



MEMBRANE
TECHNOLOGY & RESEARCH

Large Pilot Testing of the MTR Membrane Post-Combustion CO₂ Capture Process

(DE-FE0031587; FOA 1788)

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NETL Project Manager: Sai Gollakota

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

Project Overview

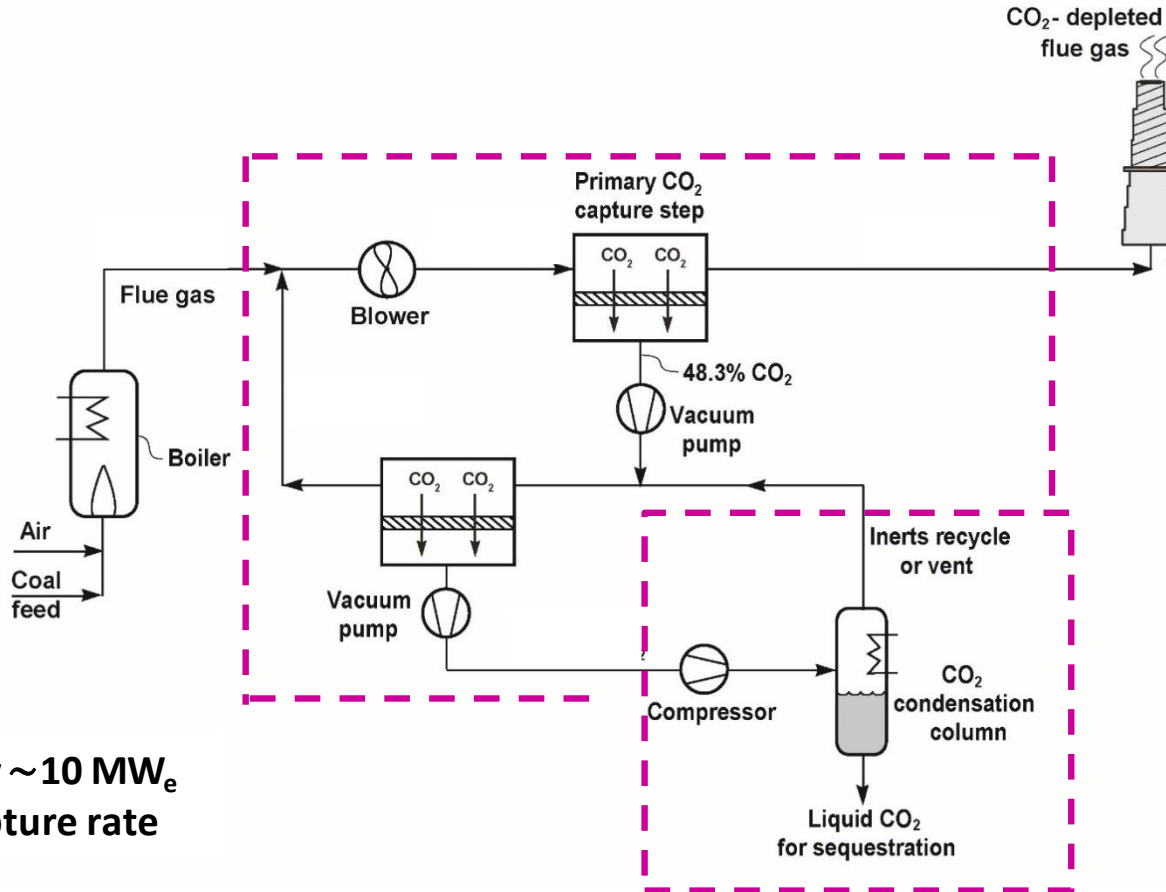
- **Award Name:** Large Pilot Testing of the MTR Membrane Post-Combustion CO₂ Capture Process (DE-FE0031587; FOA 1788)
- **Project Period (Phase II):** 9/1/19 to 5/31/21
- **Funding:** \$3.9 M DOE + \$976 k cost share = \$4.9 M total
- **DOE-NETL Project Manager:** Sai Gallokota
- **Project Team:** MTR (prime), Wyoming ITC / Basin Electric (Host), Sargent & Lundy, Trimeric, Graycor
- **Overall Goal:** Design, build, and operate a 140 TPD large pilot membrane capture system.

Phase I	Phase II	Phase III
<ul style="list-style-type: none">• Feasibility• Site selection• Create team (Complete)	<ul style="list-style-type: none">• FEED study• Permitting (Underway)	<ul style="list-style-type: none">• Build, install, operate, and demonstrate process performance and costs

Phase II Roles and Responsibilities

- Phase II award: \$3.9 million / September 1, 2019 – May 31, 2021
 - **Wyoming ITC, Basin Electric:** Host site and test facility location
 - **MTR** (prime): Technology supplier. Engineering design for membrane system including vacuum and compression equipment selection
 - **Trimeric:** Engineering design for the flue gas pretreatment, DCC and final CO₂ purification unit, compression equipment selection
 - **Sargent & Lundy:** All site work analysis, permitting, and FEED study lead
 - **Graycor:** Phase III site works-installation

