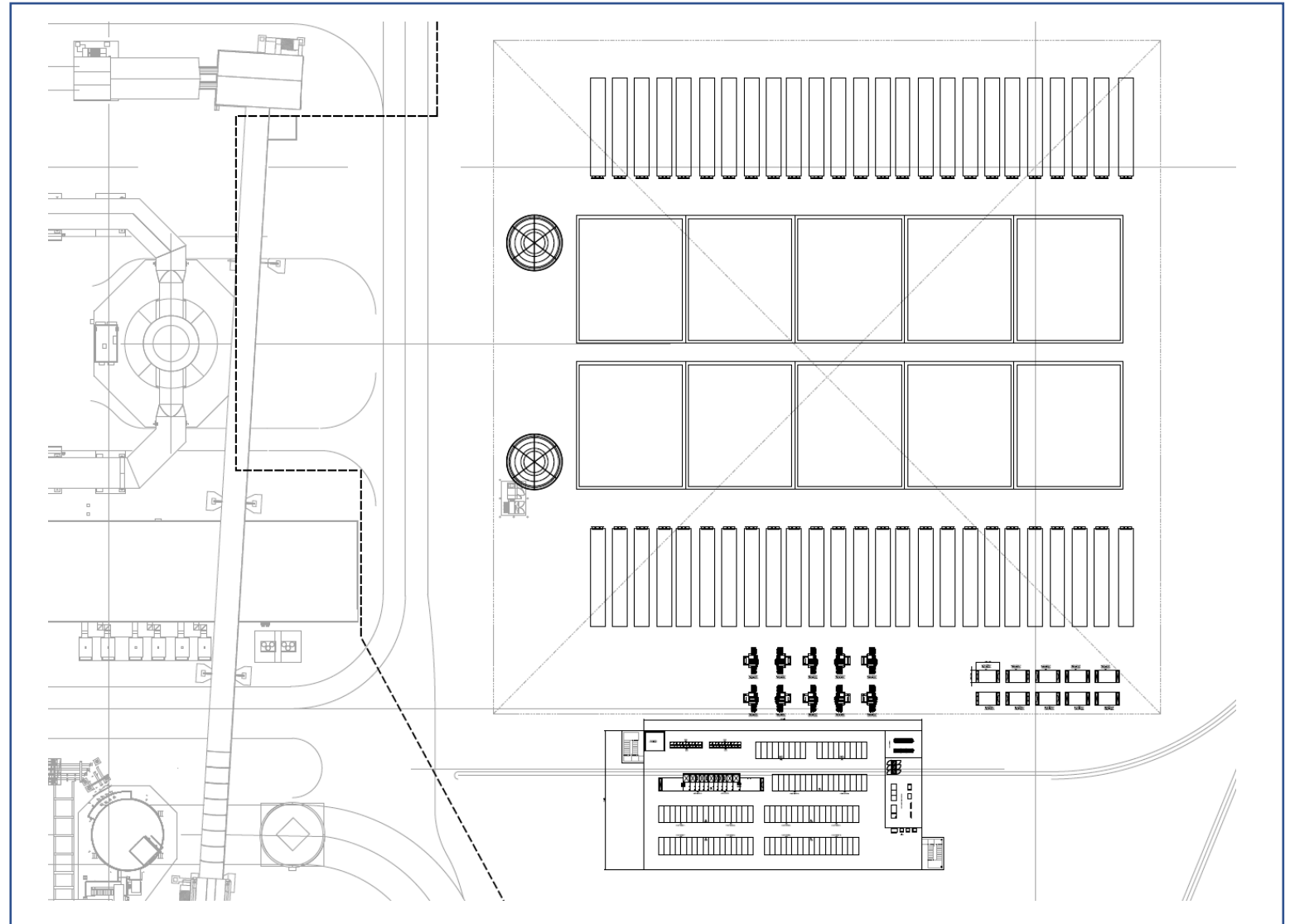
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