Advanced Technology Testing at the National Carbon Capture Center

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U.S. DEPARTMENT OF ENERGY

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NATIONAL CARBON CAPTURE CENTER

Project Facts

- Located in Wilsonville, Alabama
- Sponsored by the U.S. Department of Energy and its National Energy Technology Laboratory
- Partners include the Electric Power Research Institute and leaders in the power and coal industries

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EPRI ELECTRIC POWER RESEARCH INSTITUTE

AEP AMERICAN® ELECTRIC POWER

SOUTHERN COMPANY

CLOUD PEAK ENERGY®

DUKE ENERGY®

Luminant

Mission and Core Values

Offering a **world-class neutral** test facility and a highly specialized staff, to **accelerate the commercialization** of advanced technologies and enable coal based power plants to achieve **near-zero emissions (low cost CO_2)**.

Unquestionable Trust

Superior Performance

Total Commitment

Safety

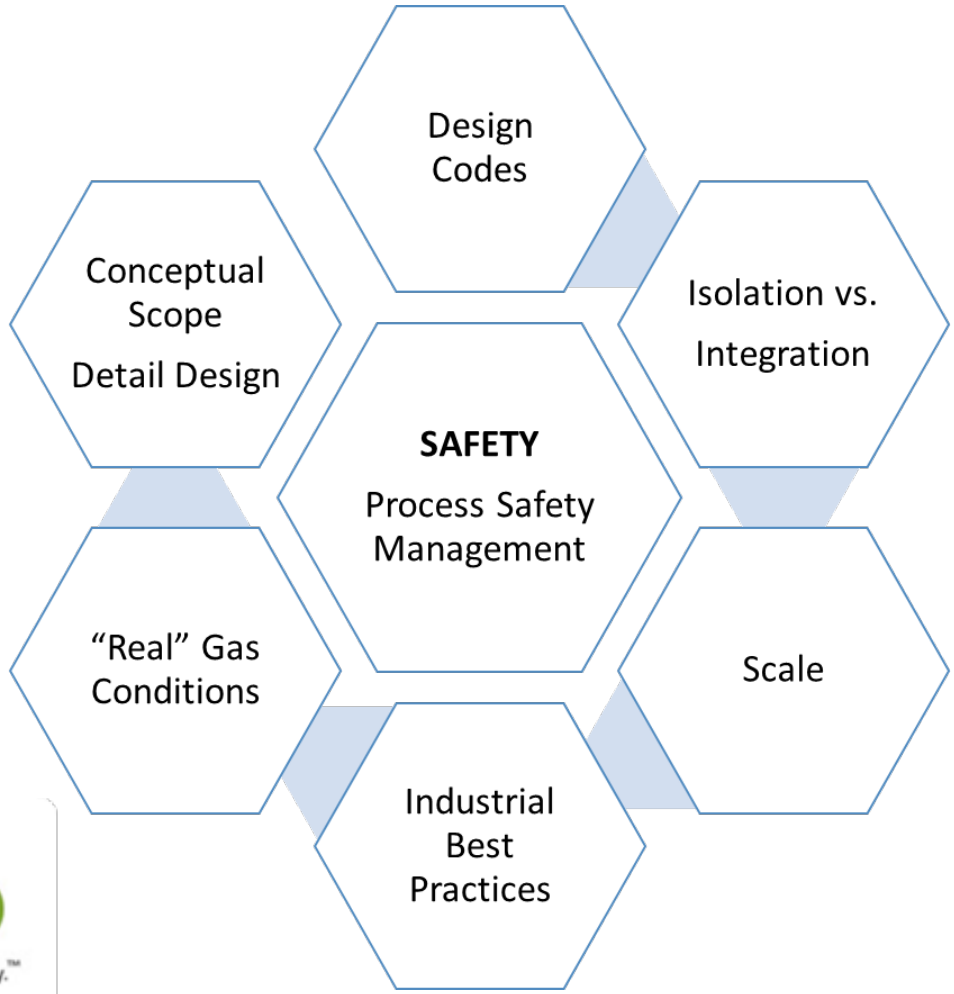
Focus Areas

- Hazard Recognition
- Site Awareness/Drills for Emergency Response
- Near Miss Reporting
- Housekeeping