MTR's CO₂ Capture Process Design

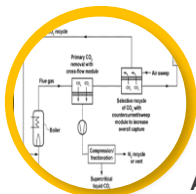


140 ton/day ~ 10 MW_e
70% CO₂ capture rate

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 kW e)



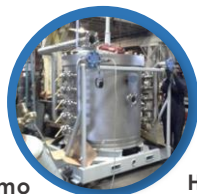
NCCC 1 MWe Demo (FE0005795)

- 11,000 hrs of 1 TPD system operation
- 1 M W e (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 M W e system with B&W's 0.6 M W e coal-fired boiler



10 MWe Large Pilot (FE0031587)

- Phase II – FEED Study, Permitting
- 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

Wyoming Integrated Test Center at Basin Electric's Dry Fork Station

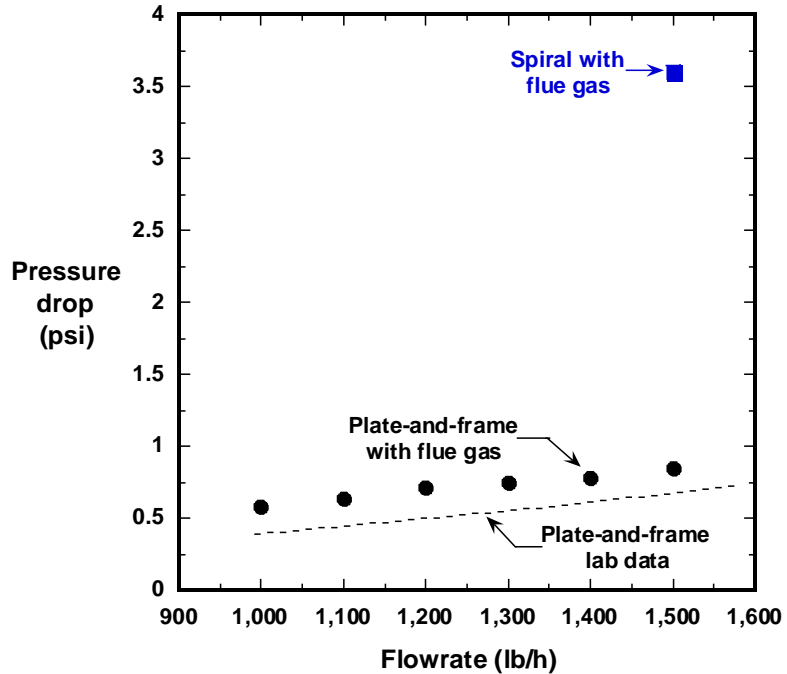


- WITC Large Test Bay has power, utilities and flue gas connections in place
- DFS is a new, modern power plant with full environmental controls
- Test center can supply 20+ MW_e of gas
- Immediately adjacent to the WY CarbonSAFE project (FE-FE0031624)
- Six miles from Denbury's Greencore CO₂ pipeline



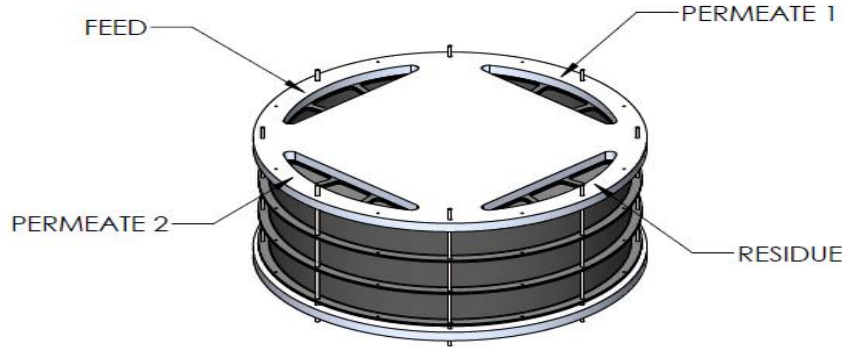
Large Pilot Uses Plate-and-Frame Membrane Modules

