CORMETECH.

Bench Scale Test of a Polyethyleneimine Monolith Carbon Capture Process for NGCC Point Sources

DE-FE0032138

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NATIONAL ENERGY TECHNOLOGY LABORATORY

Net-zero Flexible Power: High Capture Rate Project Review Meeting

Delta Hotel Philadelphia Airport - June 6-7, 2024

June 6, 2024

01 CORMETECH

02 Technology Background

03 Project Overview

04 Progress and Current Status

05 Discussion Points

CORMETECH: Environmental Catalysts, Adsorbers

Founded
1989
1st Plant
1991

Expansion
1999-2002

New High
Cell Density /
Thin-wall Line
2015

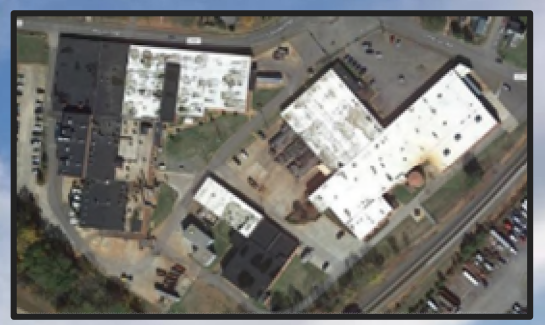
Merger Adds
Regen &
Recycling
2017

Commercial
CO_2 Adsorber
Manufacturing
2020

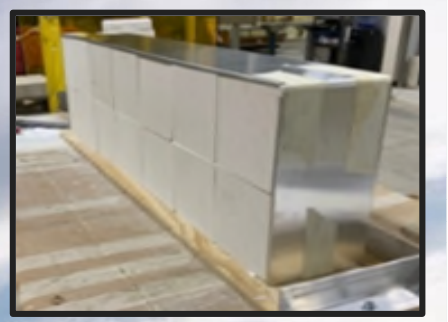
Durham, NC Plant