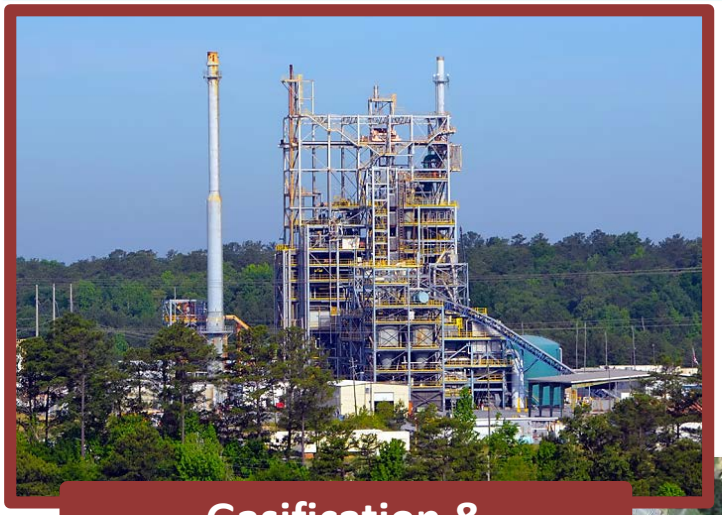
Site Programs

- Safety Task Force
- Eyes on Safety
- Target Zero

target ZERO
Every day, every job, safely.™



Test Sites



Gasification & Pre-Combustion Carbon Capture

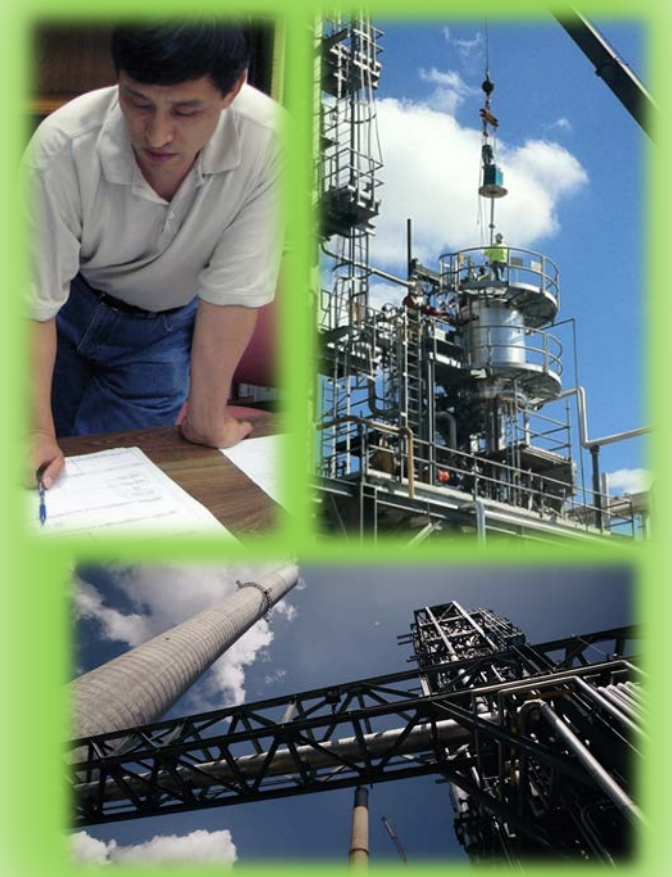
Post-Combustion Carbon Capture Center

Accomplishments

- 20 years with no lost time accidents
- 91,000 test hours for technology developers from U.S. and six other countries since 2008 founding of NCCC
- First coal-derived gas testing of solid oxide fuel cells and certain solvents, membranes, enzymes, etc.
- On-site scale-ups and process enhancements for ten technologies; scale-ups for testing at larger sites for five solvents; scale-up to commercial operation for one solvent
- Full compliance with environmental and government regulations, including on-time submittal and publication of technical reports