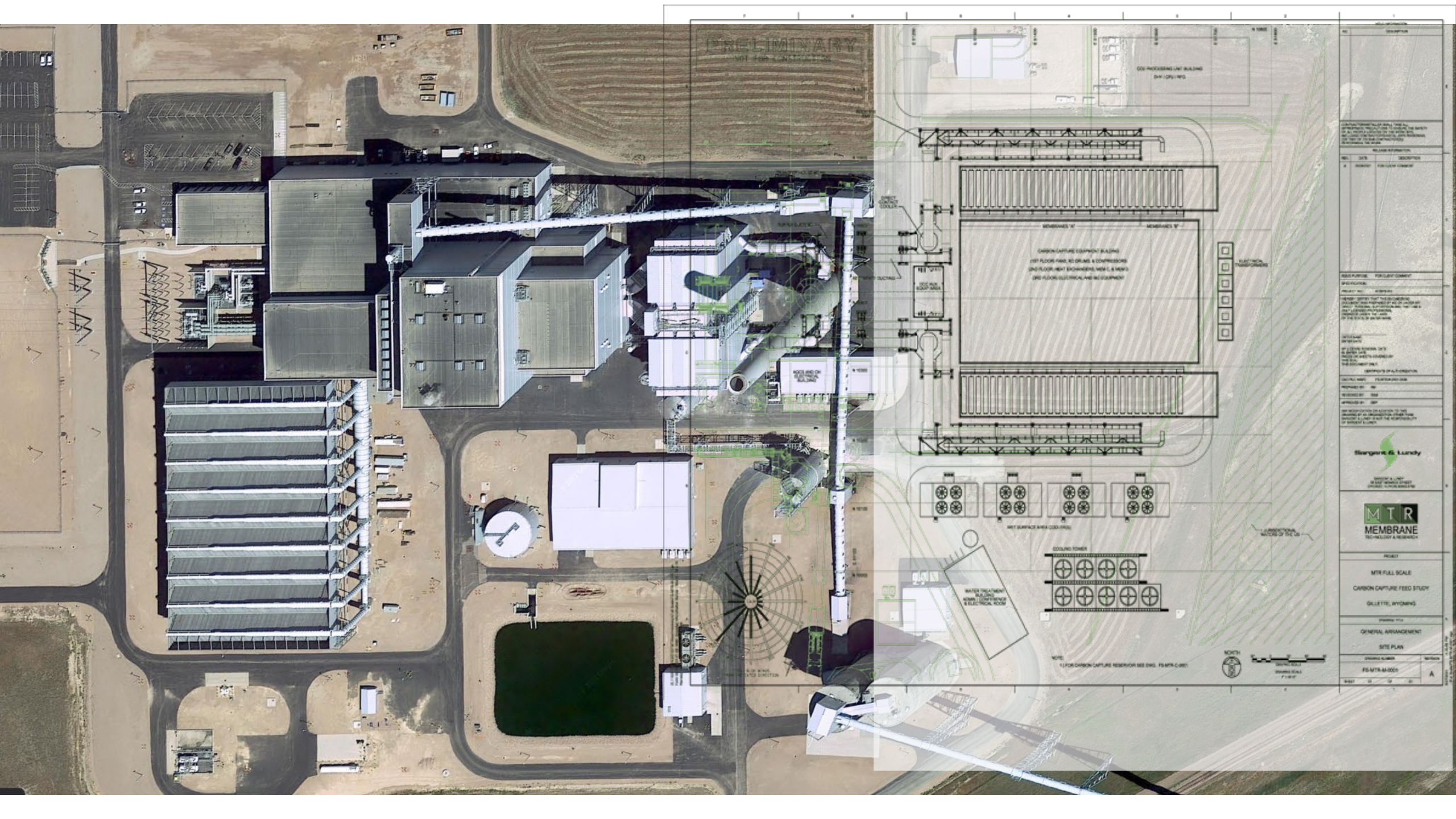
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