

# National Carbon Capture Center (FE0022596)

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Southern Company  
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U.S. Department of Energy  
National Energy Technology Laboratory  
2023 Carbon Management Project Review Meeting



U.S. DEPARTMENT OF  
**ENERGY**



**NC**  
NATIONAL CARBON  
CAPTURE CENTER

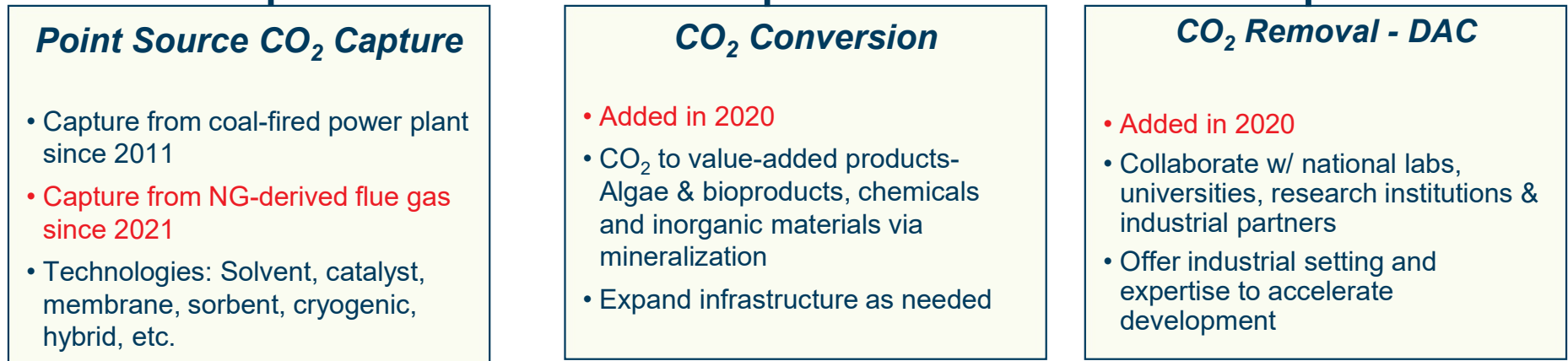
# Nation Carbon Capture Center (NCCC)

Located in Wilsonville, AL  
@ Alabama Power's Plant Gaston



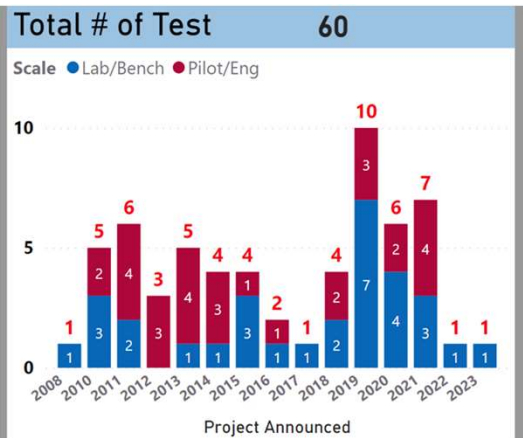
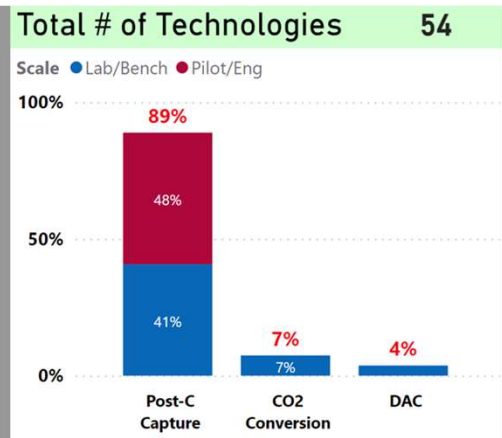
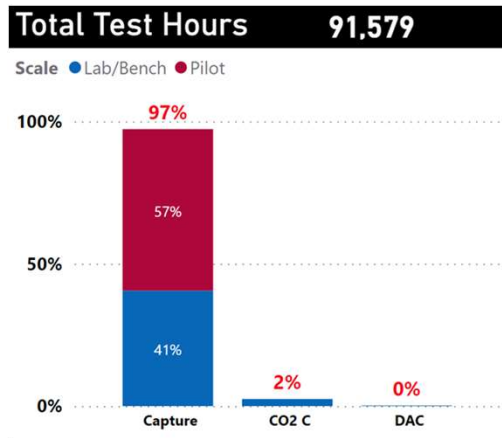
- A **centralized test facility** providing comprehensive support for technology testing and evaluation
  - Process, engineering, operational, analytical, troubleshooting and maintenance
- Goal: **Accelerating** technology development, scale-up, cost reduction and commercialization
  - CO<sub>2</sub> capture, conversion and removal
- Sponsored by **DOE/NETL, research and industrial partners**; managed by Southern Company
  - Coal, utility, research, oil & gas, policy
  - Project period: 2014-2025 (Current BP8)
  - Total \$348MM (DOE \$253.4MM / Non-DOE \$94.6MM)
  - PI: John Northington, Director of NCCC