Cleveland, TN &
Durham, NC Plants

Durham, NC Plant
>300 cpsi



Kings Mountain,
NC Plant
Full Life-cycle
Management



Durham, NC Plant
Up to 500 cpsi

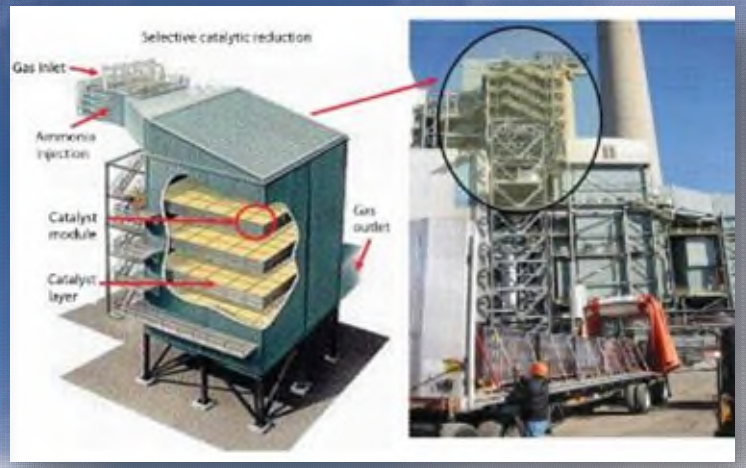
Industries Served

Global Installed Base of ~400,000 MW

Natural Gas & Hydrogen
Combined Cycle Power Plant

Large Reciprocating Engines

Refinery/Petrochemical



Coal-Fired Power Plant
~ 1 million pounds of catalyst

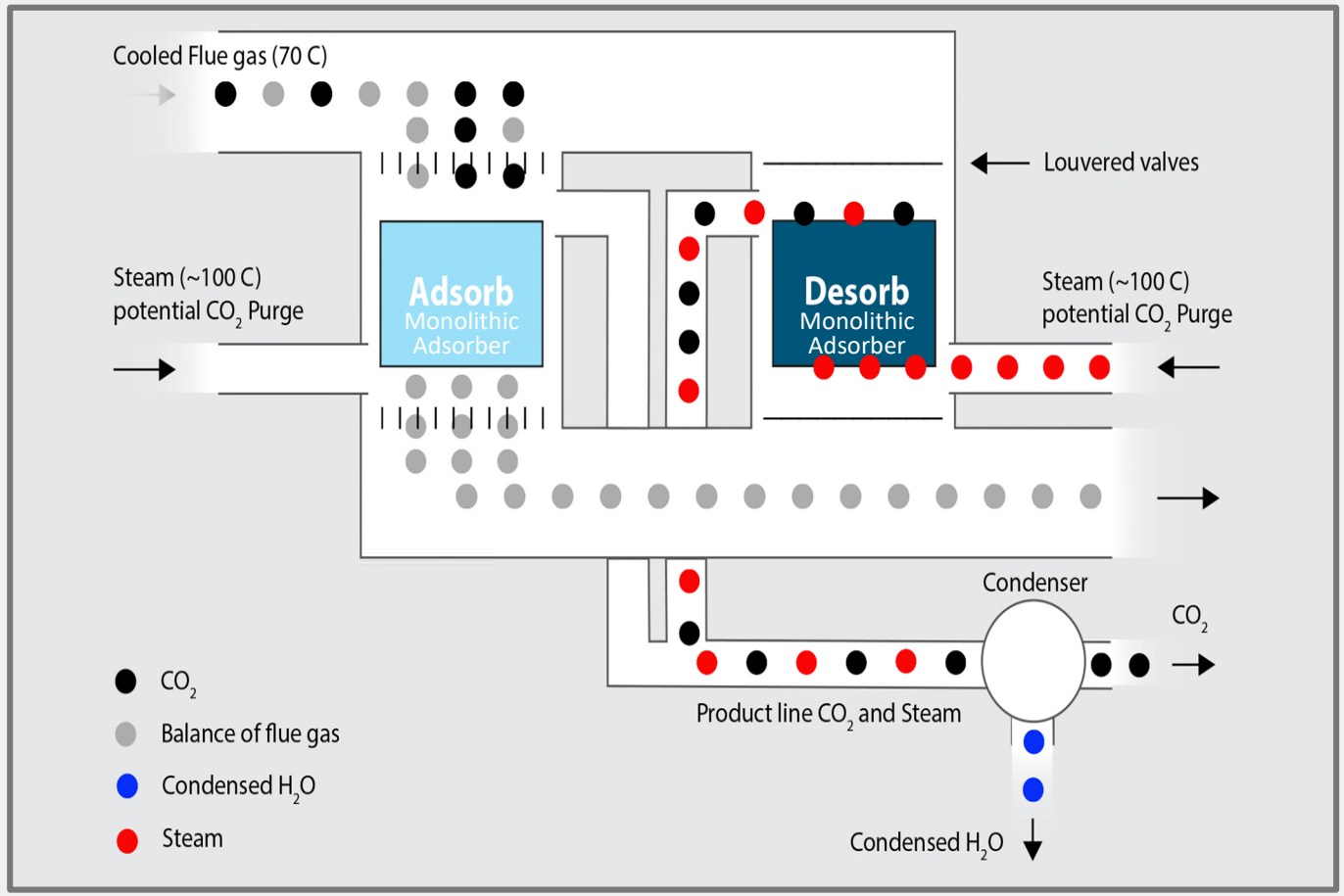
Heavy Industrial Processes

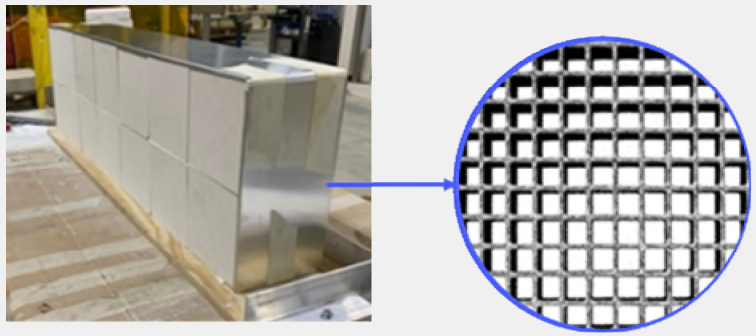
We work at large scale across multiple industries

Technology Background

PSC Process Overview

Cyclical, two-step process, centered on the solid monolith adsorber engine:
(1) CO_2 adsorption from flue gas; (2) CO_2 collection by steam-assisted desorption.