Test Data from NCCC



DE-FE0005795 and FE0007553

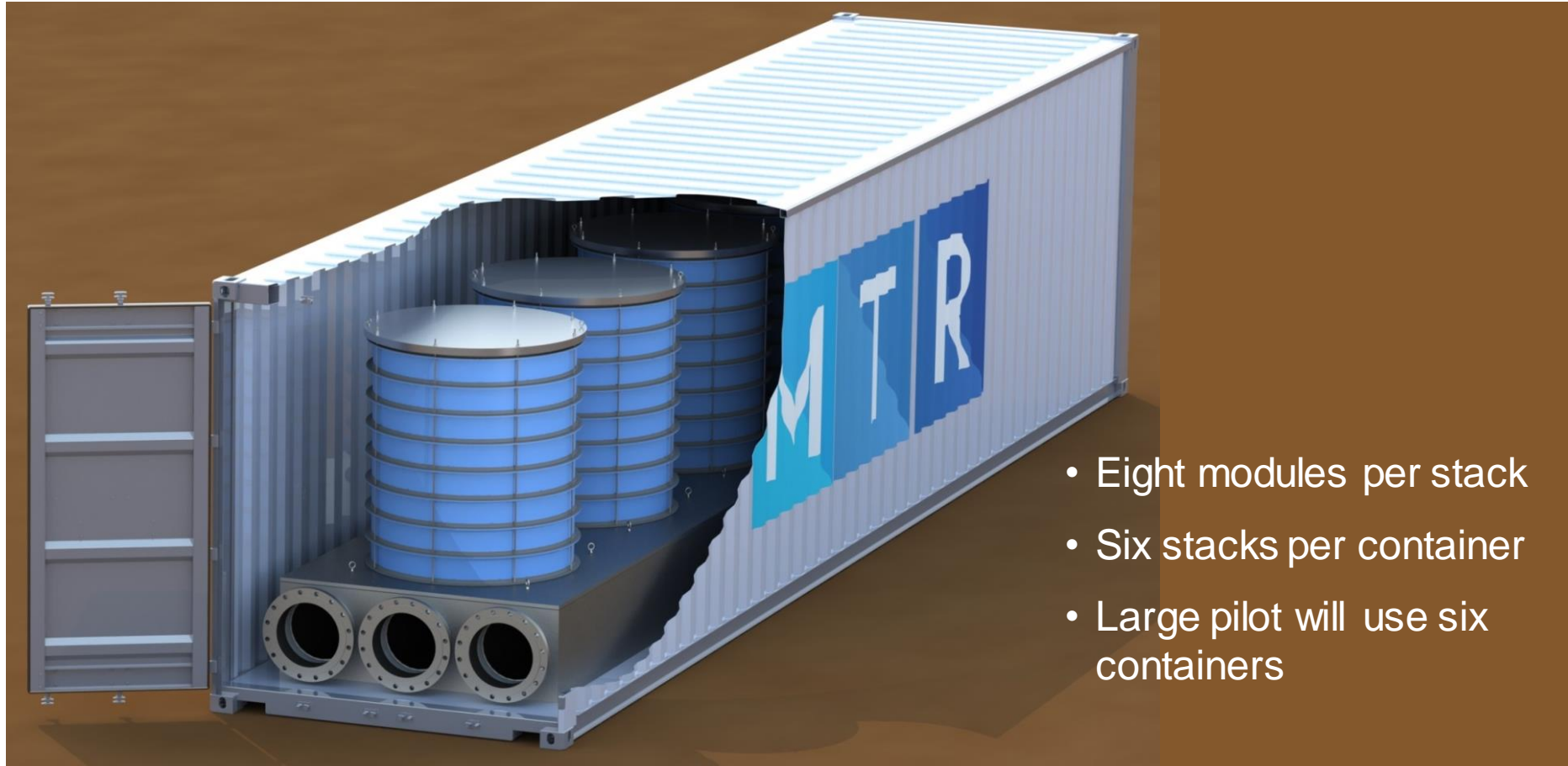
New Integrated Planar Membrane Modules Reduce Cost and Increase Packing Density