# NCCC – Technical Program



*DAC: Direct Air Capture*

# NCCC by the Numbers\*

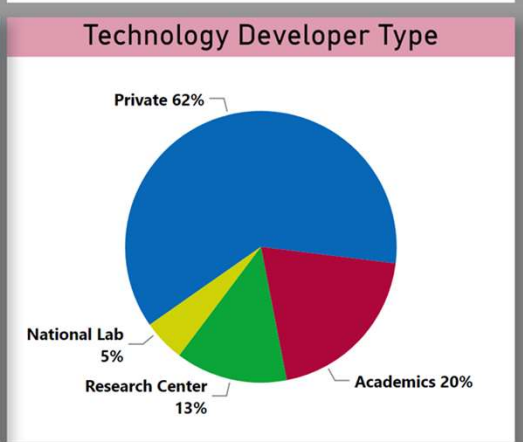


### Tech Scaled Up 10 MW +/-FEED

Aker
CANSOLV
Carbon Clean
ION Clean Energy
Linde/BASF
MTR
RTI International
UT Austin

### International Collaboration

Country	Developer
Australia	UNO Tech
Canada	Cansolv
China	CERI
Germany	Linde/BASF
India	CCS
Japan	Chiyoda
Japan	Hitachi
Norway	Aker
UK	Carbon Clean



\* Post-Combustion CO<sub>2</sub> Capture since 2011, CO<sub>2</sub> Conversion since 2021 & DAC since 2023