What NCCC Provides

- A cost-efficient test site for numerous technology developers
- Real industrial conditions with coal-derived flue gas and syngas
- Capability for testing at multiple scales and for on-site scale-ups
- Expert staff for support of design, installation, and testing
- High quality data acquisition and gas/liquid sampling and analysis



Technology Development Process


THE NATIONAL CARBON CAPTURE CENTER
AT THE POWER SYSTEMS DEVELOPMENT FACILITY

TOPICAL REPORT

BUDGET PERIOD TWO
DECEMBER 1, 2009 – DECEMBER 31, 2010

DOE Cooperative Agreement
DE-NT0000749

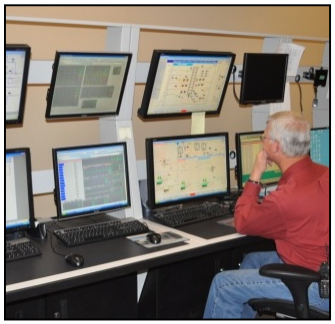
Evaluate and Screen Technologies

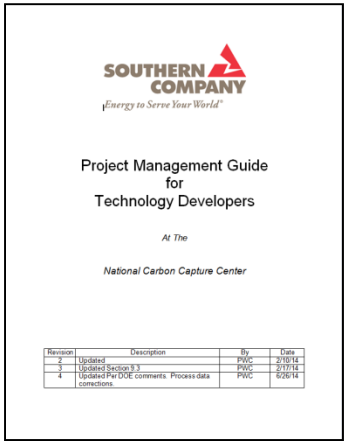
Define Scope of Work with Technology Developer

