National Carbon Capture Center (FE0022596)

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Southern Company
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U.S. Department of Energy
National Energy Technology Laboratory
2022 Carbon Management Project Review Meeting
Nation Carbon Capture Center (NCCC)

- 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
  - CO₂ capture, utilization 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 BP7)
  - Total $348MM (DOE $253.4MM / Non-DOE $94.6MM)
  - PI: John Northington, Director of NCCC

Located in Wilsonville, AL at Alabama Power’s Plant Gaston Since 2009
CO₂ Capture
- Capture from coal-fired power plant since 2009
- Added capture from NG-derived flue gas in 2020
- Solvent, catalyst, membrane, sorbent, hybrid technologies

CO₂ Utilization
- Added in 2020
- CO₂ to value-added products like building materials, fuels, plastics, chemicals & algae
- Evaluate additional infrastructure needed

CO₂ Removal - DAC
- Added in 2020
- Evaluate additional infrastructure as needed
- Look to collaborate with national labs, universities and other research institutions

DAC: Direct Air Capture
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
NCCC by Numbers (2011-2022)

• 80,000+ hours of performance data collected
  – Post-combustion capture and CO₂ utilization

• 50 technologies from 37 developers tested or planned
  – Solvent, membrane, sorbent, phase change, & hybrid-based capture technologies
  – Chemical, fuel, concrete and algae-based utilization technologies
  – 66% are private companies

• 8 technologies scaled up (or ready) to 10+ MW
  – Aker, Carbon Clean, ION Clean Energy, Linde, MTR, RTI, Shell Cansolv and UT Austin

• International testing collaboration: 7 countries
  – Canada, China, Germany, India, Japan, Norway, UK
Operation Availability and Flexibility

Flue Gas Availability

62% more flue gas availability to support testing in 2021 since NG flue gas came online

Test Flexibility – e.g. PSTU Test

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

Pilot Scale

PSTU

NG Flue Gas Infrastructure

PB3  PB2E  PB2W

Lab/Bench Scale

SSTU

Benchscale

LSTU
# Current Technology Testing Portfolio

## Test Campaign (2021 & 2022)

<table>
<thead>
<tr>
<th>Tech Areas</th>
<th>Pilot</th>
<th>Lab/Bench</th>
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| **Solvent/Contactor** | PSTU ION 🟢  
PSTU MEA (re-baseline) 🟢  
PSTU Susteon Catalyst  
PSTU UT PZAS  
GTI HFM Contactor ✓  | SSTU MEA (re-baseline) ✓  
SSTU GTI/CCSL ✓  
GTI/CCSL ROTA-CAP |
| **CO₂ Membrane**    |                                           | NETL OSU                                 |
| **Sorbent**         | TDA Sorbents ✓                             | PCI Sorbents                             |
| **Others**          | Carbon America (Cryogenic)                 |                                         |
| **CO₂ Utilization** | SR- Ethylene ✓  
UCLA- Concrete ✓  
Helios-NRG- Algae  |                                         |

- Test Completed
- Red - New Tests in 2022

**Total Test Hours ~ 17,667 hours**

*Color bars represent testing hours from different test campaigns.*
• PZ w/Advanced Flash Stripper (PZAS)
  – Two test campaigns completed in 2018 & 2019
  – Current campaign funded by DOE (FE0031861), EU LAUNCH and private company

• Test Objectives
  – NGCC FG conditions: 4% CO₂, 8% H₂O, 110 °C
  – Study solvent degradations, corrosion & mitigations

• PSTU/AFS Main Modifications
  – New FG heater for temperature control
  – 2-stage washes: water and acid
  – NO₂ removal from FG
  – N₂ sparger to remove O₂ in solvent
  – Carbon filters for solvent containments removal
  – 7 new corrosion ports

• Status
  – Detail design completed; Construction in progress
  – Target Oct for commissioning
2022 Test Campaign- Solvent & Contactor

**GTI HFM Contactor (FE0012829)**
- High surface areas membrane contactor w/aMDEA
- Installed in Apr 2017
- Testing concluded in Mar 2022 for a total of 2,600 hours on both coal and NG FG
- Project decommissioned in May

**GTI ROTA-CAP (FE0031630)**
- CCSL intensified solvent $\rightarrow$ reduced energy & equipment size
- GTI rotating packed bed (RPB) absorber & regenerator $\rightarrow$ improve mass transfer
- CCSL solvent tested in SSTU (baseline) Aug-Nov, 2021
- Skids installed in Oct 2021
- Testing started in Oct 2021 and continues

**Susteon Catalyst (Non-FOA)**
- Patented ionic liquid catalyst in amine solvent to Improve kinetics & CO2 loading
- Similar catalyst is being tested with sorbents for DAC
- Test w/ MEA solvent in PSTU w/wo catalyst
- Testing started in Aug and continues

Pilot Solvent Test Unit (PSTU)
2022 Test Campaign - Sorbents

**TDA (FE0012870)**
- Alkalized alumina adsorbent - Low cost & heat of ads
- Near isothermal op at 150 °C
- Skids installed in Oct 2017
- Testing concluded in Oct 2021 for a total of ~2,900 hours on both coal and NG FG
- Project decommissioned in May 2022

**PCI (SC0017221)**
- Nano-sorbents on tailorable mesh substrate (Microlith®)
- High surface areas, heat & mass transfer rates
- Lower ΔP vs. pellet sorbent, and comparable ΔP vs. monoliths
- Tested at NCCC briefly in Mar 2020
- Skid installed in Mar and initial testing completed in Apr. More test is planned later this year

**Altex (SC0013823)**
- Intensified Sorbent Process-sorbents coated on both sides of HX
- Low cost and compact Microchannel Heat Exchanger (MCHEX) wash-coated w/ PSU Molecular Basket Sorbents (MSB)
- Testing targets Jan 2023
2022 Test Campaign- Membrane

OSU (FE0031731)
- Facilitated transport membrane
- CO$_2$ transport via reaction with amine
- CO$_2$ selective amine polymer layer on polymer support
- Two test campaigns completed in 2015 & 2018
- Skid delivery targets for Aug/Sep
- Testing to start in Sep

NETL
- Ongoing membrane material evaluation since 2015
- Test membranes in hollow fiber and flat sheet configurations
- Plan to restart testing in Sep
2022 Test Campaign - Other Capture & CO$_2$ Utilization

Carbon America (non-FOA)
- Phase changing cryogenic process - FrostCC
- FG compressed, cooled, and expanded to solidify and separate CO$_2$
- Skid delivery in Q4 2022
- Testing to start in Jan 2023

Helios NRG (FE0031713)
- Algae growth w/ CO$_2$ in FG
- Multi-stage continuous (MSC) process and closed system
- High water recycle
- Natural sunlight, top lit
- Skid installed in May
- Testing started in June and continues
Future Testing Outlook – 2023 & beyond

• Solvent (PSTU)
  – EPRI/PNNL/RTI
    ▶ Water lean solvent by PNNL
    ▶ Plastic packing in absorber
    ▶ Moisture control in FG is critical
  – China Huaneng CERI (Clean Energy Research Institute)

• Membrane
  – GTI, MTR, SUNY Buffalo

• Sorbent
  – Altex
  – SUNY Buffalo
  – Cormetech

• CO₂ Utilization
  – UCLA concrete (2nd test)
  – Texas A&M algae
  – Helios-NRG (2nd test)

• DAC
  – Southern States Energy Board/AirCapture
  – Innosepra
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