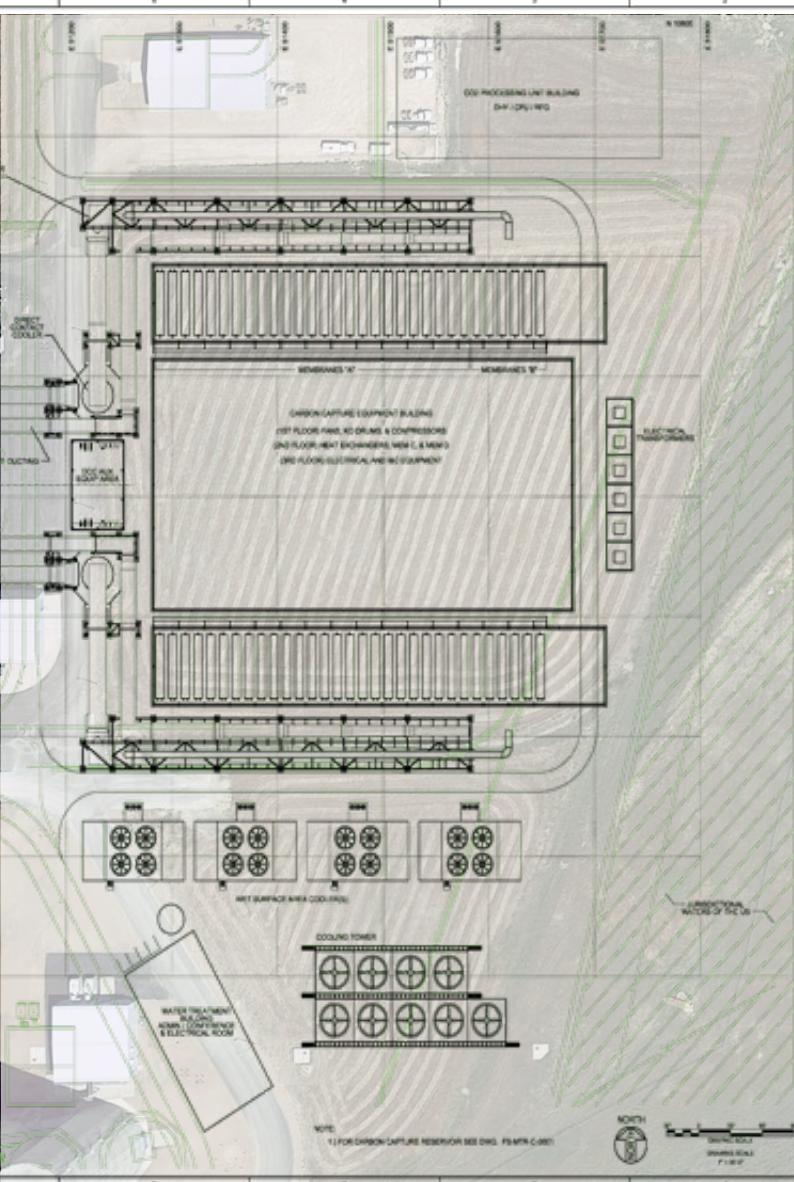
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March 2022