Design and Construct

Operate according to Test Matrix

Analyze Data and Report

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Energy to Serve Your World

Project Management Guide
for
Technology Developers

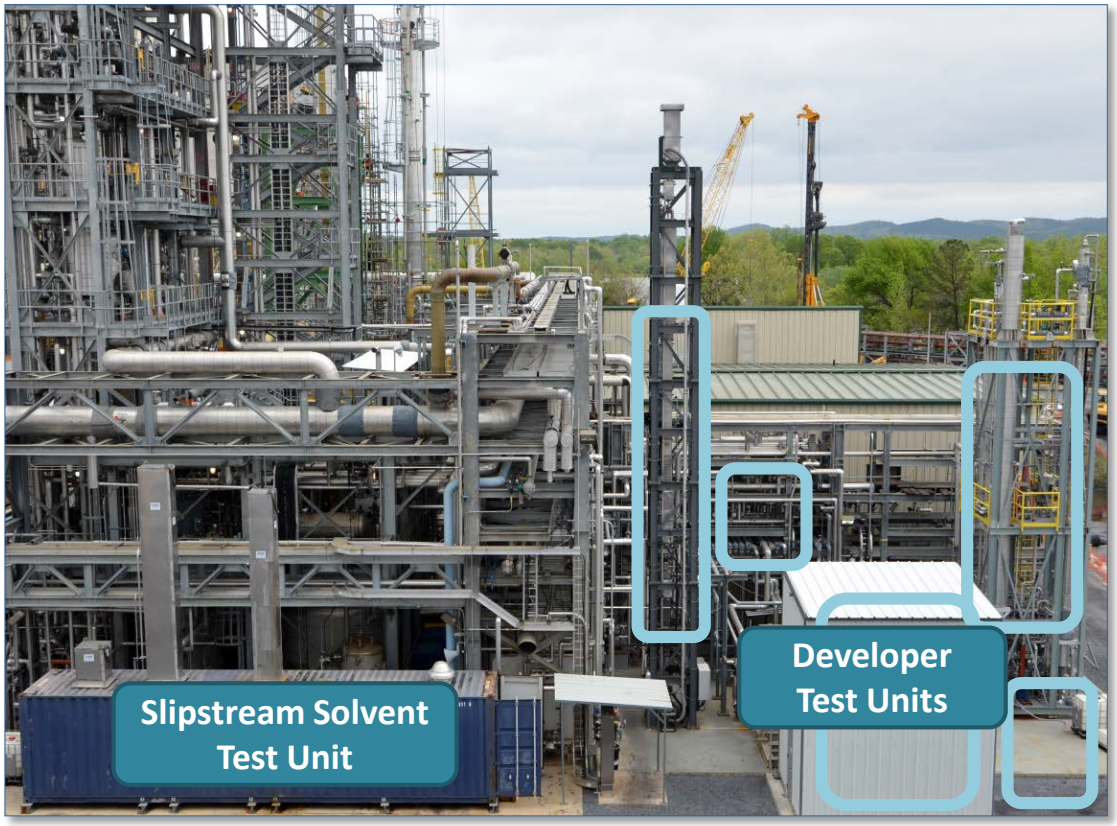
At The

National Carbon Capture Center

Revision	Description	By	Date
2	Updated	PWC	2/10/14
3	Updated Section 9.3	PWC	2/17/14
4	Updated Per DOE comments. Process data corrections	PWC	6/26/14

PC4 Bench-Scale

- Simultaneous operation of up to five developers' test units
- Slipstream Solvent Test Unit (SSTU) for solvents in early development
- SSTU also used for solvent emissions studies and emission mitigation processes
- Flue gas/utilities and gas analysis systems operating independently of PC4 pilot-scale area



PC4 Pilot-Scale

- Simultaneous operation of developer test units and Pilot Solvent Test Unit (PSTU)
- PSTU offers flexible operation to match developers' planned commercial configuration
- PSTU also supports solvent emissions and degradation studies

Post-Combustion Accomplishments

- PC4 operation supported over 41,500 hours of technology testing
  - Over 6,000 hours under natural gas conditions
  - More than 20 developer projects completed
  - Tested enzymes, membranes, sorbents, solvents, and associated systems
  - Continued relationship with technology developers to achieve scale-ups and process enhancements
- PSTU operation for more than 13,000 hours
  - Demonstrated near 100% mass and energy balance closures
  - Supported commercial developers and DOE Carbon Capture Simulation Initiative
  - Several solvents progressed to further testing at other facilities
- Facility construction and upgrades
  - PC4 constructed in under three years
  - Plant capacity more than doubled from 12,000 to 30,000 lb/hr flue gas
  - Added systems (SSTU, air dilution, etc.) and enhanced instrumentation, sampling methods, and analysis systems