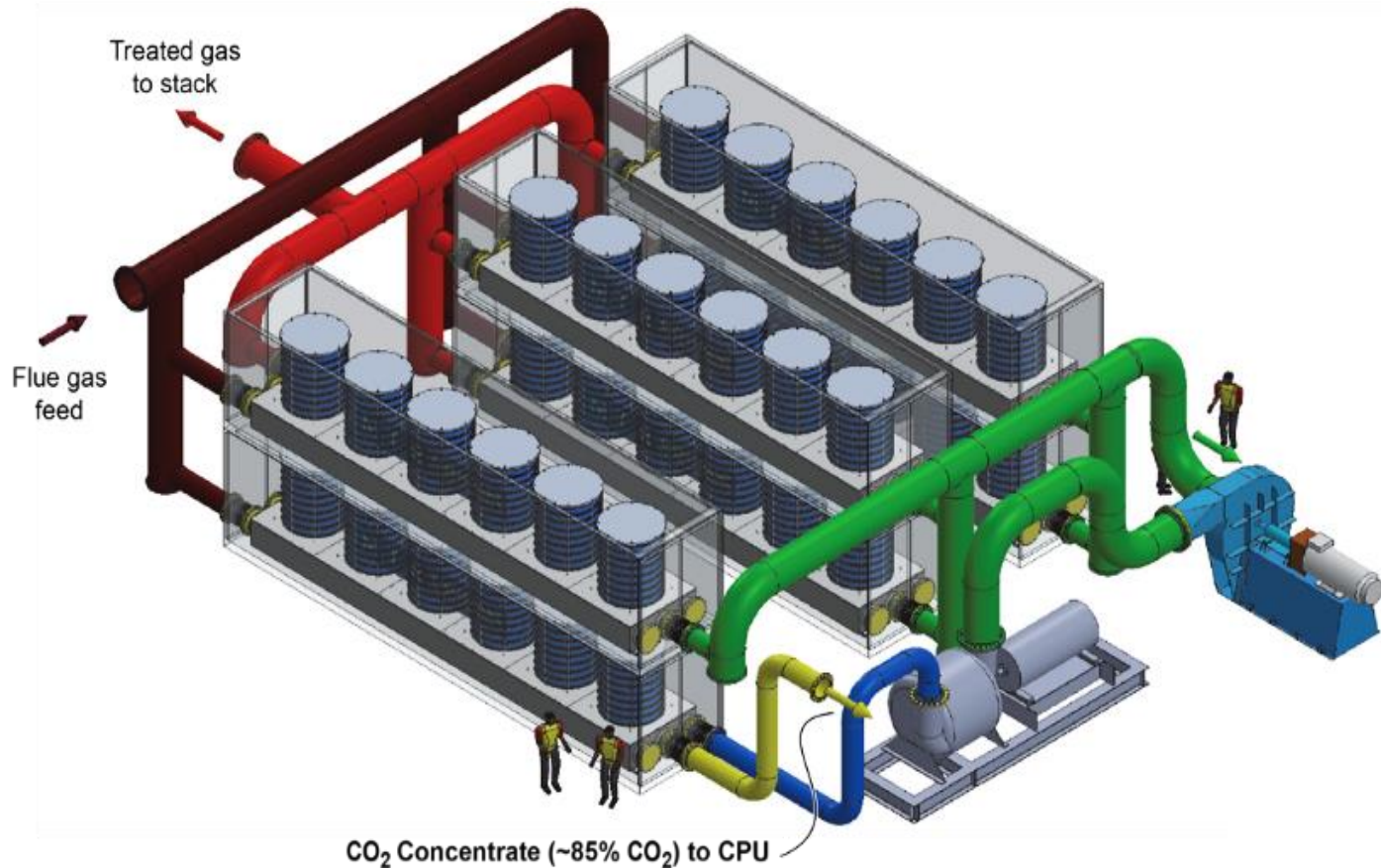
New module design
will be tested at TCM
under DOE FE-0031591



— Membrane Modules Packaged into a Containerized Skid —



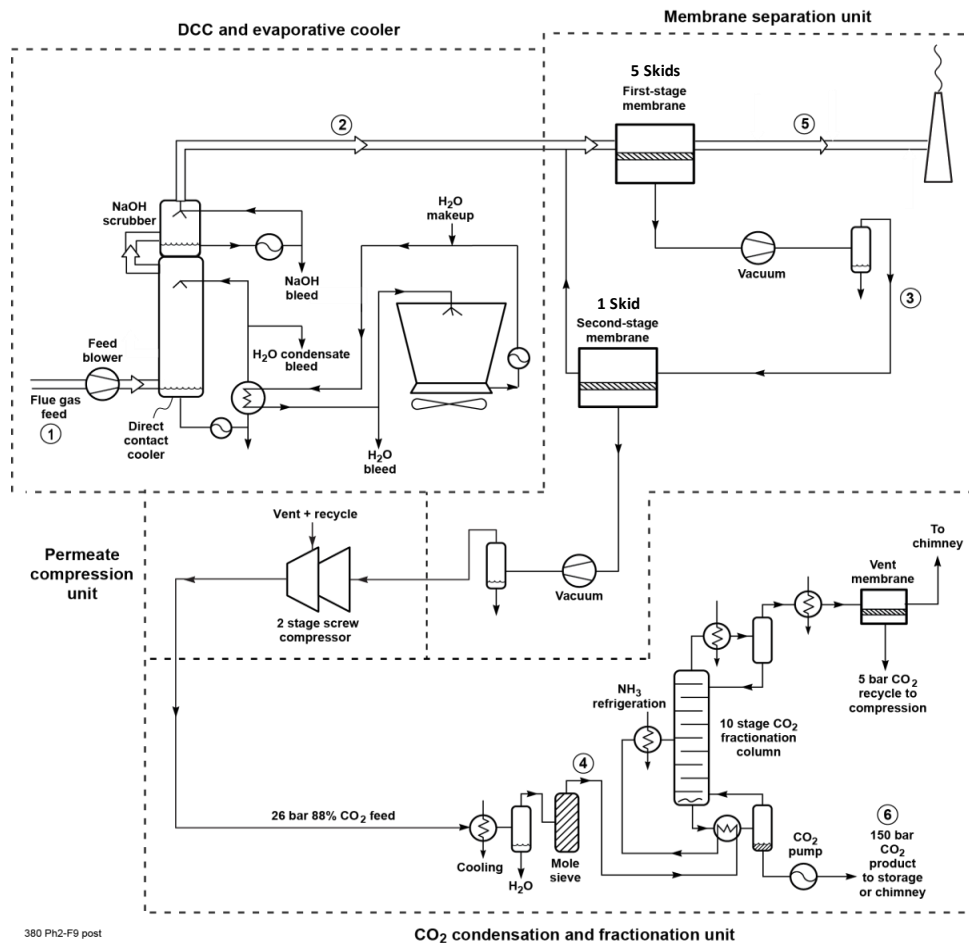
Preliminary Arrangement of the Membrane Section (Phase I Feasibility Study)