CORAL TECHNOLOGY

HONEYCOMB: PROVEN, DOMINANT STRUCTURE OF CHOICE
- Minimizes pressure drop & associated parasitic energy
- Maximizes gas contact & CapEx utilization

FUNCTIONAL WALLS MINIMIZE ENERGY COSTS
- Captures CO_2 throughout the wall
- Less inert material maximizes thermal efficiency
- Minimizes pressure drop & associated parasitic energy

VERSATILE STRUCTURING FOR ADSORBER OPTIMIZATION
- Structuring variety of sorbents into honeycombs
- Meets diverse needs of DAC customers
- Meets needs of various PSC applications
- Accommodates sorbent innovations

FULL LIFECYCLE MANAGEMENT
- CO_2 adsorbers are regenerable and recyclable
- Lower costs and CO_2 footprint
- Fewer supply chain risks

Sorbent Agnostic: Various sorbents and continuous R&D improvements in sorbent and structuring technology can easily be incorporated into this PSC process.

Technology Background

Anticipated Benefits

CORMETECH Monolithic NGCC PSC Process	
Lower & Flexible Footprint	✓
Simple & Familiar SCR-Like Components	✓
Lower Pressure Drop	✓
Lower Heat Load	✓
Lower Amine Emissions	✓
No Amine Disposal Required	✓
Full Lifecycle Management	✓
Lower Cost per mt CO_2 Captured	✓
Scalable	✓
95%+ CO_2 Removal	✓