# NCCC – Facility Infrastructure

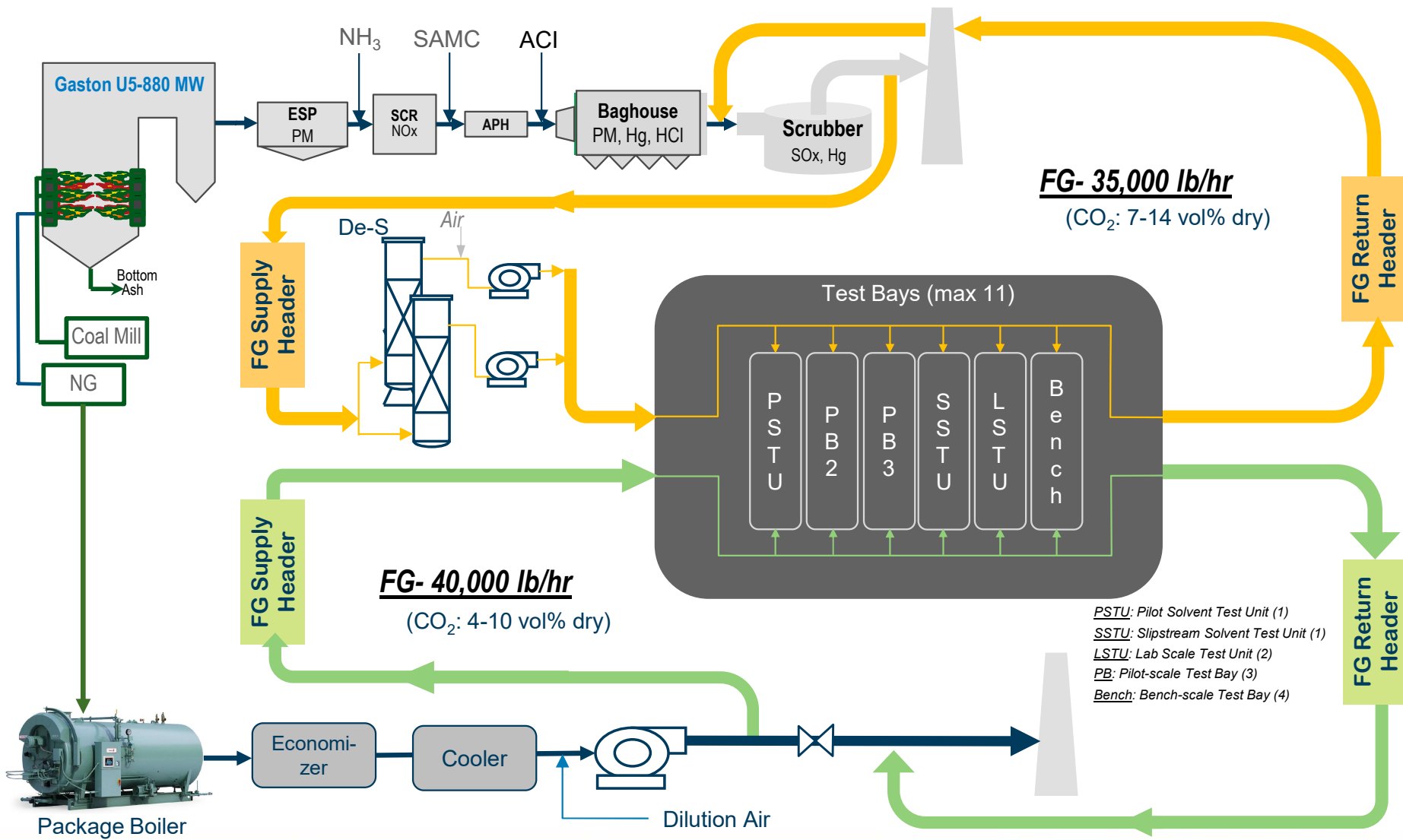
## Plant Gaston: Host Site

- Unit 5 (U5) -890 MWe supercritical
  - Dual fuel – coal and natural gas
  - 35,000 lb/hr slipstream flue gas (FG) from U5
  - Exhaust gas from NCCC returns to U5 stack
- Low/Medium pressure steam, water (demin, potable, filter-treated), instrument air and power
- Wastewater returns to plant Gaston for treatment and disposal

## NCCC

- NG flue gas from package boiler (new 2021)
  - 40,000 lb/hr flue gas
  - Exhaust stack
- Low pressure steam, nitrogen and cooling water
- Test equipment, test bays and infrastructure





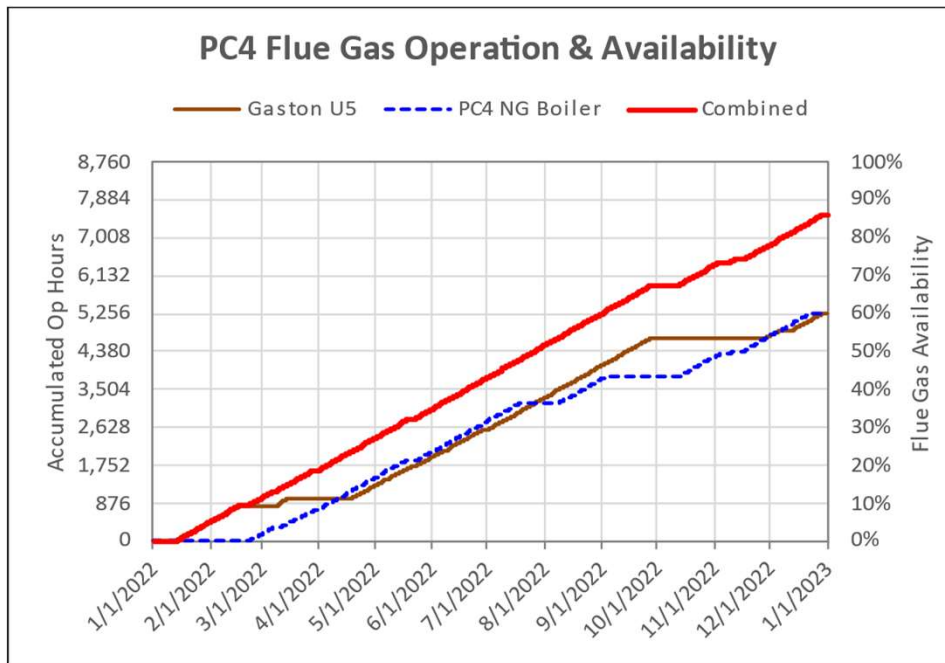
**Coal FG Config**

**NG FG Config**

*PSTU: Pilot Solvent Test Unit (1)*  
*SSTU: Slipstream Solvent Test Unit (1)*  
*LSTU: Lab Scale Test Unit (2)*  
*PB: Pilot-scale Test Bay (3)*  
*Bench: Bench-scale Test Bay (4)*