— The 10 MWe Large Pilot System Will Test of the Complete Capture Process —

Flue gas cooling and
pre-treatment

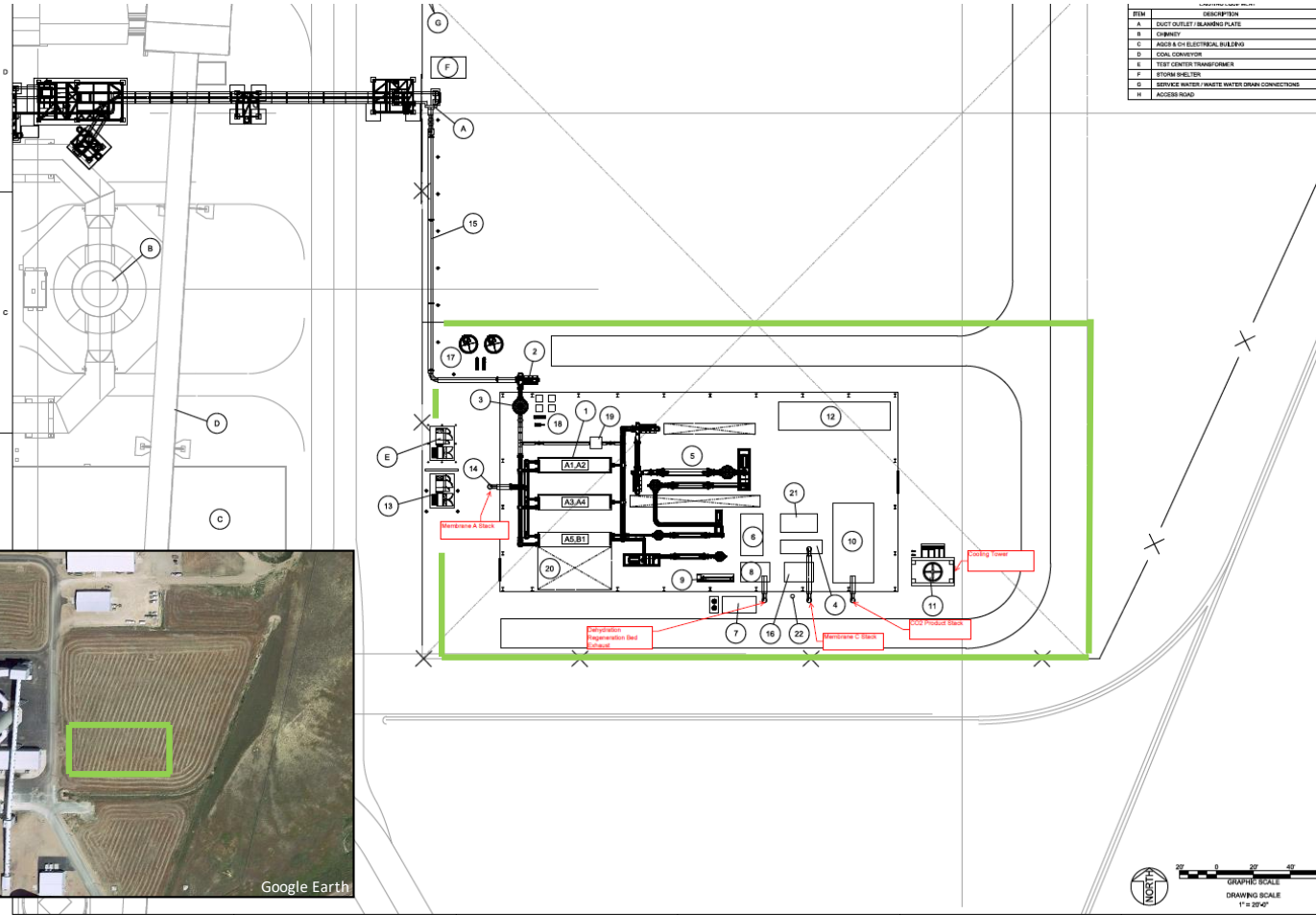
CO₂ Compression



First and second
stage membrane
equipment

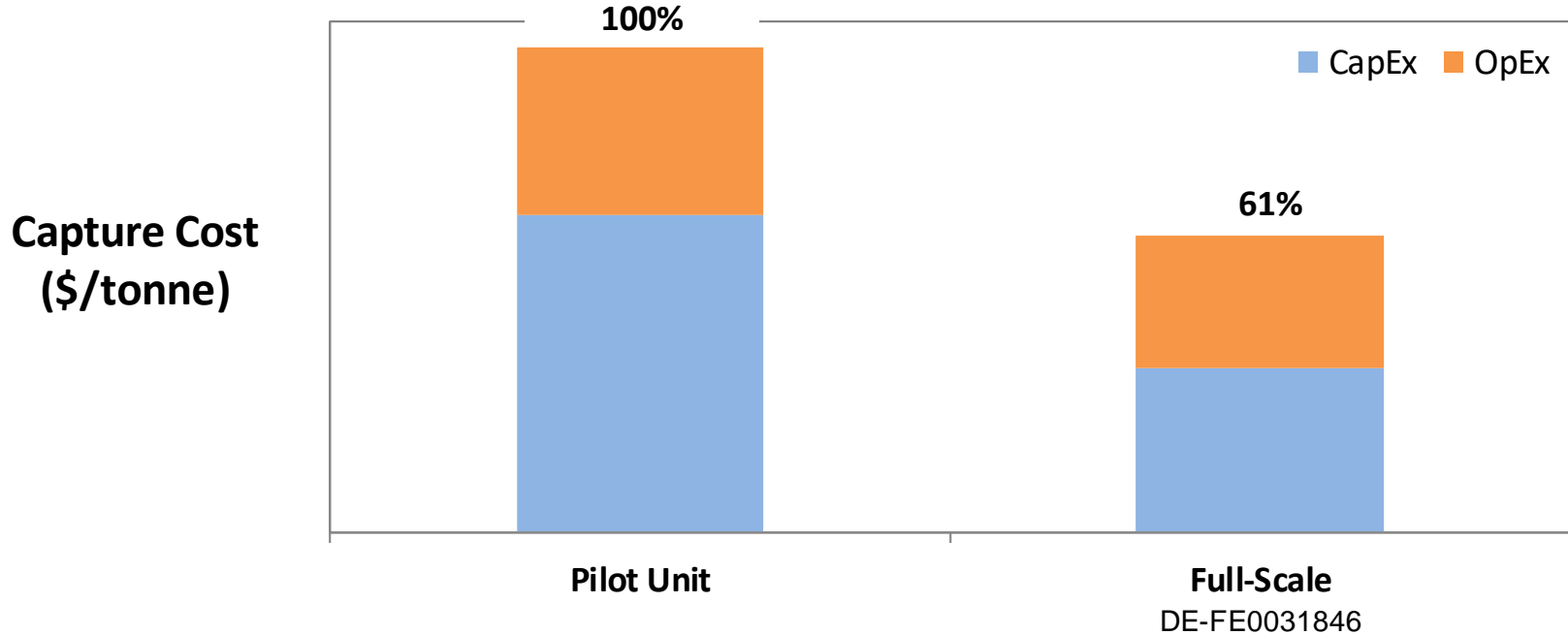
Refrigeration
skid and final
CO₂ product
pump

General Arrangement – Large Test Bay South



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SPECIFICATION: —	
PROJECT NO.:	
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PRELIMINARY GENERAL ARRANGEMENT SITE PLAN	
DRAWING NUMBER	REVISION
SK-MTR-M-0001	A
SHEET 01 OF 01	1

System Cost Comparison



Improvements moving from Large Pilot to Full-Scale:

- Rotating equipment – 45% lower CapEx for larger scale equipment