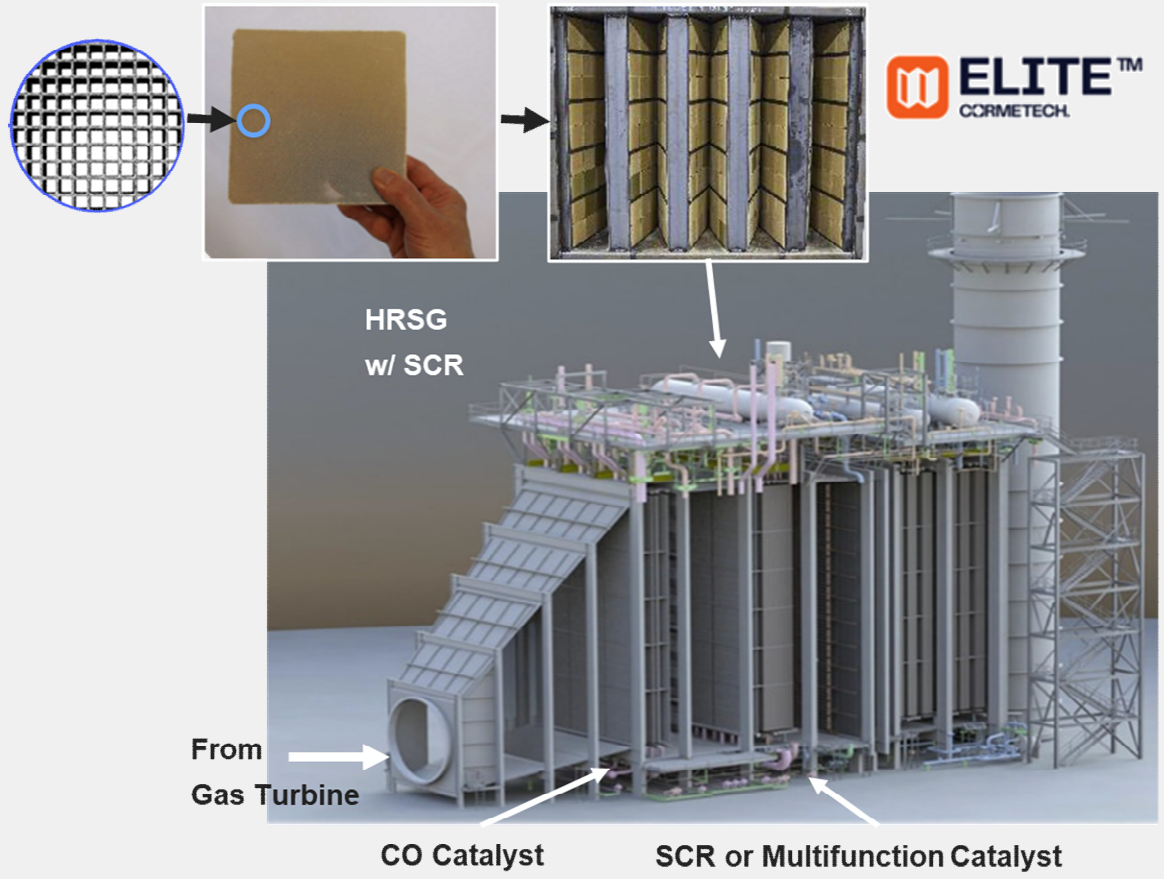
Technology Background

Scale-Up Approach

SCR System Experience

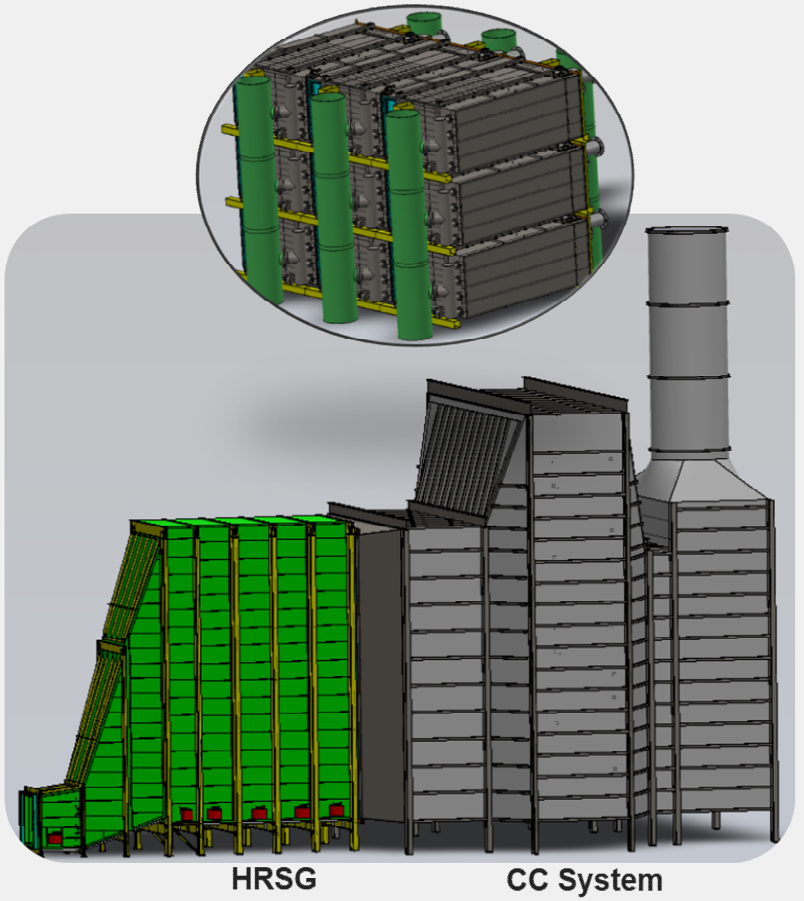
Functional Wall Honeycomb Catalyst

Low Pressure Drop
Modular Design



PSC System

Patent Pending
Adsorber Modules



Project Overview

Bench Scale Test of a Polyethyleneimine Monolith Carbon Capture Process for NGCC Point Sources (DE-FE0032138)

- Three years total period, in three budget periods.
- Total Federal Share = $2,500,000.
- Cost share ~ 20%.

Project Team

CORMETECH.

Southern Company

NC NATIONAL CARBON CAPTURE CENTER

MIDDLE RIVER POWER

NOOTER ERIKSEN

DOE Federal Project Manager: Mariah Young. DOE Award Administrator: Mark Solomon

Project Objectives

- **Develop and validate** a high performance, lower cost integrated process for NGCC point source CO_2 capture incorporating an **oxide monolith + amine structured contactor** (achieve TRL 6).
- **Refine the process model** with experimental data (for capture performance and accelerated life-cycle tests performed under relevant process conditions) collected during the project to **optimize the process** prior to the bench-scale system test and to support the techno-economic analysis.
- **Refine the process techno-economic analysis**, with multiple stakeholder inputs, to outline the roadmap towards **achieving a 20% cost reduction** with the new integrated process relative to the NETL benchmark carbon capture process.