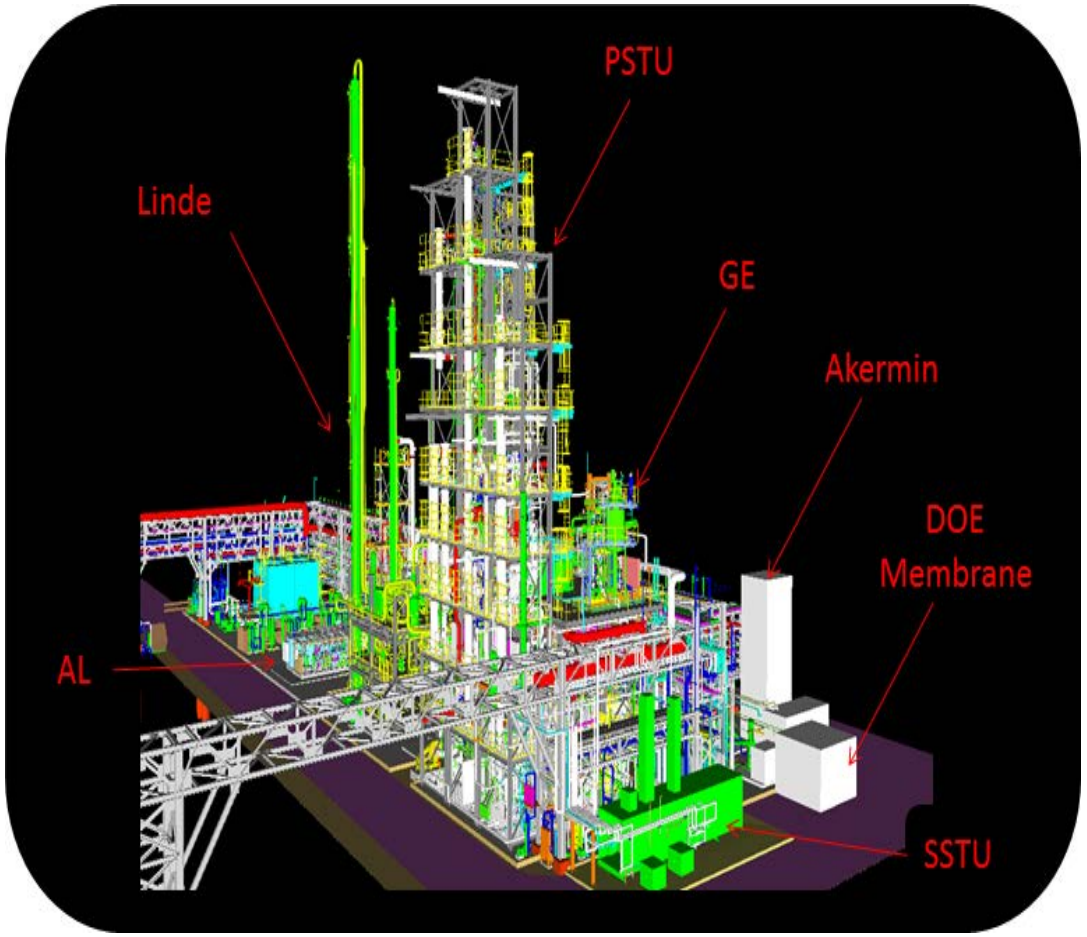
Current Post Combustion Tests

Pilot-scale

- GE w/ PSTU
- Linde/BASF @PB2
- Air Liquide @PB3

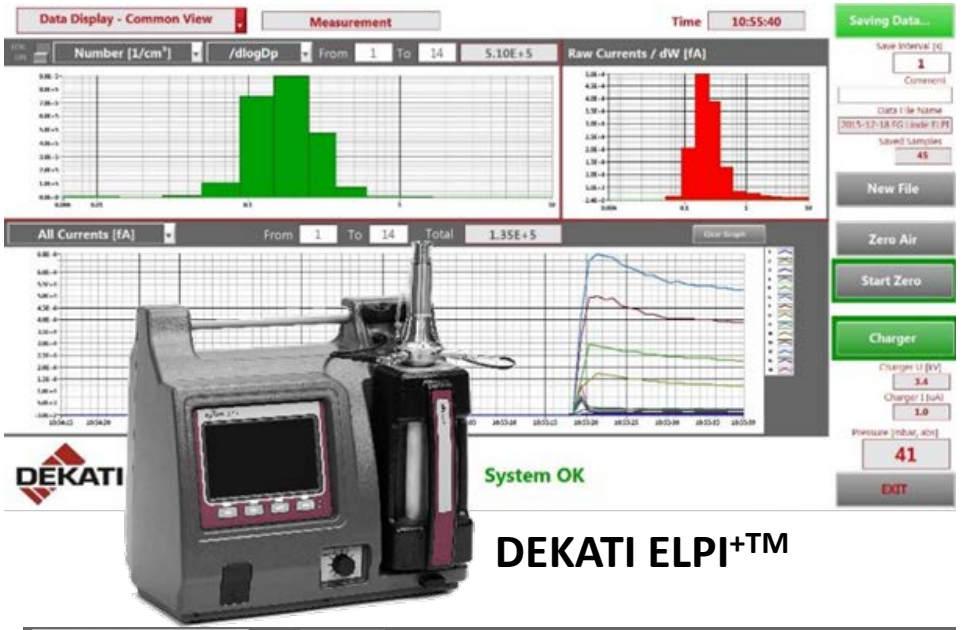
Bench-scale

- DOE Membrane
- Akermin (PH2)
- SSTU
  - Baseline/emission
  - Green Technology: additive to amine
  - Cansolv

