National Carbon Capture Center: Pre-Combustion Activities

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NETL CO_2 Capture Technology Meeting
Pittsburgh, 9th to 12th July 2012

National Carbon Capture Center

- The NCCC gratefully acknowledges the support and encouragement of the DOE and all our co-sponsors.
- Special thanks to Mike Mosser, our NETL Project Manager.

NCCC Test Facilities in Wilsonville, Alabama

Power Systems Development Facility (PSDF) started combustion testing June 1996 and gasification Sept. 1999.

In May 2009 PSDF transitioned to the National Carbon Capture Center (NCCC).

Existing facilities used to support development of pre-combustion CO_2 capture.

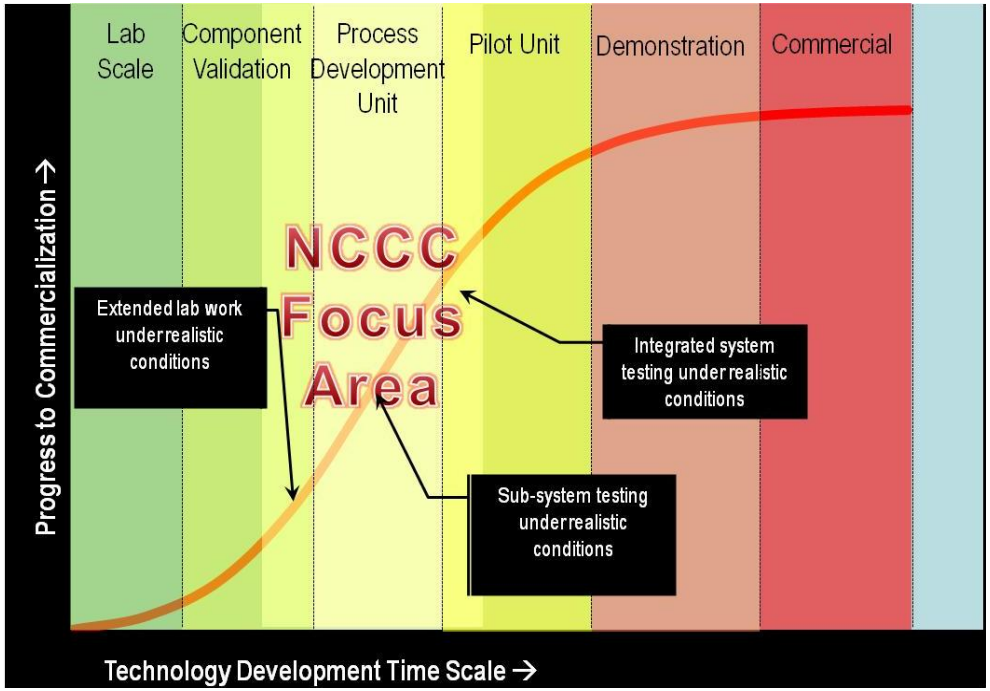
Additional facility, the Post-Combustion CO_2 Capture Center (PC4) built and started testing March 2011.

Located at adjacent power plant, Alabama Power's Plant Gaston.