Project Steps – BP1 and BP2

Decision Point	Date	Success Criteria	
Completion of BP1	**1/31/2023**	❑ PEI durability meets specified target before adsorber amine regeneration [i.e., adsorber can still achieve the carbon capture efficiency goal (95%) and CO_2 purity goal (95%)]. ❑ Fixed price (±10%) and process unit delivery timing established.	✓ ✓
Completion of BP2	**1/31/2024**	❑ Capacity of durability optimized PEI-monolith meets specified target for PSC conditions. ❑ Process optimized to meet and exceed carbon capture efficiency goal (95%) and CO_2 purity goal (95%) in bench test. ❑ NCCC Technology Collaboration Agreement with letter indicating acceptance of hazard review and design. ❑ FAT complete and unit ready to ship to NCCC site.	✓ ✓ ✓ ✓

Project Steps – BP3

BP3 activities (2/1/2024 – 1/31/2025; in Tasks 8 & 9)

- **Complete the test campaign for the bench-scale IPU at NCCC.**
  - Demonstrate a minimum of one-month continuous, steady state operation achieving >95% carbon capture efficiency and >95% CO_2 purity.
  - Test the impact of dynamic operation on system performance (e.g., trip conditions, and quick start-up and shutdowns).
  - Assess the impact of NOx and SOx on the PEI monolith durability.
- **Complete the TEA, LCA, and Technology EH&S Risk Assessment.**

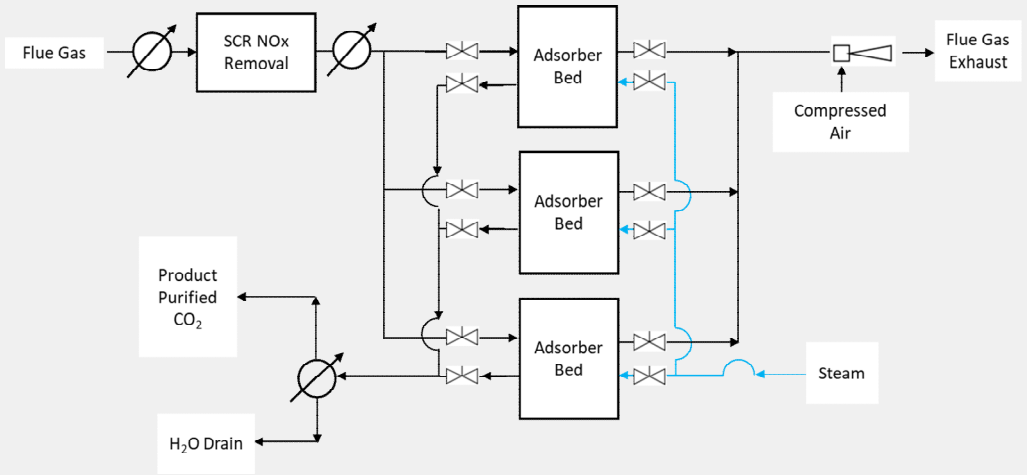
Decision Point	Date	Success Criteria
Project Completion	1/31/2025	❑ >95% carbon capture efficiency and >95% CO_2 purity demonstrated for minimum 1-month continuous operation. ❑ Impact of flue gas contaminants (NOx, SOx) on system performance / durability quantified, to yield <20% adsorber degradation. ❑ The TEA/LCA show advantages of novel PSC system and road map towards 20% reduction in carbon capture cost relative to the NETL standard CANSOLV system. ❑ EH&S risk assessment shows no issues for commercial deployment.

BP1 Task 3

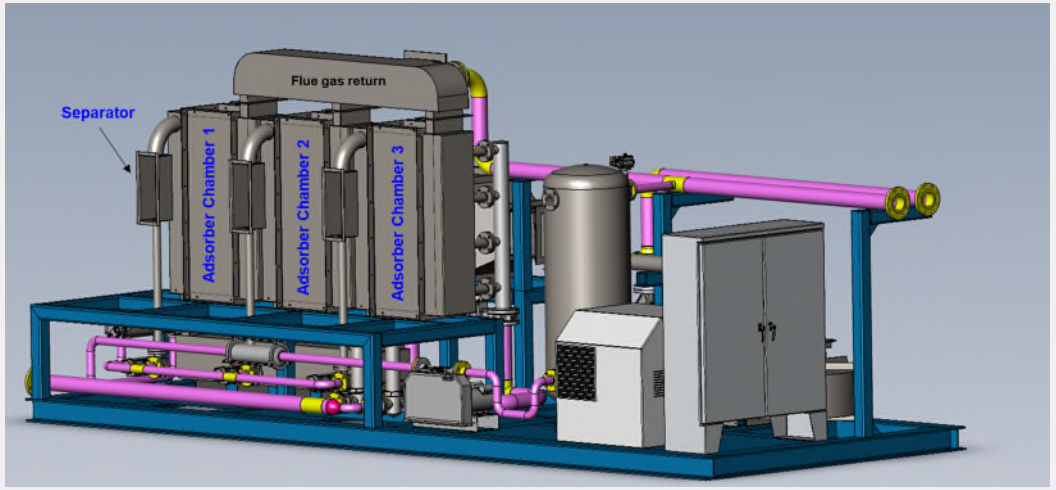
Basic Engineering of the Integrated Process Unit

