Post-Combustion Testing

2104 NETL CO₂ Capture Technology Meeting
July 29 to August 1
Performance Period for DE-FE0022596: 5/01/2014 to 04/30/2019
DOE funding $150M with $38M industrial cost share
DOE Project Manager Mike Mosser
Role of NCCC in CO$_2$ Capture Technology Development

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 to accelerate development of cost-effective technologies.

- Supports transition from lab to commercial environment.
- Full support for testing of developer’s technology.
- Experienced operators and maintenance staff.
- Comprehensive data collection and analysis capability.
- Local access to advanced analytical techniques.
- Flexible facilities for scale-up from bench- to pilot-scale.

Testing support to advance developer’s technologies is top priority.
Located in Wilsonville AL, 30 miles S-E of Birmingham.

- Gasification and pre-combustion CO₂ capture testing carried out at Power Systems Development Facility: in service since 1996.
- Post-combustion CO₂ capture testing carried out at Post-Combustion Carbon Capture Center (PC4) located at Alabama Power’s Plant Gaston: in service since 2011.
- Base-loaded, 900-MW supercritical unit with SCR and wet FGD firing medium-sulfur bituminous coal providing a commercially representative flue gas slipstream to PC4.
Infrastructure recently expanded to meet demand for testing
Pilot-Scale Test Bays at PC4

Current Occupants
1. 0.5-MW PSTU (solvent)
2. 1.0-MW Linde (solvent)
3. 1.0-MW MTR (membrane)

Once testing complete, other developers accommodated

Each Bay complete with foundations, services, and gas connections to accept future technologies with limited modification.
Bench-Scale Test Bays at PC4

Current occupants
1. Akermin (solvent); to be modified for testing first half 2015 with new solvent.
2. MTR (membrane). Near end of program; provided valuable data to support design of 1-MW unit.
3. SRI International (sorbent): in progress
4. DOE (sorbent): in progress
5. Slipstream Test Unit (SSTU) (solvent): being completed ready for testing first half 2015.

Once testing complete, other developers accommodated

For PC4 test bays, in typical three-month period flue gas available for 1750 hours, allowing a lot of data to be collected in short period of time.
Progression Along Technology Time Line

Lab Scale | Component Validation | Process Development Unit | Large Pilot | Demonstration | Commercial
--- | --- | --- | --- | --- | ---

Enzymes
Membranes
Sorbents
Solvents
Solvent & membrane

PSTU
Example of Scale-Up Support Provided by NCCC

Data collected and lessons learned on MTR’s 500 lb/hr flue gas bench-scale membrane used to support design and equipment selections of 10,000 lb/hr pilot-scale membrane.
Solvents from six developers, plus MEA, tested some with diluted coal-derived flue gas to mimic NGCC flue gas
- High quality data collected with mass balance closures better than ±3 percent
- Monoethanolamine (MEA) heat of regeneration with 7°F approach temperature ~1550 Btu/lb
- Solvent tested with heat of regeneration as low as ~900 Btu/lb, 40 percent lower.
- Lower values possible with improved heat integration (CCSI modeling)
- Close to achieving Clean Coal Research Program 2020-2025 objective of lowering cost of CO₂ capture to $40/tonne.

MEA data supporting DOE’s CO₂ Capture Simulation Initiative (CCSI) modeling activity
- Investigation of performance aspects of value to end users: solvent emissions, ash accumulation, instrumentation testing.
Wide Range of Data Collected

- PSTU can gather solvent density, viscosity, and specific heat data for a range of CO$_2$ loadings to validate and/or expand physical property database.

- Coupons installed throughout the PSTU to assess how corrosion rates of different materials vary with location.

Operation with intercoolers raised capture efficiency 6 percentage points (90 to 96%)
Issues Revealed by PC4 Testing

- MEA emissions from the PSTU as high as 500 ppmv (5.7 lb/hr)
  - Emissions predicted to be less than 3 ppmv
  - SO$_3$ aerosol present in flue gas leaving Gaston FGD responsible
  - All amine solvents had similar experience but not potassium carbonate
  - Increases solvent make up rate, may infringe emission limits
  - Cost effective approaches to reduce amine emissions from absorber required.

- Although flue gas low in metals content, they accumulate in solvent
  - Selenium exceeds RCRA limit: rate of accumulation will be reduced for plants meeting new Mercury and Air Toxics Standards
  - Anions (sulfate, nitrate, and chloride) also present in addition to solvent degradation products (e.g. aldehydes and ammonia)
  - Economic cleanup for optimal solvent and plant performance required.

- SO$_3$ (present as ammonium sulfate/bisulfite) resulted in deposits forming in outlet of 0.05-MW MTR flue gas compressor.
  - Resulted in changes to 1-MW membrane design

Results emphasize benefits of testing with commercially representative flue gases
### Tests Completed or Planned at PC4 Pilot Bays

<table>
<thead>
<tr>
<th>PSTU</th>
<th>Pilot Bays 2 &amp; 3</th>
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<tbody>
<tr>
<td><strong>Completed or in progress</strong></td>
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<tr>
<td>MEA Baseline</td>
<td>Aker Clean Carbon</td>
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<tr>
<td>Babcock &amp; Wilcox Opticap</td>
<td>Linde solvent (*)</td>
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<td>MEA solvent carry over</td>
<td>MTR membrane (*)</td>
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<td>Hitachi H3-1</td>
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<td>Cansolv 201 (12% CO₂)</td>
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<td>Chiyoda T-3</td>
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<tr>
<td>Cansolv 201 (4% CO₂)</td>
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<tr>
<td>Clean Carbon Solutions</td>
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<tr>
<td>Cansolv 103</td>
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<tr>
<td><strong>Planned (not necessarily confirmed)</strong></td>
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<tr>
<td>Univ. Texas Austin (*)</td>
<td>Air Liquide membrane (*)</td>
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<tr>
<td>MEA Sampling Techniques</td>
<td>SRI sorbent (*)</td>
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<td>GE Global Research (*)</td>
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(*) presenting at this meeting
## Tests Completed or Planned at PC4 Bench-Scale Bays

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<thead>
<tr>
<th>Completed or in progress</th>
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<tr>
<td>Codexis enzyme</td>
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<tr>
<td>MTR membrane (*)</td>
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<td>Akermin enzyme (*)</td>
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<td>SRI sorbent (*)</td>
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<td>NETL sorbent (*)</td>
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<tr>
<td>Carbon Capture Scientific (*)</td>
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<td>Sustainable Energy Solutions</td>
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<tr>
<td>Akermin Advanced Process (*)</td>
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<td>TDA Research sorbent (*)</td>
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<td>SSTU for novel solvents</td>
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Closing Comments

• 17 test campaigns completed or in progress at PC4 with over 24,000 data collection hours using 50 to 10,000 lb/hr of flue gas
  – In service just over three years: cost-effective testing and data collection
  – Supporting scale up from bench- to pilot-scale, advancing technologies along the developmental time line
  – Several other developers are scheduled to test their technologies.

• An advanced solvent has been tested on the PSTU with a regeneration energy 40% lower than that of 30-wt% MEA
  – Close to achieving Clean Coal Research Program 2020-2025 objective of lowering cost of CO₂ capture to $40/tonne.

• Need to continue identifying improved technologies that lower the cost of CO₂ capture and satisfy Clean Coal Research Program 2030-2035 objectives
  – NCCC will continue to support developers in advancing commercialization of their technologies in pursuit of this goal.