- Membrane – 50% cost reduction through higher volume manufacturing



Status of FEED Study Elements



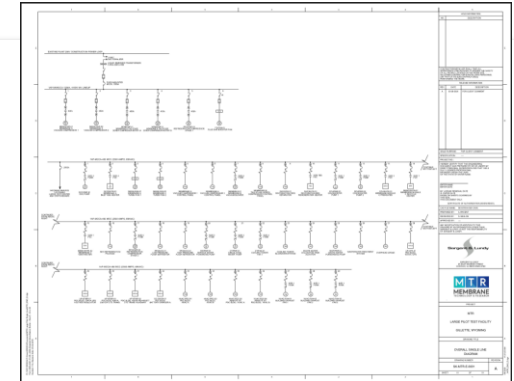
Design basis developed



Permit application prepared for Wyoming Department of Environmental Quality

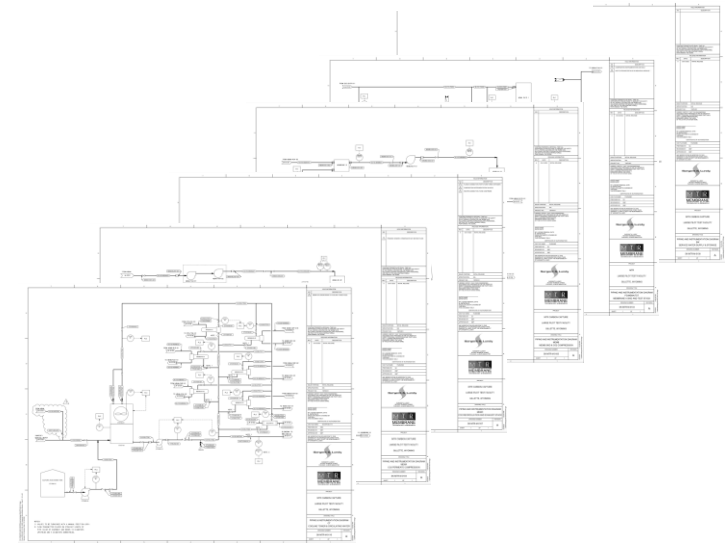


Large Pilot control system developed



Electrical load list and single line diagrams developed

15



- 

Remaining Phase II Activities



- Develop construction schedule and update the construction/installation budget and plan
- Complete BOP design drawings (foundations, ductwork, pipe racks, electrical controls, etc.)
- Prepare GWC specification package
- Complete technoeconomic assessments
- Receive permit from Wyoming DEQ
- Conduct HAZOP
- Complete Phase III continuation application