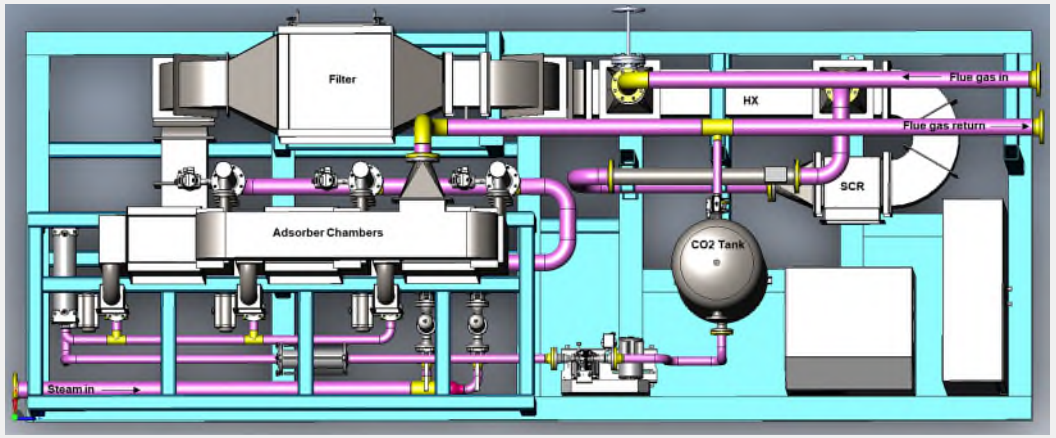
~1 ton/day CO_2 production rate.

Block Diagram of IPU Layout



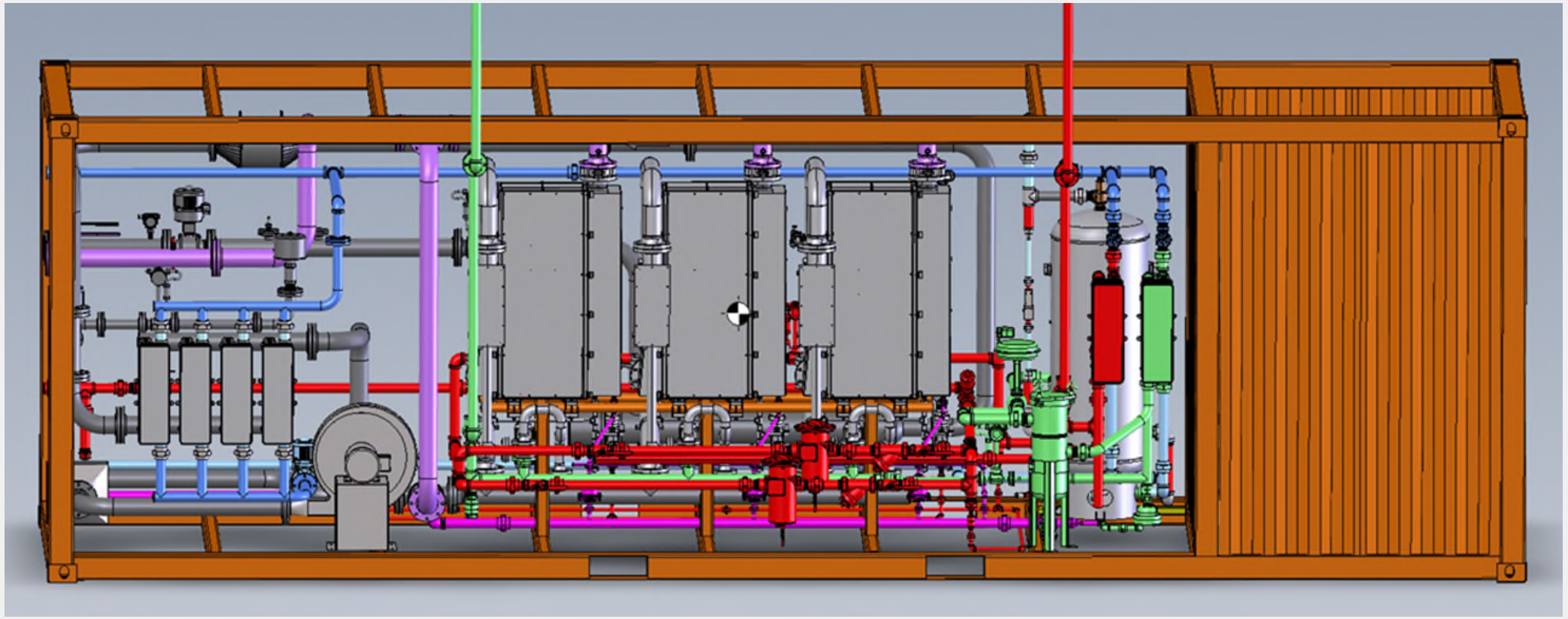
Three adsorber beds for test flexibility on adsorb/desorb times (1:1, 1:2, 2:1).