Role of NCCC in CO_2 Capture Technology Development

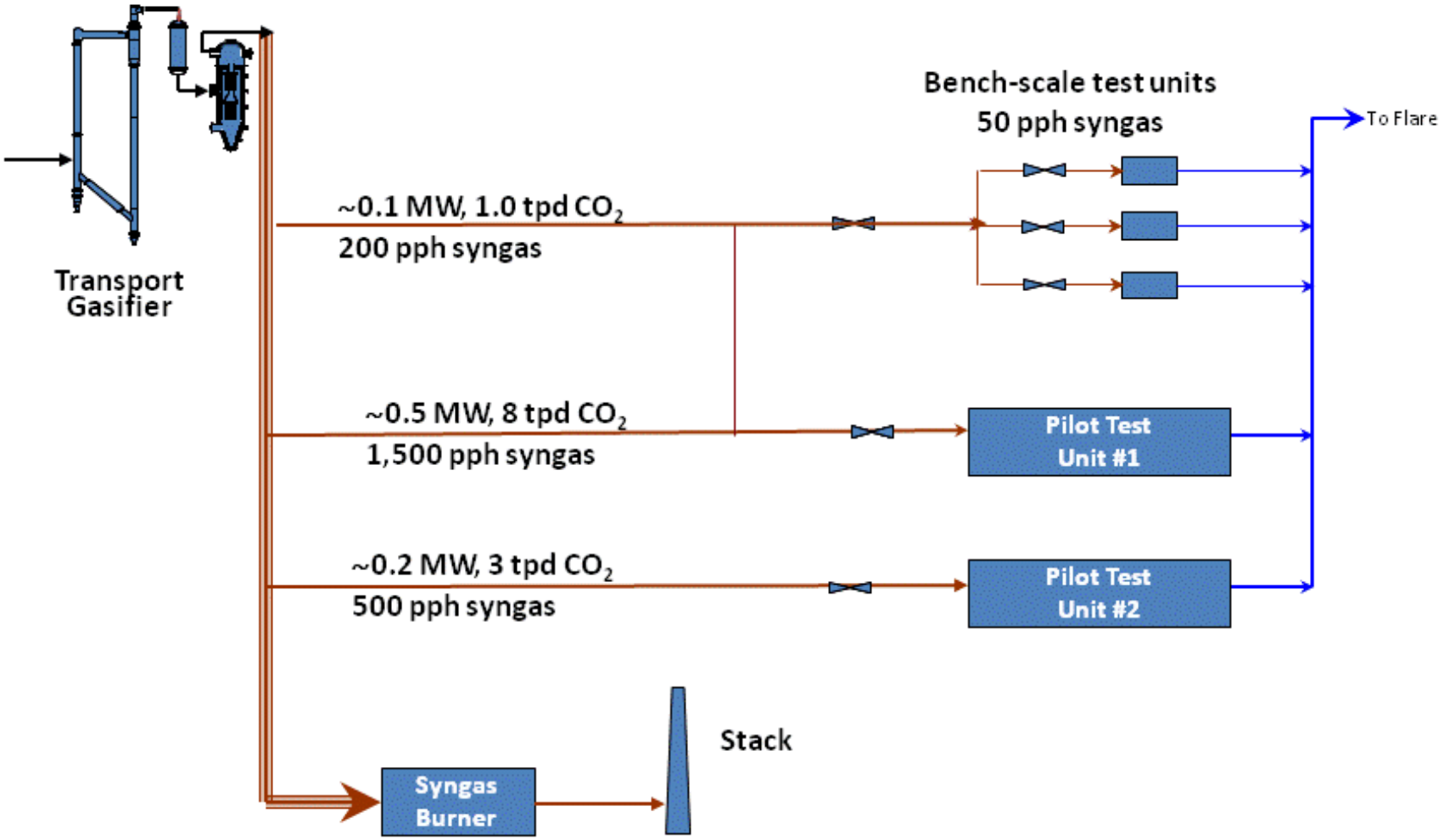
Provides first-class facilities to test developer's technologies for extended periods under commercially representative conditions with coal-derived flue gas and syngas. Simultaneous testing at a range of sizes helps accelerate development of cost-effective carbon capture technologies.

- Supports transition from laboratory to commercial environment.
- All necessary infrastructure to support testing of developer's technology.
- Experienced operators and maintenance staff.
- Comprehensive data collection and analysis capability.
- Access to advanced analytical techniques at SRI/UAB Birmingham.
- Flexible facilities allow for scale-up from bench- to engineering-scale.