Summary

- MTR's 10 MWe Large Pilot will demonstrate all aspects of the CO₂ capture plant
- System uses MTR's improved low-cost plate-and-frame membrane module
- FEED study elements are progressing on schedule
- The assembled project team is experienced and capable of executing the Phase III project plan
- Completion of this project will bring the technology to TRL-7

Acknowledgments

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APPENDIX

The Project Team

DOE Office of Fossil Energy
Program Management
Sai Gallokota



Membrane Technology & Research, Inc.
Co-Principal Investigators:
Richard Baker, Project Coordination
Brice Freeman, DOE and Team Coordination

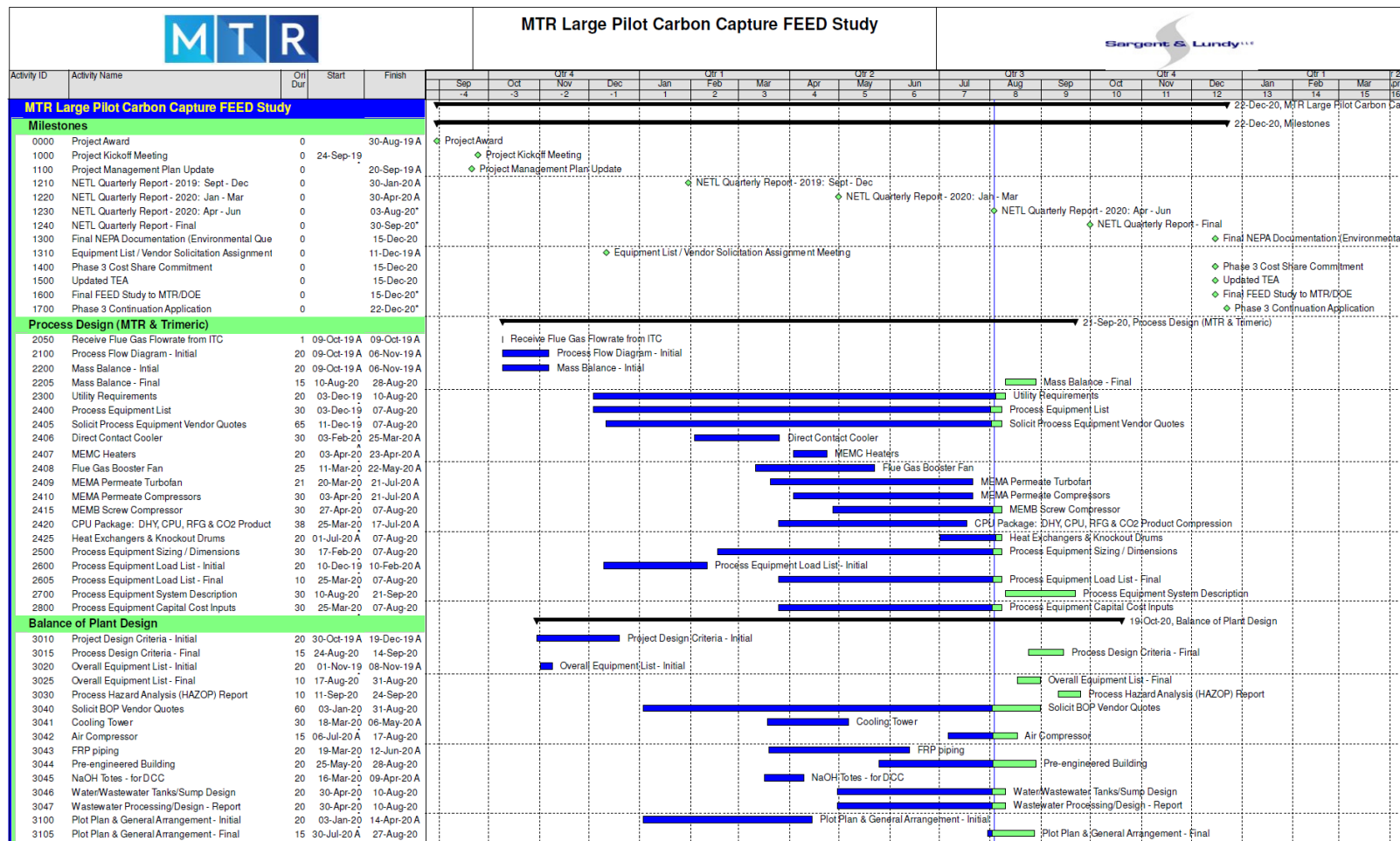


The Project Team - Phase II

WITC / Basin Electric <i>Host Site</i>	MTR <i>Technology Supplier</i>	Trimeric <i>Engineer</i>	Sargent & Lundy <i>EPCM</i>
Will Morris , WITC - All test site issues John Jacobs , Basin - All power plant issues	Thomas Hofmann Erik Westling Engineering Design: - Membrane system - Permeate compression	Ray McKaskle Engineering Design: - Direct Contact Cooler - CO ₂ Purification Unit	Dana Pierik / Holly Hills FEED and Permitting Lead: - Construction planning - Scheduling - Utilities & power - Process control - Permitting