PRELIMINARY
NOT FOR CONSTRUCTION



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Borgers & Lundberg

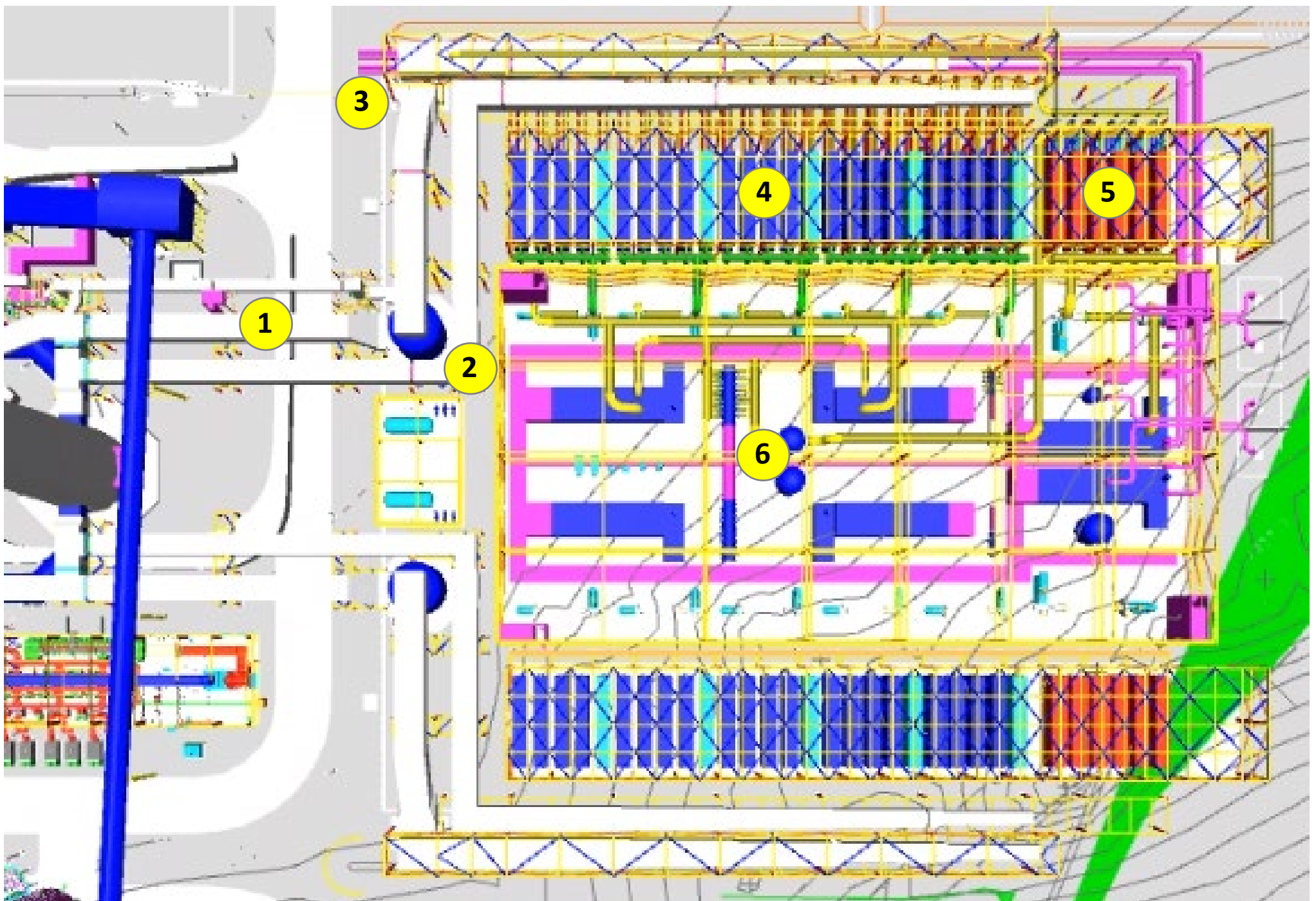
MTR
MEMBRANE
TECHNOLOGY & RESEARCH

PROJECT