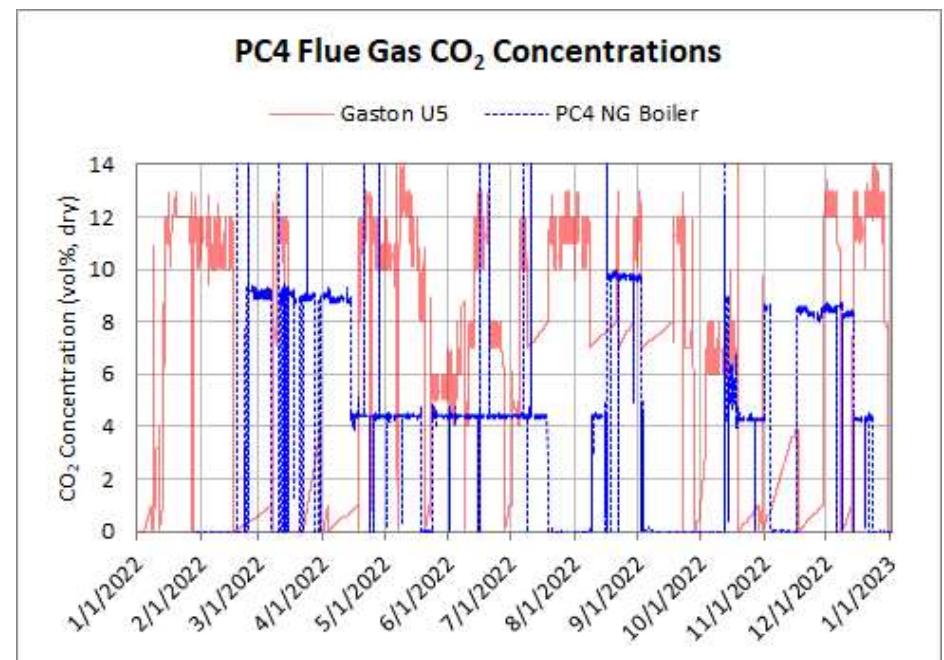
# Operation 2022

## Flue Gas Availability



43% more flue gas availability to support testing in 2022 for the combined U5 and NG boiler operation

