Advanced Technology Testing at the National Carbon Capture Center
National Carbon Capture Center

Project Partners
Offering a **world-class neutral** test facility and a highly specialized staff, to **accelerate the commercialization** of advanced technologies and enable coal (fossil fuel) - based power plants to achieve **near-zero emissions (low cost CO₂).**
Technology Development Process

1. Evaluate and Screen Technologies
2. Define Scope of Work with Technology Developer
3. Design and Construct
4. Operate according to Test Matrix
5. Analyze Data and Report
Post Combustion Carbon Capture Center (PC4)

Coal Combustor

- PSTU
  - 0.5 MWe
  - 10 tpd CO₂

- Bench Scale
  - < 0.1 MWe
  - < 2 tpd CO₂

- Pilot Test Area
  - 1 MWe
  - 20 tpd CO₂

Scrubber
PC4 Design and Construction

- Initiated site preparation
- Completed design
- Awarded bids - major equipment
- Began fabrication of PSTU
- Started negotiations with developers

- Completed site preparation and installation of the PSTU and utility bridge
- Developed quality control procedures and analytical methods
- Established PSTU commissioning team
PC4 Testing Completed

**PSTU**
- MEA baseline test
  - Commissioning, confirm design and validate data
- B&W
  - Advanced solvent, support modeling
- Hitachi
  - Advanced amine, preparation for pilot test
- Cansolv
  - Advanced polyamine in preparation for demonstration

**Pilot**
- Aker
  - Mobile test unit, test emission control system, advanced amine solvent, long-term operations

**Bench**
- Codexis
  - Enzyme module, encapsulation process
- MTR
  - Membrane, long term testing, generate critical data to use in scale-up
PC4 Recently Complete/Ongoing Tests

**PSTU**
- **Chiyoda**
  - Advanced amine to establish commercial design
- **Cansolv**
  - Advanced polyamine under simulated natural gas fired conditions
- **MEA**
  - Test modified demister, conduct reclaimer tests
- **Carbon Clean Solutions**
  - Advanced amine

**Pilot**
- **BASF/Linde**
  - Novel amine solvent based process
- **MTR**
  - Scale-up of membrane, long term operations

**Bench**
- **Akermin**
  - Modular unit utilizing carbonic anhydrase enzyme with potassium carbonate
- **MTR**
  - Membrane, long term testing, generate critical data to use in scale-up
- **SSTU**
  - Slipstream Solvent Test Unit, test innovative solvents
Power Systems Development Facility **Accomplishments**

- **Safety First** - No lost time accidents
- **Extensive operations experience** - 25,000 Hours of Operations
- **Learn-By-Doing** - Technology transfer relationship with over 50 vendors – **Informed Decision** on Technology Selection
- **Global Presence** - Visitors from over 100 countries

- **Technology Development**
  - Transport Gasifier, particulate filter, filter safe-guard, coal feed and ash removal, syngas cooler, syngas cleanup
  - Resulted in a **commercial product**
Gasification Technology

- Feed System Development
- Particulate Removal
- Ash Removal
- Fuel Flexibility
- Sensor Development
- Automation

Temperature (degF) vs. Time, hours
Operating History
Visual Comparison of Main Gasifier Types

(Not to Scale)

**GE**
- Oxygen blown
- Burner-type, slagging

**Conoco**
- Syngas

**Shell**
- Syngas

**Siemens**
- Air- or O₂-blown
- No-burner
- Non-slagging

**MHI**

**TRIG™**

Syngas
Gasification Process
Testing Completed/Ongoing

**Water Gas Shift Catalyst**
- evaluating the effects of temperature, pressure, steam-to-CO molar ratio, and space velocity.
- good mass balance

**High-temperature mercury sorbent**

**CO₂ capture solvent**
- advanced physical solvents
- confirm the CO₂ capture results with syngas
- evaluate the absorption and regeneration characteristics of H₂S

**Gas Separation Membranes**

**CO₂ capture sorbent**
- features 4 sorbent reactors
- novel sorbent is mesoporous carbon-based materials modified with surface functional groups
WGS Catalysts

\[ \text{CO} + \text{H}_2\text{O} \rightarrow \text{CO}_2 + \text{H}_2 \]

Results implemented at Kemper County TRIG™ Project

NETL News Release 05/09/2012

DOE-Sponsored IGCC Project Could Lead to Lower-Cost Carbon Capture Technologies

Successful Catalyst Tests Also Increase Power Production

Washington, DC — Changes in operating conditions coupled with changes in commercially manufactured catalysts can produce both power generation increases and significant cost savings at integrated gasification combined cycle (IGCC) power plants, according to new research from a U.S. Department of Energy (DOE)-sponsored project.

Results from the project at DOE’s National Carbon Capture Center (NCCC) could ultimately lead to lower-cost carbon capture technologies and help provide affordable, reliable, and clean energy from our nation’s domestic coal resources. Carbon capture, utilization and storage (CCUS) technologies are viewed by experts as an important solution in helping reduce atmospheric carbon dioxide (CO₂) emissions linked to potential global climate change.

Advanced power plants using IGCC technology convert coal into a syngas, or “synfuel,” which can then be combusted to produce electricity. The syngas contains combustible hydrogen and carbon monoxide (CO), along with water, nitrogen, and CO₂, a greenhouse gas.

To capture CO₂ and prevent its release into the atmosphere, the syngas is “shifted” in a chemical process called the water-gas shift (WGS) reaction. The reaction converts CO into CO₂ in the presence of a catalyst and steam and produces additional hydrogen for combustion. A large amount of steam ensures maximum conversion of CO and inhibits side reactions, but it also reduces the overall efficiency of the IGCC plant. The amount of steam is quantified by the steam-to-CO ratio of the gas fed to the WGS reactor.

Testing a variety of commercially available WGS catalysts, NCCC researchers were able to significantly reduce the steam-to-CO ratio while still achieving high CO conversion without side reactions. A reduction in the ratio translates into increased net power output and a smaller increase in the cost of electricity associated with carbon capture. Specifically, the 1.0 reduction in steam-to-CO ratio that was achieved corresponds to a 40-megawatt increase in power generation in a 600-megawatt IGCC plant. This could result in cost savings of more than $275 million over a plant’s estimated 50-year lifetime at current IGCC power costs of about $333 per megawatt-hour.

NCCC researchers are providing the test results to manufacturers to assist them in specifying future WGS systems for IGCC plants that incorporate carbon capture. The researchers are also planning further tests with other commercially available, newly formulated WGS catalysts. In addition, the findings are being implemented at a commercial IGCC plant now under construction in Kemper County, Miss. The plant will showcase a transport catalyst technology developed at the NCCC.

Located in Wilsonville, Ala., the NCCC is a state-of-the-art test facility dedicated to the advancement of clean coal technology. The Office of Fossil Energy’s National Energy Technology Laboratory, in cooperation with Southern Company Services, established the NCCC to bolster national efforts to develop cost-effective technologies to capture the CO₂ produced by coal-fired power plants and help secure the nation’s energy future.
National Carbon Capture Center

Project Partners

- U.S. Department of Energy
- NETL
- Southern Company
- Luminant
- Cloud Peak Energy
- ArchCoal
- EPRI
- AEP
- Duke Energy