MTR FULL SCALE
CARBON CAPTURE FEED STUDY
GILLETTE, WYOMING

GENERAL ARRANGEMENT
SITE PLAN

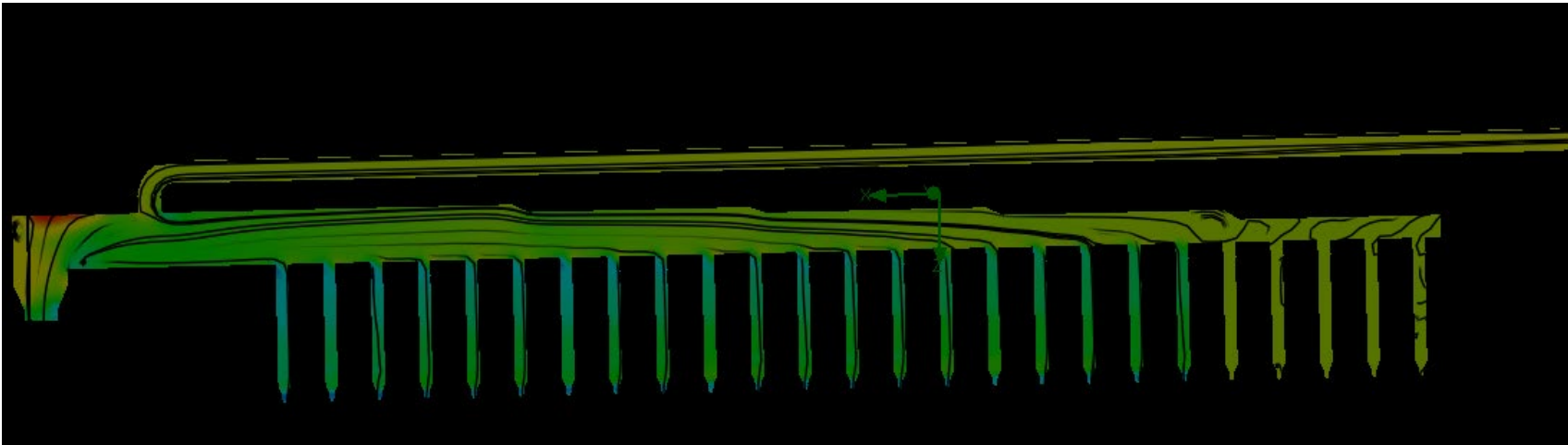
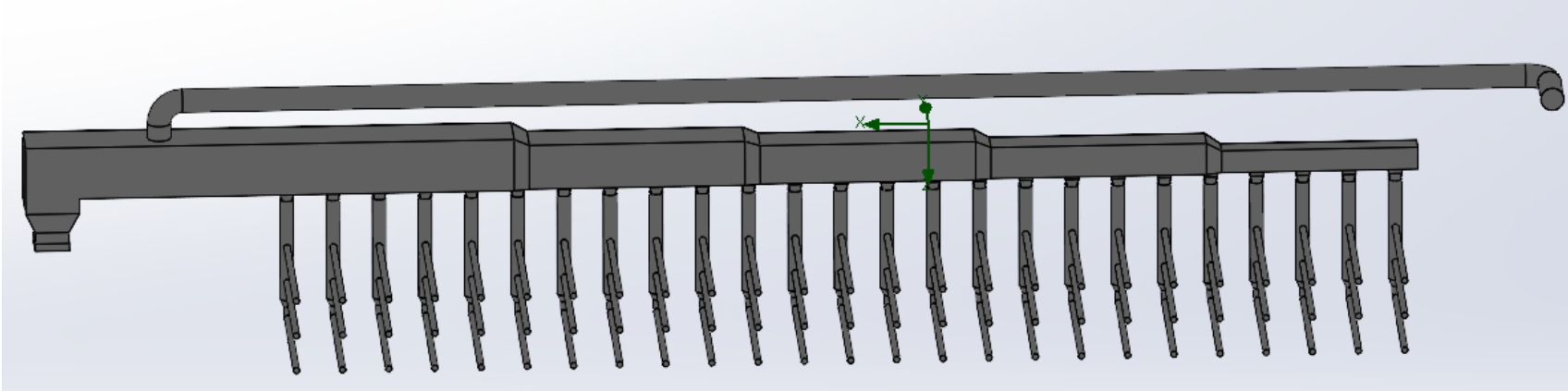
CREATING BLUES
FS-MTR-M-001