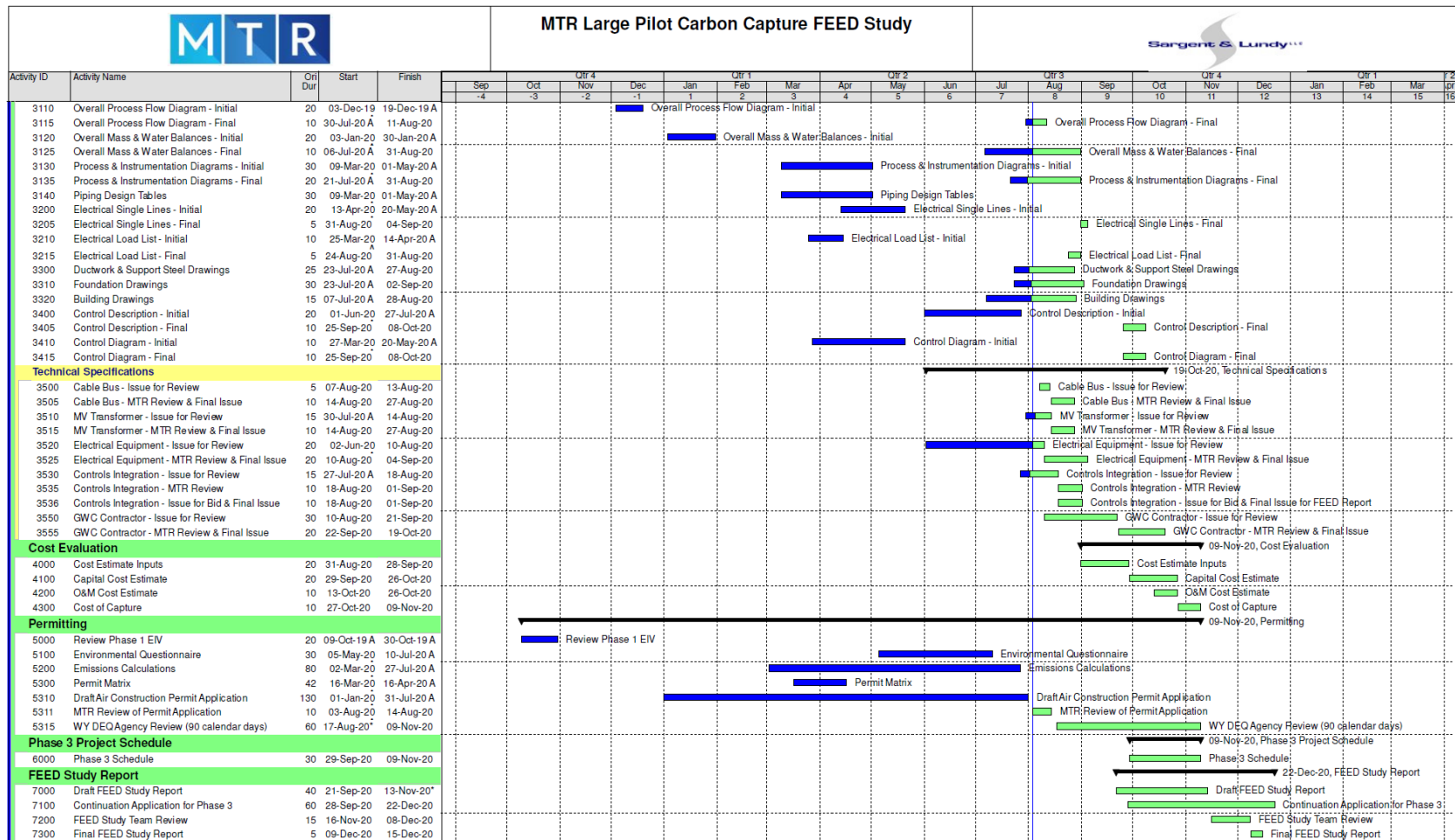
Project Schedule 1/2



Project Schedule 2/2



MTR Large Pilot Carbon Capture FEED Study



Changes from Phase I to Phase II

- Phase I - 200 tonne/day CO₂ @ 60% capture
- Phase II - Available flue gas from WITC was reduced, so now 140 tonne/day CO₂ @ 70% capture
- Rotating equipment and membrane resized to reflect the new conditions