Testing support to advance developer's technologies is our top priority

Syngas Cleanup Test Loop



Expansion to +5000 lb/hr of syngas possible if required

Pre-Combustion CO_2 Capture: Simultaneous Testing

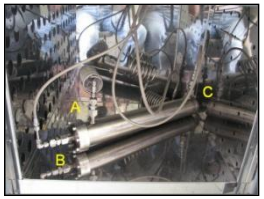
Water Gas Shift Catalyst

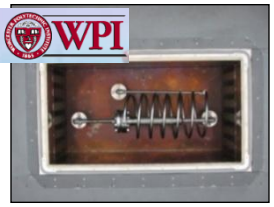
- Evaluating the effects of temperature, pressure, steam-to-CO molar ratio, and space velocity.
- Good mass balances

CO_2 Capture Solvents

- Advanced physical solvents
- Confirm the CO_2 capture results with syngas
- Evaluate the absorption and regeneration characteristics of H_2S

CO_2 and H_2 Gas Separation Membranes



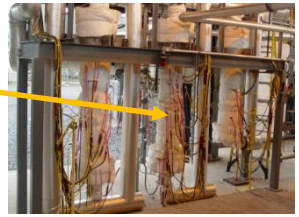


CO_2 Capture Sorbent

- Features 4 sorbent reactors
- Novel mesoporous carbon-based sorbent modified with surface functional groups

High-Temperature Mercury Sorbent

JM Johnson Matthey



Future Work

- Chemical looping pilot (800 lb/hr)
- CO_2 capture solvent pilot (300 lb/hr) with sulfur recovery
- CO_2 separation membrane (500 lb/hr)
- Additional CO_2 solvents

Able to provide raw and sweet syngas up to 200 psia and 450°F for up to 1000 hours

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Syngas Conditioned and Augmented for Different Applications

- Water gas shift catalysts and high-temperature mercury sorbents: raw syngas at 450 F.
- MPT carbon molecular sieve membrane: raw syngas at 450 F augmented with bottle hydrogen.
- TDA CO_2 sorbents sulfur-free syngas at 450 F.
- Worcester Polytechnic Institute palladium membrane: shifted, sulfur-free syngas at 1000 F augmented with bottle hydrogen.
- MTR polymeric CO_2 and hydrogen membranes: raw syngas at 100 F and ~250 F, respectively.
- Chemical and physical solvents: raw syngas at 100 F.
- Bottle gas blends of nitrogen, CO_2, and hydrogen supplied for off-line testing

Syngas can be conditioned to suit a developer's requirements

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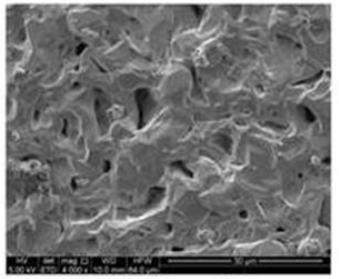
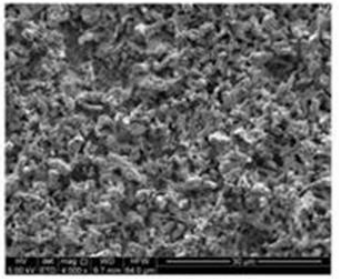
Exposing Membrane Materials to Syngas

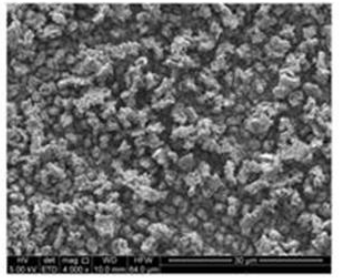
- On behalf of DOE, exposed multiple formulations of hydrogen membrane materials to determine how they react to “sour” syngas.
- Over 1000 hours exposure at 740°F and 228 psia.
- Post-run analysis by X-ray photoelectron spectroscopy, X-ray diffraction, scanning electron microscopy, energy dispersive microscopy, inductively-coupled plasma optical emission spectrometry, inductively coupled plasma mass spectrometry, and weight loss.
- Results indicate palladium can resist sulfidation when amalgamated with appropriate elements in correct proportions.
- Testing accelerated understanding and opened up new opportunities.