SCALE
1" = 100'

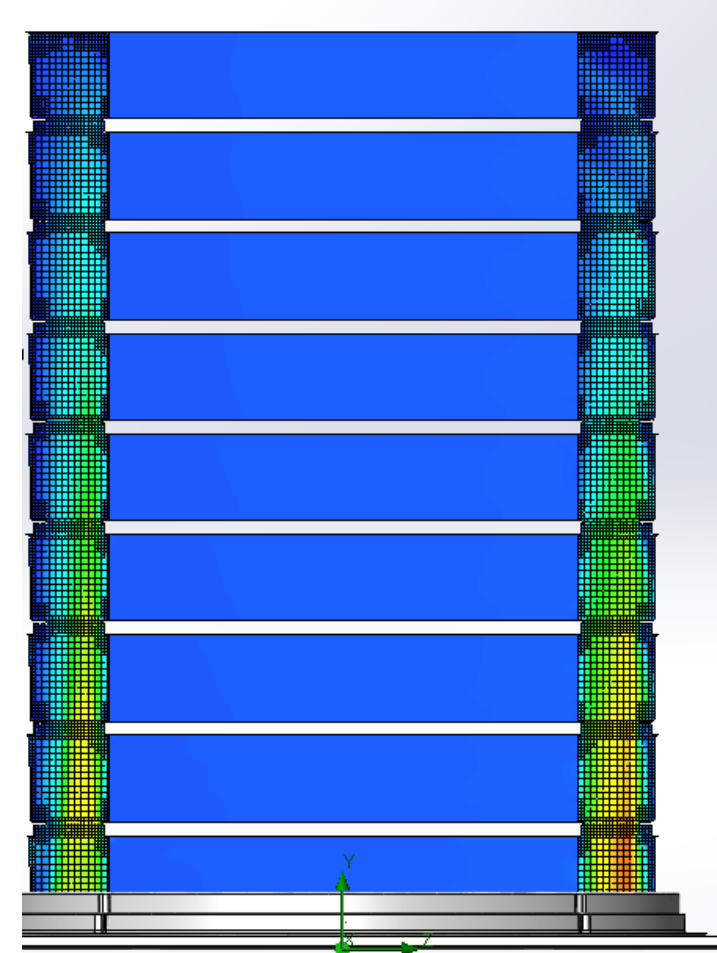


Gas Distribution Design and Flow Analysis

Flue Gas Distribution Duct and Manifolds



CFD Analysis of Gas Flows through Membrane Stacks



Full-Scale FEED of MTR's Capture Process at Dry Fork Station

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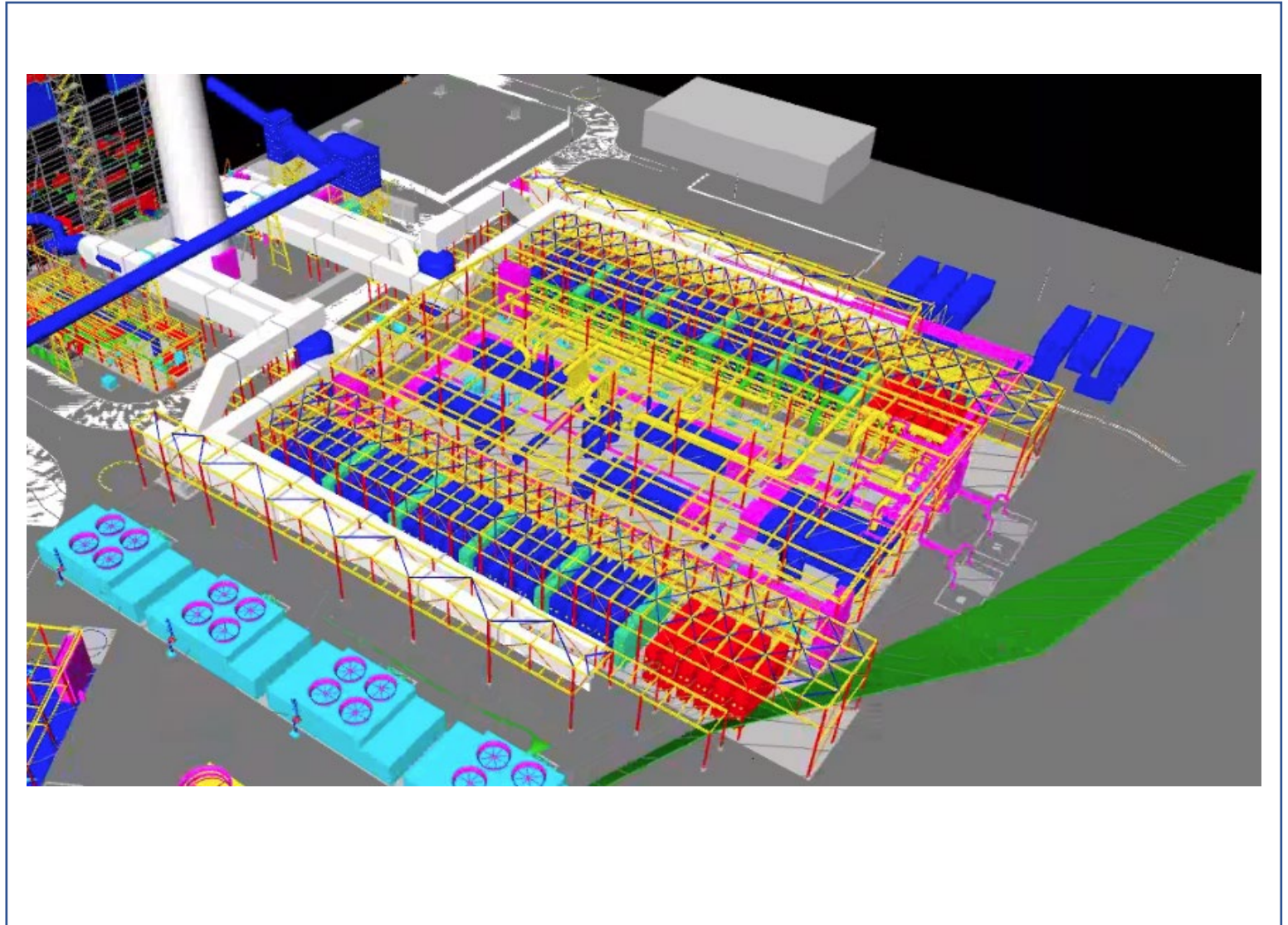
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Summary

- FEED study for the retrofit application of MTR's membrane process to the 420 MW_e Dry Fork Station (DFS), Gillette, WY
- Process design is complete, and all process details are defined
- A zero liquid discharge compliant cooling system and overall water management was developed
- Selected the majority of vendor specific process equipment
- Detailed layout and general arrangement of equipment are underway
- Remaining BOP and building design, layout, and equipment and construction cost estimating will occur by year's end

Project Team

MTR

- Richard Baker
- Alicia Breen
- Brice Freeman
- Pingjiao Hao
- Thomas Hofmann
- Tim Merkel
- Erik Westling

NETL

- Carl Laird

Sargent & Lundy

- Christie Ainge
- Kelly Gandy
- Holly Hills
- Elizabeth LaMere
- Kevin Lauzze
- Ryan Miller
- Steve Nealon
- Dana Pierik
- Jim Robeson
- Mike Rosen
- Marion Teslik
- Alex Vincent