BP2 Task 4

Detailed Engineering of the IPU



PATHFINDER™ Point Source Capture (PSC) Integrated Process Demonstration Unit (IPU)

Fabrication complete at MERTEK

Loading for transport to NCCC

PATHFINDER™ Point Source Capture (PSC) Integrated Process Demonstration Unit (IPU)

Arrival at NCCC and unloading in bench bay.

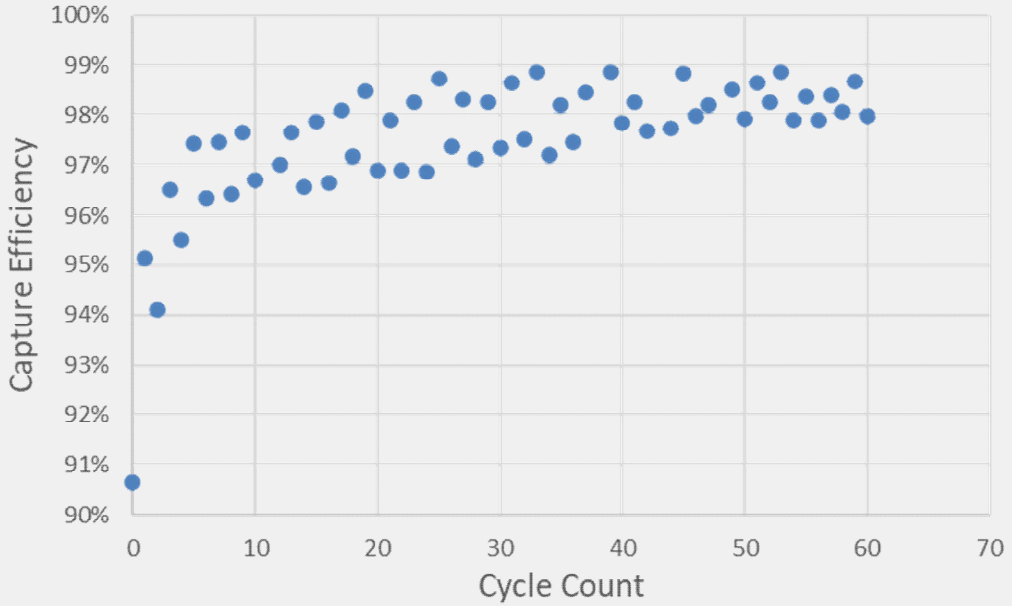
Installation currently in progress!

Unit commissioning starts in late June 2024. Test campaign completion by January 2025.

95% Capture Efficiency and Beyond

- 95% CE for 1-month continuous operation is goal of NCCC test campaign.
- Technology can achieve > 95%. Scale-up considerations are important:
  - SV, bypass/leakage, CO_2 purity. No moving parts except for inlet/outlet dampers.
  - Adsorber isotherms, and degradation rate (NO_2, SO_2, O_2). Servicing and regeneration.

