Pre-combustion CO$_2$ Capture @ National Carbon Capture Center (NCCC)

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PSDF and NCCC
PSDF and NCCC

PSDF
1996 Adv. Combustion
1999 Gasification & Hi Temp Filtration

PSDF: Power Systems Development Facility
PSDF and NCCC

NCCC 2008 CO₂ Capture

PSDF: Power Systems Development Facility

Pre-Combustion

Post-Combustion @ Plant Gaston
Benefits of NCCC

• Serve as centralized R&D testing facility
  – Capable of multiple testing simultaneously
  – ~8,000 gasifier run hrs produce 2.5X testing hrs
  – Effective performance comparison between technologies tested
• Make available realistic syngas for performance verification
  – Flexible in capacity & process conditions
• Leverage existing infrastructure and on-site expertise in power plant, process engineering and integration, design, and O&M areas
• Provide independent data acquisition and analysis for developers as needed
  ➔ Accelerating CO₂ capture technology commercialization
CO₂ Capture Technology Landscaping

Based on NCCC’s Technology Database
NCCC Program Focus

Technology Development Time Scale →

Progress to Commercialization →

Basic R&D Lab Scale

Small Pilot

Large Pilot

Demonstration

Commercial

Transfer laboratory work to more realistic conditions

Integrated CO₂ capture system testing

Sub-system or component testing at larger-scale

NCCC Focus Area
Simplified SCU Slipstream Schematic

**SCU: Syngas Conditioning Unit**

- **Fixed Bed Rxr** 50-80 pph/each
- **200 pph**
- **500-1,000 pph**
- **0.45 MWe, 7.5 tpd CO₂**
  - 1,500 pph Syngas
- **0.30 MWe, 5.0 tpd CO₂**
  - 1,000 pph Syngas
- **SCU Expansion**
  - Pilot Test Unit #1
- **Future Upgrade**
  - 1.5 MWe, 25 tpd CO₂
  - 5,000 pph Syngas

Continued R&D
- Coal Feeder
- Biomass co-feed
- Hi Temp Filtration
- Ash Handling
- Hi Temp Sensor

Transport Gasifier

T.O./Stack

T.O./Stack
Syngas In
1,500 pph

Syngas out

Interface to Capture Test

SCU – 2009 (100 lb/hr Syngas Treatment Capability)
SCU Expansion 2012

- Expanded SCU - 2012
  - (1000 lb/hr Syngas)

- Existing SCU - 2009
  - (100 lb/hr Syngas)
NCCC Roles

Civil/Construction
• Ground preparation
• Weather protection
• Skid installation
• Interconnecting interface piping & wiring

Process Development
• Develop PFD for syngas, N2, Air, cooling water
• Low temp gas cleanup process
• Warm gas cleanup process
• H2 enrichment

Mechanic, Electric Design and I&C
• Design for syngas/N2/Air/cooling water supply
• Design for electrical supply, heat tracing
• Provide necessary instrumentation for process monitoring and alarm
• Vendor skid design review and recommendation for improvement and safe operation

Operation
• 24x7 monitoring and operating
• Trouble-shoot field issues
• Component replacement
• Data logging and analytical support

Four 12-pack H2 Cylinders
Current Technology Testing Scope

Bench
- WGCU (warm gas cleanup)
  - JM/NETL Hg Sorbent

Pilot
- (>500 lb/hr)
  - Catalyst
    - WGS
      - Southern Research F-T
  - Solvent
    - NETL/U of Pitt
      - U of AL
    - SRI International
  - Membrane
    - H₂/CO₂
      - WPI
      - MTR
      - MPT
      - Eltron
    - MTR CO₂
  - Sorbent
    - TDA
  - Chemical Looping
    - OSU SCL

Logos:
- TDA Research
- Johnson Matthey
- Southern Research Institute
- The University of Alabama
- NETL
- MTR
- Eltron Research & Development
- University of Pittsburgh
- Süd-Chemie
- Haldor Topsoe
- WPI
- The Ohio State University
WGS Catalysts Evaluation

CO + H₂O → H₂ + CO₂

- 1.0 reduction ~ 40 MW gain (500 MW Plant)
- $275 MM saving over 30-year plant life
- Results implemented at Kemper County IGCC TRIG™ Project
Solvent Characterization

- Parr Reactor
  - Flexible batch absorption and regeneration process
  - Capacity: 5 liter
  - Syngas and bottle gases
- Chemical Solvents
  - Ammonia-based solvent
  - Amino acid salts (potassium-prolinate)
  - Carbonates (K & Na)
- Physical Solvents
  - DEPG (dimethyl ether and polyethylene glycol)
  - PDMS (polydimethylsiloxane)
  - GTA (glycerol triacetate)
  - MEI (methylimidazoles)

Note: PDMS, GTA (U of Pitt/NETL) and MEI (U of AL)
Membrane Test Configuration

WGS → H₂S Removal → COS Hydrolysis → 10 lb/hr

WGS → Cooler / Condenser → Coalescing Filters → 50 lb/hr

H₂ Enrichment

1,500 lb/hr Syngas Header

WPI H₂ Membrane

MTR CO₂ Membrane

MPT H₂ Membrane

MTR H₂ Membrane
CO$_2$ Solid Sorbent (TDA)

Cabinet #2 - CO$_2$ Removal

- Sorbent reactors (6.8 liter) w/ heating jackets (4)

Cabinet #1 - Syngas Pre-treatment

- Dry-Rite
- Gas Analyzers
- Chiller
- Sulfur guard beds (2)
- WGS/Heater

Cabinet #2

Cabinet #1

WGS/Heater
Technology Scale Up

MTR CO₂ membranes

Field Small module, 50 lb/hr

OSU SCL
(Syngas Chemical Looping)

Lab 25 kW

Field Pilot Skid
260 kW, 880 lb/hr Syngas

Field Pilot Skid (500 lb/hr Syngas)
MTR CO$_2$ Membrane and OSU SCL

Integrated MTR CO2 Membrane System Commissioned in Summer 2012

Compressor Skid
Chiller Skid
Membrane Skid

OSU SCL System Plan for Commissioning in Fall 2013
Summary: NCCC Focus

- **Basic R&D Lab Scale**
  - Syngas: ≤ 10 lb/hr
  - Membrane
  - DOE FOA-785 (Up to 1,700 lb/hr)

- **Small Pilot**
  - Syngas: ≈ 50 lb/hr
  - MTR CO₂ Membrane
  - SRIT Ammonia Solvent

- **Large Pilot**
  - Syngas: ≈ 900 lb/hr
  - OSU Chemical Looping

- **Demonstration**
  - Syngas: <10 lb/hr
  - WPI H₂ Membrane
  - MTR H₂ Membrane
  - MPT H₂ Membrane
  - TDA Solid Sorbent
  - NETL/UPitt/UA Solvent

- **Commercial**

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**Technology Development Time Scale** →
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  – Coal producer: Arch Coal, Peabody, Rio Tinto

• **Technology Developers’ Participation**
  – Eltron, JM, NETL, MPT, MTR, OSU, Southern Research, SRI International, Stanford U, TDA, UPitt, UA, WPI, WGS catalyst developers