Trimeric

- Kevin Fisher
- Mike Marsh
- Ray McKaskle
- Anne Ryan

CMS

- Will Morris

EPRI

- Andy Howell
- Joe Swisher

Basin Electric

- Nolan Bray
- Gavin McCollam
- Jim Sheldon
- Tom Stalcup
- Troy Tweeten

Acknowledgments

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Appendix

Milestone Number	Task/ Subtask No.	Milestone Description	Planned Completion	Actual Completion	Verification Method	Comments
Budget Period 1 Milestones						
1	1	Kickoff meeting completed; Project Management Plan updated	12/31/19	11/1/19	Revised PMP	Milestone completed in Q1.
2	2	Project design basis completed	7/31/20	7/31/20	Quarterly Report	Milestone completed on time.
3	3	Preliminary process design complete	9/30/20	3/31/21	Quarterly Report	Was delayed due to COVID-related issues at the start of the project, and cooling system design requirements; completed this quarter.
4	4	All engineering drawings (PFDs, P&IDs) completed; Hazop done	6/30/21	TBD	Quarterly Report	This milestone will be adjusted in the updated PMP following NCTE
5	6	Final report and FEED study documents completed	9/30/21	TBD	Quarterly Report	This milestone will be adjusted in the updated PMP following NCTE

Role of Participants

DOE Office of Fossil Energy
NETL Federal Project Management, Carl Laird

Membrane Technology & Research, Inc.
Co-Principal Investigators, Tim Merkel, Brice Freeman

The Project Team

Basin Electric <i>Host Site</i>	MTR <i>Technology Provider</i>	Trimeric <i>Engineering</i>	S&L <i>EPCM</i>	CMS <i>Engineering</i>	EPRI <i>Engineering</i>
<ul style="list-style-type: none">• Design input• Interconnection and operational issues	Process Design: <ul style="list-style-type: none">• Overall process design• Membrane system	Engineering Design: <ul style="list-style-type: none">• DCC• CPU	Engineering & Design: <ul style="list-style-type: none">• FEED study lead• Permitting	<ul style="list-style-type: none">• CO₂ off-take requirements	Engineering Study: <ul style="list-style-type: none">• Water treatment and utilization• Process Cooling

Role of Participants

- MTR – project lead and liaison with DOE; will coordinate project activities, prepare membrane system design, and report to DOE
- Basin Electric – operator of the Dry Fork Station (DFS), host site for the proposed capture plant; will provide plant specific information needed for the FEED study
- S&L– previously managed construction of the DFS, will lead the FEED study
- Trimeric – will provide engineering services related to flue gas pretreatment and the CO₂ purification unit (CPU)
- EPRI – will work with Basin to determine best use of water collected by the capture plant
- Carbon Management Strategies – will provide engineering support related to CO₂ take off requirements that inform capture design

Project Objectives

- Complete FEED study of MTR capture process applied to the 400 MW_e Dry Fork Station
- Complete an environmental review (NEPA) of full-scale MTR membrane capture at Dry Fork Station
- Provide a path to commercialization (detailed costs and construction plan) for a full-scale membrane capture plant

Coordination with Wyoming CarbonSAFE

- MTR is coordinating our Full-Scale FEED project with the Wyoming CarbonSAFE project (FE-FE0031624).
- The University of Wyoming recently received their Phase III award, *“Wyoming CarbonSAFE: Accelerating CCUS Commercialization and Deployment at Dry Fork Power Station and the Wyoming Integrated Test Center”*
- Will finalize characterization and obtain a Class VI permit to construct a storage complex in Campbell County, Wyoming.
- The project utilizes Basin Electric’s Dry Fork Station to source 2.2 million metric tons of CO₂ per year for storage at three nearby sites within the same storage complex.
- Results of a FEED study of CO₂ capture utilizing MTR’s two-stage membrane will be integrated into this project.



Pilot Well adjacent to Dry Fork Station
(source: Basin Electric)