## Test Flexibility & CO<sub>2</sub> Variations

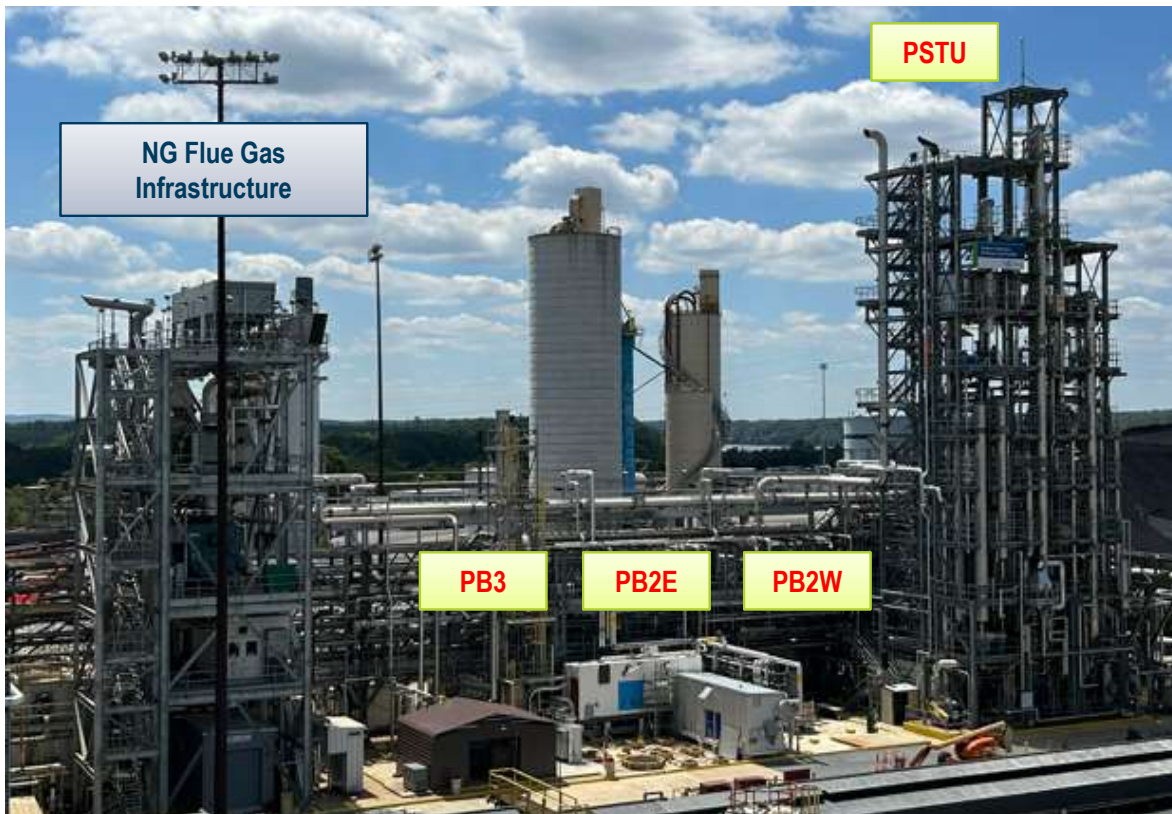


Developer can switch between coal and NG flue gas during test campaign



# Test Bays and Equipment

## Pilot Scale



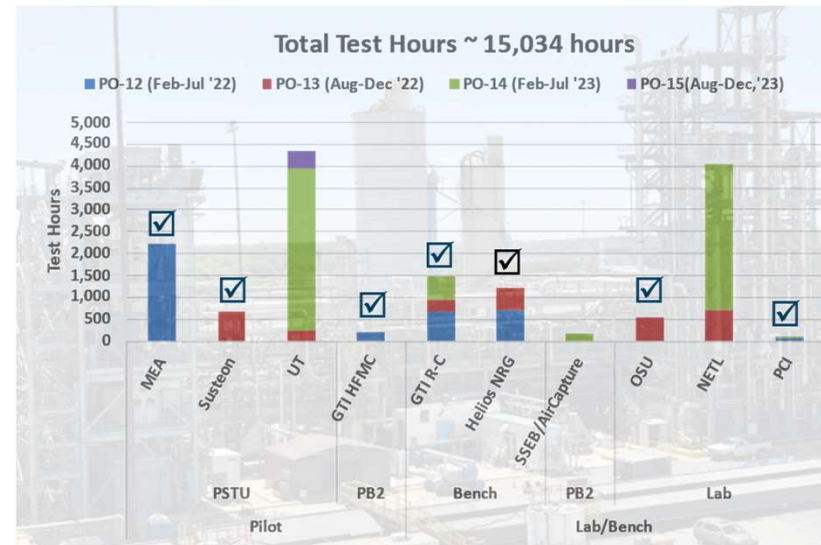
## Lab/Bench Scale





# Technology Testing Portfolio

		Test Campaign (2022 & 2023)	
Tech Areas	Technologies	Pilot	Lab/Bench
CO <sub>2</sub> Capture	Solvent/ Contactor	PSTU MEA <input checked="" type="checkbox"/> PSTU Susteon Catalyst <input checked="" type="checkbox"/> PSTU UT PZAS GTI HFM Contactor <input checked="" type="checkbox"/>	SSTU MEA <input checked="" type="checkbox"/> GTI ROTA-CAP <input checked="" type="checkbox"/>
	CO <sub>2</sub> Membrane		NETL OSU <input checked="" type="checkbox"/> GTI Helios-NRG/UB
	Sorbent		PCI <input checked="" type="checkbox"/> Altex
	Cryogenic	Carbon America FrostCC	
CO <sub>2</sub> Conversion	Mineralization		UCLA- Concrete
DAC	Sorbent		SSEB/AirCapture



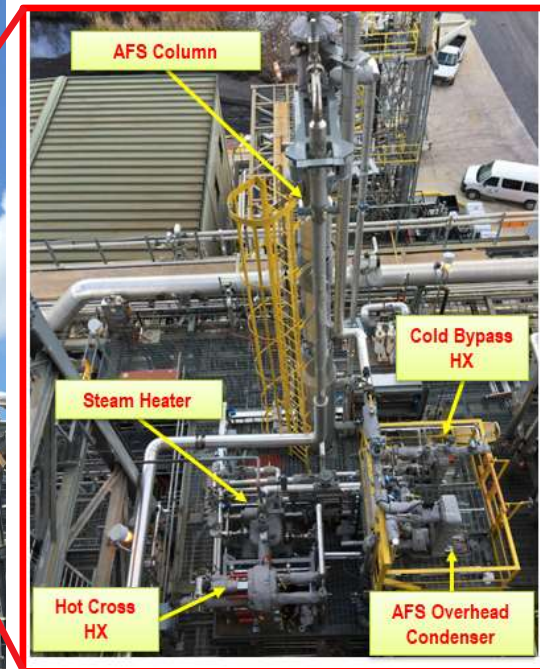
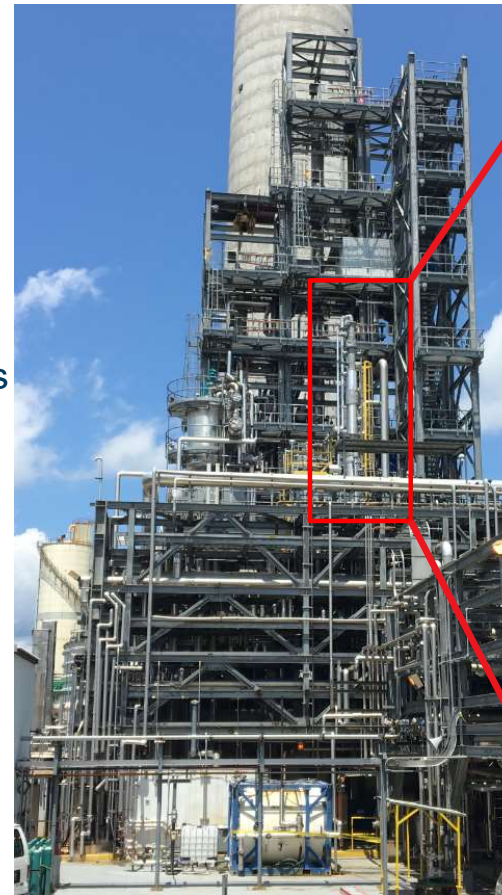
Test Completed