Palladium only



80-wt.% Pd with Cu

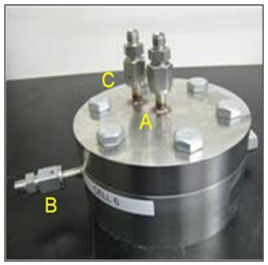


60-wt.% Pd with Cu

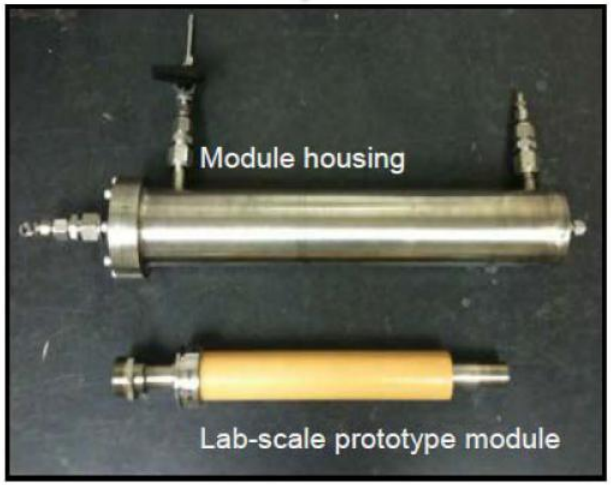
Ready to test other developer’s materials in similar manner