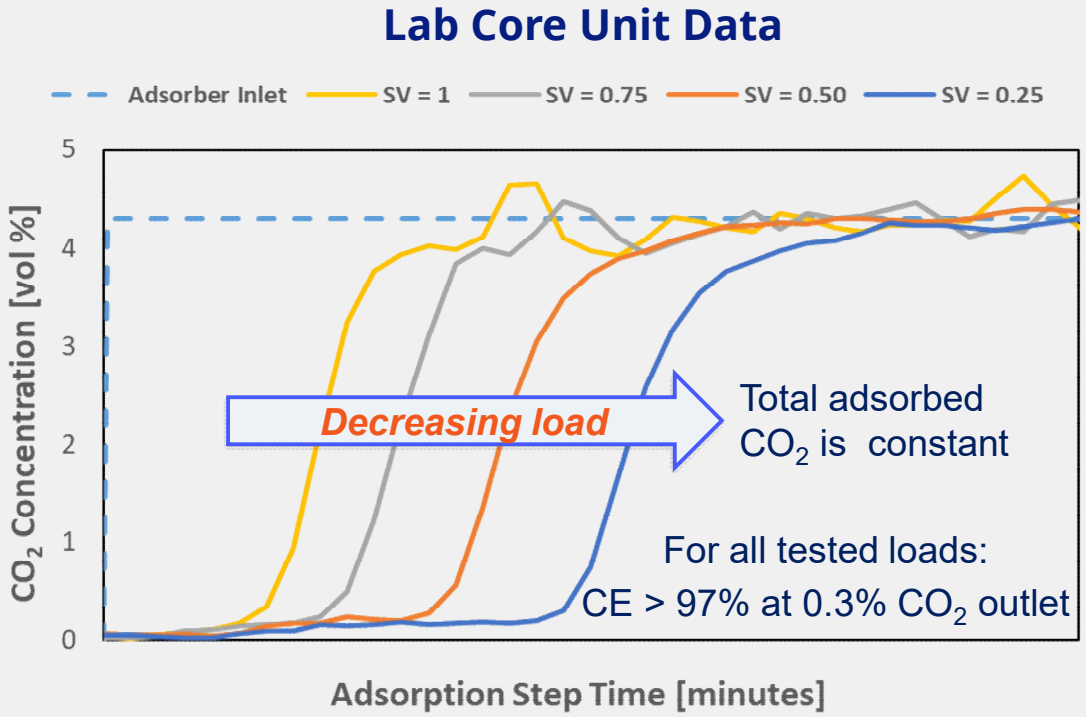
Lab Bench Unit Data / with Steam Desorption

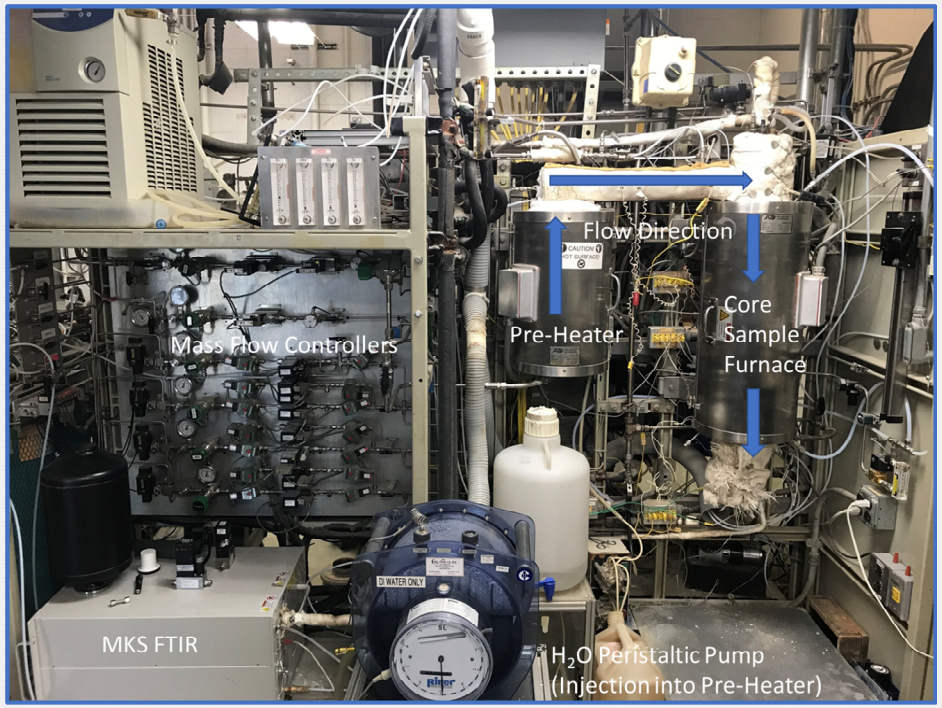


Lab Bench Unit / Two Chamber Design

Flexible Operation

- PSC system is passive for adsorption: no sorbent or reagent injection.
  - Steam desorption cycle step is “independent” from the adsorption cycle step.
  - SUSD and transient load operation are thus more straightforward.





Lab Core Unit / One Chamber Design

Thank You

Dr. Christopher Bertole

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