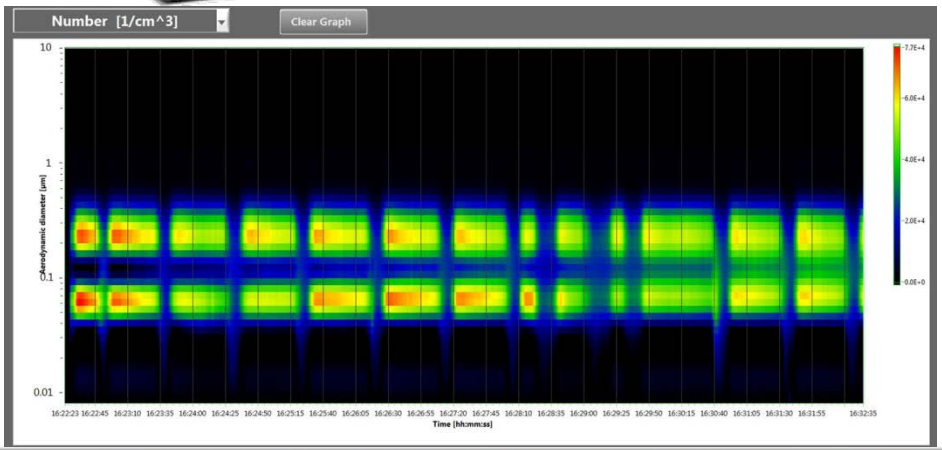


Aerosol/Emissions Testing

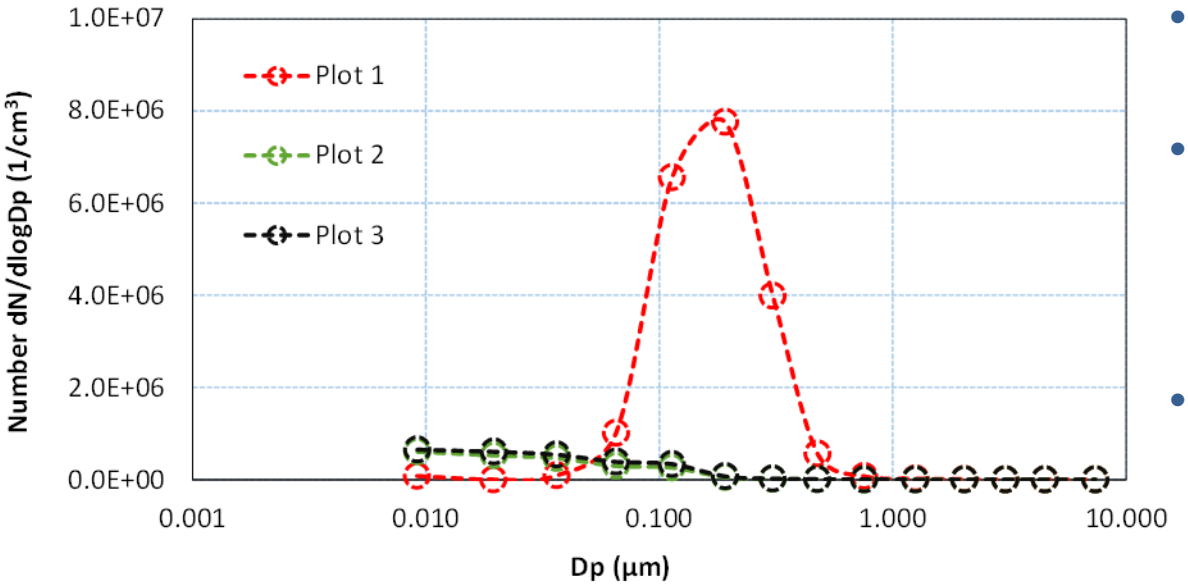
- Post-baghouse installation effects on flue gas properties underway.
- Effect on amine emissions from capture units being quantified.
- Use Electric Low Pressure Impactor (ELPI^{+TM}) to measure particle size distribution and count in real time.