Scale-Up Support for MTR Syngas Membranes

Hydrogen membranes



Membrane stamp,1 lb/hr

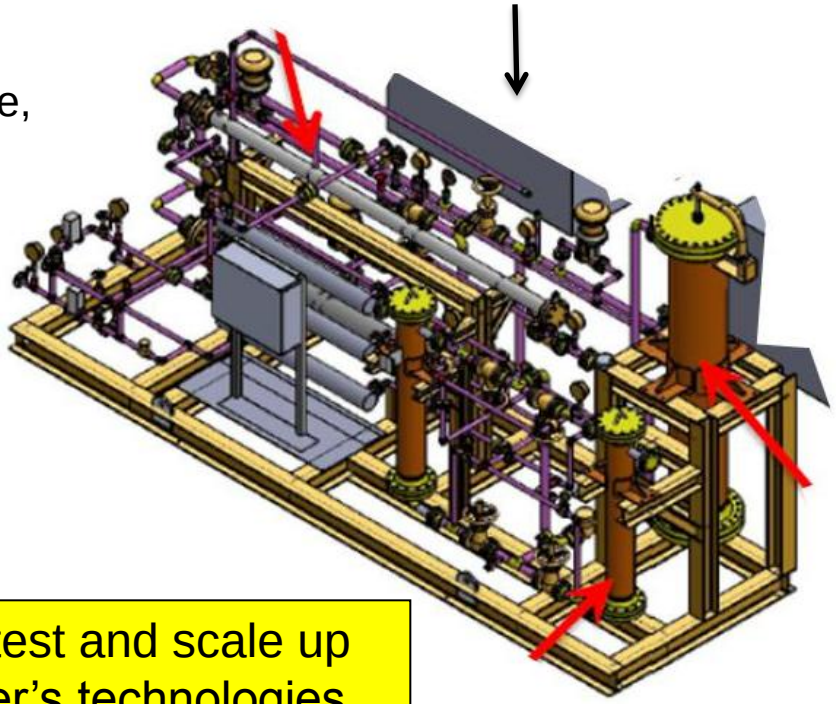


Lab-scale module, 10 lb/hr

CO_2 membranes

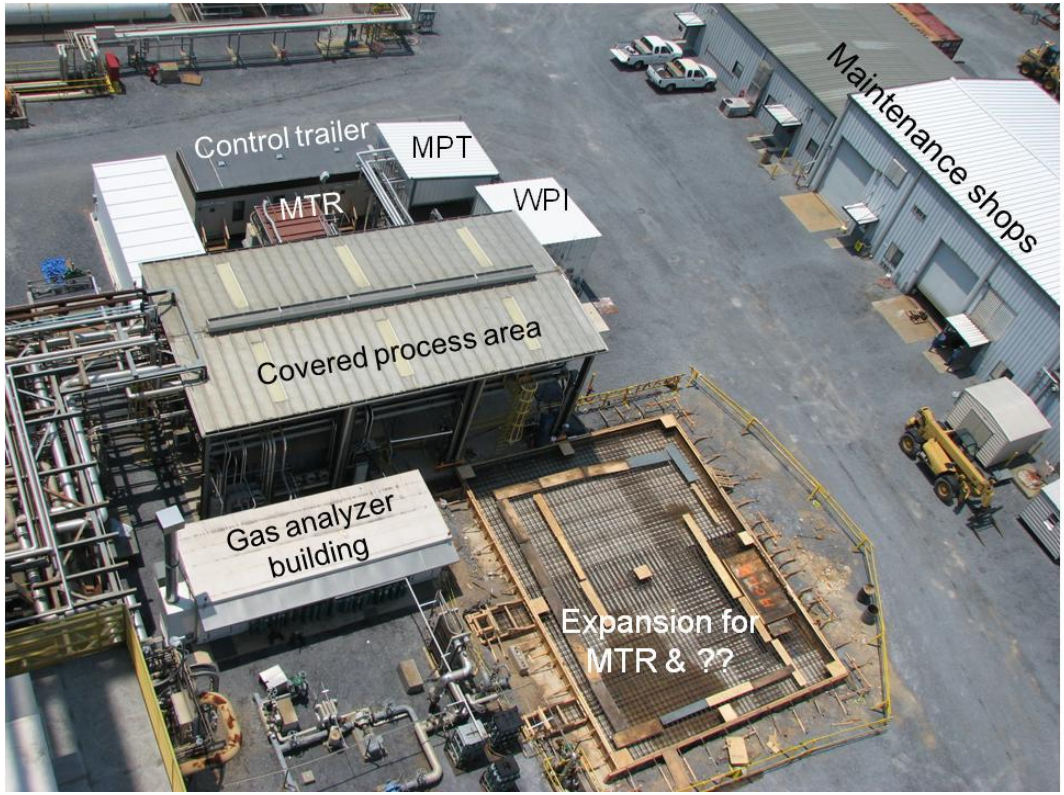
Small pilot module, 50 lb/hr

Pilot module, 500 lb/hr



We can test and scale up developer's technologies

Expansion of SCU Testing Capability



- New area will supply 500 lb/hr syngas to MTR's CO_2 separation membrane (late 2012) and 300 lb/hr to developer in negotiation (mid 2013).
- Ohio State's 800-lb/hr Chemical Looping Module to be located to left of photograph (early 2013).
- Contract discussions in progress with other technology suppliers and further test campaigns are expected.

- Covered area includes solvent, high-temperature mercury sorbent, and water gas shift catalyst test units.

Space and enthusiasm to support other developers

Engineering Support to Ensure Safe Operation

- Full compliance with National Electrical Code Class 1, Div 2 by removing possible sources of ignition and relocating combustible gas pipe runs and bottled gases (e.g. hydrogen)
  - Class 1, Div 2 instrumentation.
- Developer designs reviewed to ensure compatible with site requirements and applicable design and fabrication codes
  - Work with developers to determined services required and then implement any site upgrades needed to supply them.
  - Support developer's design hazard review process.

Closing Comments

- The NCCC is able to test multiple pre-combustion technologies simultaneously over a range of syngas flow rates
  - This flexibility accelerates technology development.
- Testing developer's technologies is NCCC's top priority
  - Support provided at design stage and during operation (with operators and mechanical, electrical, and I&C services) to ensure reliable accurate data are collected, efficiently and safely, and allow the next stage of development to be planned successfully.
- Testing capabilities are being expanded to accommodate more developers and test additional technologies.
- If you believe we can help you be successful, please contact:

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