Red - New Tests in 2023

# PSTU- UT PZAS



- PZ w/Advanced Flash Stripper (PZAS)
  - Two test campaigns completed in 2018 & 2019
  - Current campaign funded by DOE (FE0031861), EU LAUNCH and industrial sponsors
- Test Objectives
  - NGCC FG conditions: 4% CO<sub>2</sub>, 8% H<sub>2</sub>O, 110 °C
  - Study solvent degradations, corrosion & mitigations
- PSTU/AFS Main Modifications
  - New FG heater before absorber
  - 2-stage washes: water and acid
  - Chemical additions for NO<sub>2</sub> reduction
  - N<sub>2</sub> sparger to remove O<sub>2</sub> in solvent
  - Carbon filters for solvent contaminants removal
  - 7 new corrosion ports



Advanced Flash Stripper (AFS) on PSTU 4<sup>th</sup> Floor

# PSTU- UT PZAS



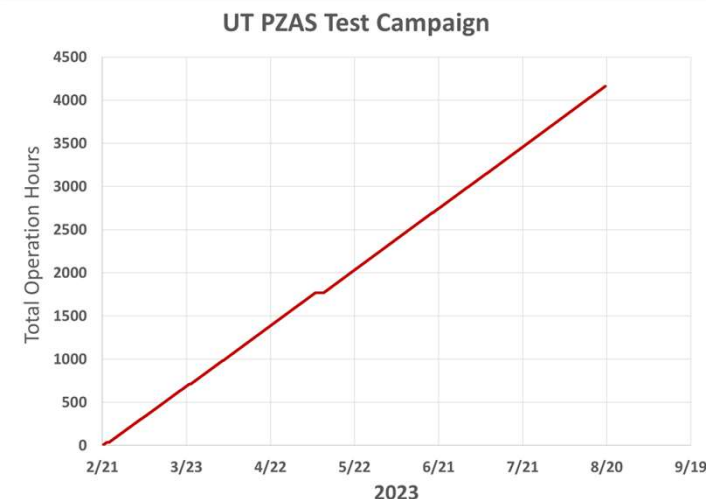
- Status

- Commissioned in Dec 2022 and began testing in Feb 2023
- 5 test matrix to study emissions, degradation, and mitigation mechanisms
- Expand the test scope to include solvent reclaiming and post-reclaiming solvent performance verification

- Expansive Analytical Tools

- Collaboration b/t NCCC, UT Austin and U of Oslo
- Solvent: titration, GC, GC/FID, TOC/TIC, HPLC, IC, ICP-MS, UV-Vis and DO sensor
- Gas: NDIR, UV, Paramagnetic, emission sorbent tube, AMI O<sub>2</sub> sensor, FTIR, PTR-TOF-MS\* and low ppb NO<sub>2</sub> analyzer

\* Proton Transfer Reaction Time of Flight Mass Spectrometry (from U of Oslo, Norway)





# Carbon America FrostCC

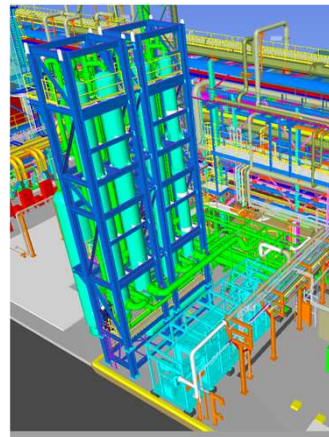
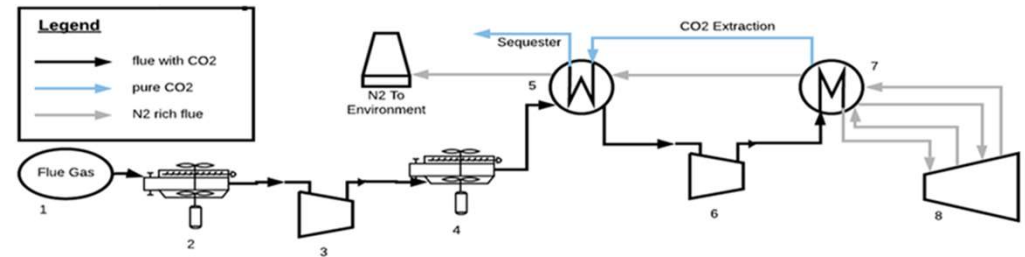