DEKATI ELPI^{+TM}



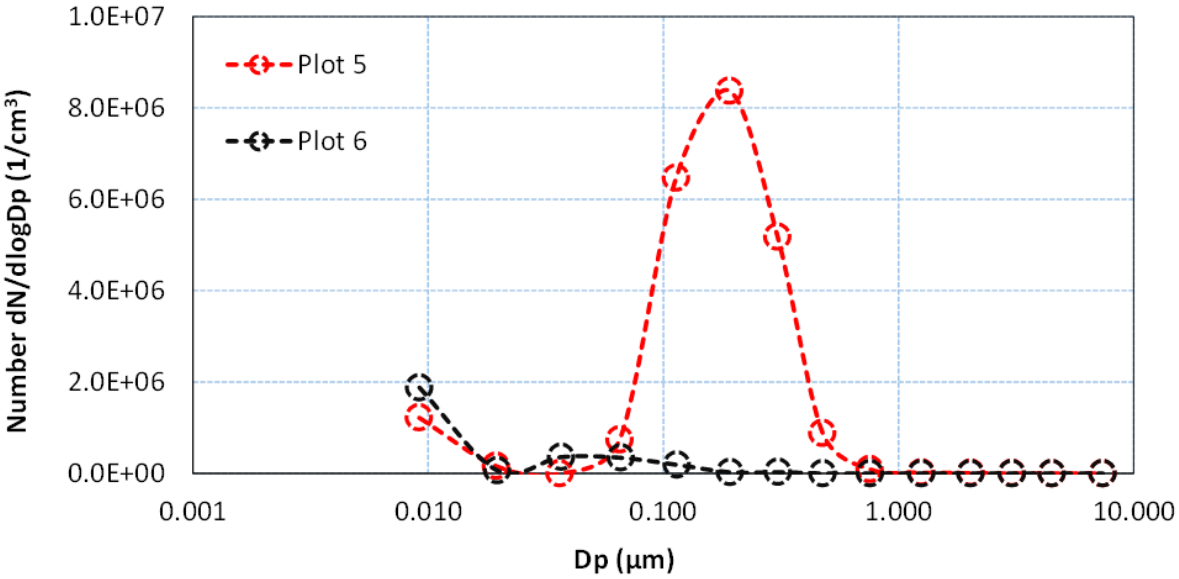
Aerosol Test Results



- Aerosol number dropped significantly after the bag-house installation
- Low dilution temperature has very minimal effect on aerosol number concentration measured after the bag house installation
- More than 97% of cumulative aerosol number is below 0.1µm after the bag house installation

- E.C. Gaston power plant operating at low load
- Aerosol number concentration plotted before (Plot 1) and after (Plot 2 & 3) the E.C Gaston bag house installation
- Plot 1: Relatively high 150°F of Dilution Temperature as tests done in December, 2015
- Plot 2 and 3: 150°F and 110°F Dilution Temperatures respectively, tests done in June 2016