- FrostCC Technology (non-FOA)

- First cryogenic technology to be tested at NCCC
- No external refrigerant
- Compression/expansion and heat integration make flue gas self-refrigerating
- CO<sub>2</sub> is collected as a liquid product

- Status

- BOP skids arrived in Mar
- Commissioning of BOP in progress
  - ▶ Piping interconnections completed and pressure-checked
  - ▶ Instrumentation and valves wired, loop-checked, calibrated, and stroked
  - ▶ Cryo-insulation of pre-cooling skid complete
  - ▶ Compressor initiated and ramped to full load on air
  - ▶ Flue gas dryer commissioned
  - ▶ Expander commissioned and tested at full speed
- Liquid CO<sub>2</sub> and Frost heat exchange equipment will arrive this fall



3D Model of FrostCC at PB2W



Initial Skid Placement at NCCC 3/16/23



# Carbon America FrostCC – Progress to Date



Initial Skid Installation – March 2023



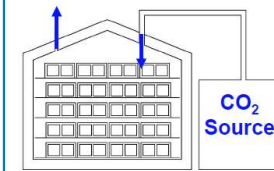
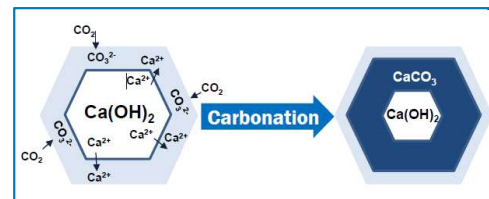
Piping, Electrical Installation – May 2023



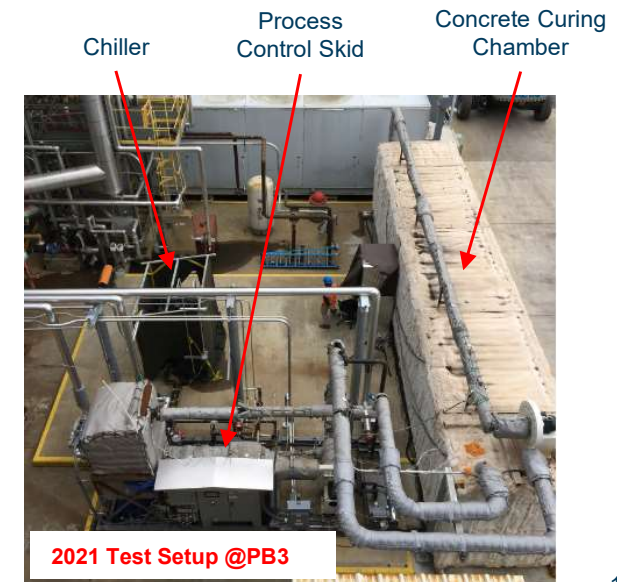
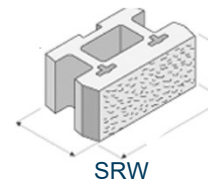
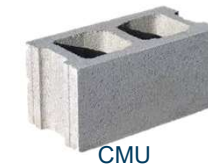
Ph 2 Foundation Preparation – July 2023



- CO<sub>2</sub> Mineralization for Concrete Production (FE0031915)
  - One of the two XPRIZE winners in 2021
  - **$\text{Ca(OH)}_2 + \text{CO}_2 \rightarrow \text{CaCO}_3 + \text{H}_2\text{O}$**
- Main Changes from Previous Test in 2021
  - Demonstrate 3 products: concrete masonry units (CMU), segmental retaining wall (SRW) units, and wet-cast manholes (WCM).
  - Process improvement based on previous test and process simulation
  - New fans & gas distribution inside the reaction chamber
- Status
  - Review skids changes and layout w/ UCLA
  - Planning for supplement HAZOP for the changes
  - Skids redelivery targets Oct 2023



- Flow through reactor – uses CO<sub>2</sub> straight from emitter
- Requires gas processing
- Utilizes 2-100% CO<sub>2</sub>





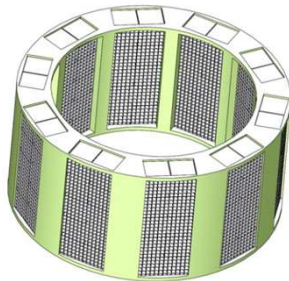
# SSEB/AirCapture DAC



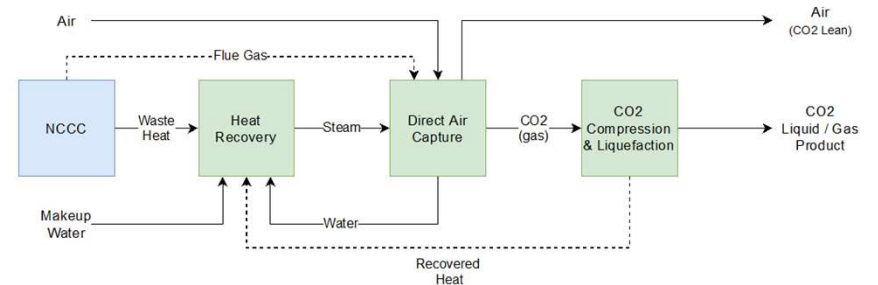
- Solid Amine for DAC (FE0031961)
  - First DAC technology test at NCCC
  - GT's solid-amine sorbent monolithic contactors
  - Advantages
    - ▶ Low pressure drop
    - ▶ Low thermal mass
    - ▶ High geometric surface area
    - ▶ Abs/Des: 10:1 (900/90 sec)
- Status
  - Skids delivered in Feb 2023 and commissioned in Apr
  - AirCapture is executing their test plan



100 tonne/yr SSEB/AirCapture Skids Installed at NCCC



2x5 Contactor Arrangement (100 tonne/yr)

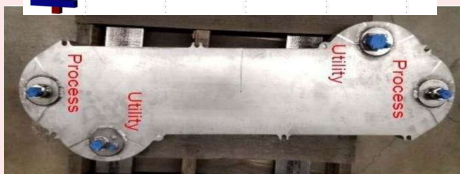


# Solvent/Contactor & Sorbents

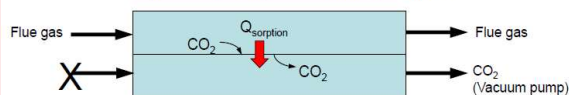
## Altex (SC0013823)



- Intensified Sorbent Process-sorbents coated on both sides of HX
- Compact Microchannel Heat Exchanger (MCHEX) wash-coated w/ PSU Molecular Basket Sorbents
- Sorbent coating on HX reactor completed
- Skid fabrication completed and shakedown in progress at Altex
- Test targets for Q4 2023



**Double-Sided Absorber – Combined Sorption and Desorption Cycles**  
Integrate heat of sorption with heat of desorption.



## GTI ROTA-CAP (FE0031630)



- CCSL intensified solvent → reduced energy & equipment size
- GTI rotating packed bed absorber & regenerator → improve mass transfer
- Solvent tested in SSTU Aug-Nov, 2021
- Skids arrived 10/5, 2021
- Testing started 10/31, 2021 and concluded 7/10, 2023 for over 1,500 hours of operation
- Decommissioning in being planned



## Susteon Catalyst (Non-FOA)



- Patented Ionic liquid catalyst in amine solvent to Improve kinetics & loading
- A separate DOE funded DAC project using same catalyst in solid form (FE0031965)
- Test w/ MEA solvent in PSTU
- Test completed 8/10 - 9/9 for 680 hours



Pilot Solvent Test Unit (PSTU)



# Membrane

## NETL



- Test various membranes
- Skid was reinstalled 10/3/2022
- **Test started 10/19/2022 and continues**
- **NCCC swaps membrane materials periodically as requested by NETL**



## OSU (FE0031731)



- Facilitated transport membrane
- Selective amine polymer layer on polymer support
- CO<sub>2</sub> transport via reaction with amine
- **Skid delivered 10/31, 2022 & set in LSTU**
- **Tested membrane 11/3- 12/19, 2022 for 500+-hour continuous operation**
- **Project concluded and skid returned**



## GTI (FE0031598)



- Develop a transformational Graphene Oxide (GO) based membrane process
- GO<sup>2</sup>: high-selectivity GO-1 membrane and a high-flux GO-2 membrane
- **Skid delivered on 8/14, 2023 and set in LSTU.**
- **Commissioning completed on 8/18 and parametric and long-term tests will start soon**



# Future Testing Outlook – 2024 & beyond

- Solvent
  - EPRI/PNNL/RTI WLS
  - SRI Int. MSP
  - UNO Tech MK3 Precipitating Solvent
  - China Huaneng CERI (Clean Energy Research Institute)
  - U of Sheffield
- Membrane
  - U at Buffalo
- Sorbent
  - Altex
  - Cormetech
  - RPI/U at Buffalo
- CO<sub>2</sub> Conversion
  - UCLA Concrete (2<sup>nd</sup> Test)
  - Helios-NRG Algae (2<sup>nd</sup> Test)
  - Texas A&M Algae
- DAC
  - InnoSeptra



# Acknowledgements



[Nationalcarboncapturecenter.com](http://Nationalcarboncapturecenter.com)

Special  
Thanks to  
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