Aerosol Test Results

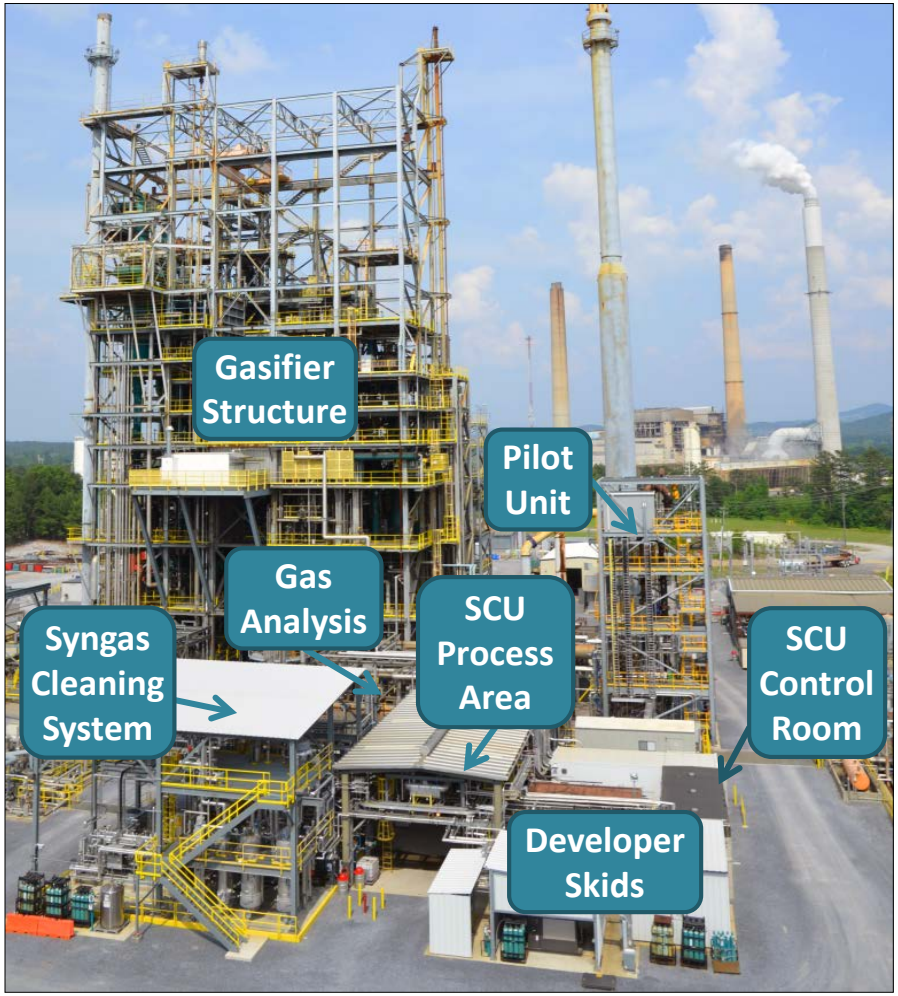


- E.C. Gaston power plant operating at relatively high load
- Aerosol number concentration plotted before (Plot 5) and after (Plot 6) the E.C Gaston bag house installation
- Aerosol number dropped significantly after the bag-house installation

- Aerosols in the size of around 0.01µm can be observed when the load increased
- More than 98% of cumulative aerosol number is below 0.10µm after the bag house installation
- Further tests are on-going to investigate the effect of bag house installation on aerosol numbers

Pre-Combustion/Gasification Infrastructure

- Coal-derived syngas from the Transport Gasifier train, in operation since 1996
- Operations conducted for nominally three 750-hour runs per year
- Syngas Conditioning Unit (SCU) with slipstreams at 5 to 500 lb/hr and syngas pre-treatments and process conditions tailored for each developer's needs
- Pilot unit for operation at 1,000 lb/hr
- State-of-the-art gas analysis and data acquisition
- On-site labs for sample analysis and processing



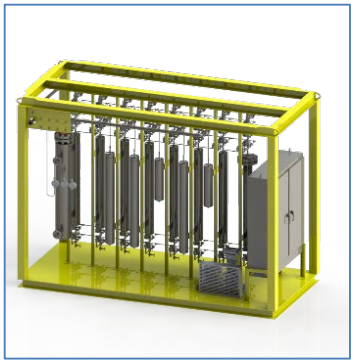
Gasification & Pre-Combustion Accomplishments

- Gasifier operation supported over 47,000 hours of technology testing
  - Biomass gasification in air- and oxygen-blown operation
  - Sensors: Tunable Diode Laser, particulate monitor, thermowells, coal feeder instrumentation
  - Catalysts: Fischer-Tropsch, water-gas shift, and COS hydrolysis
  - Sorbents: trace metals, CO_2, ammonia
  - Membranes: hydrogen and CO_2
  - Advanced processes: ammonium carbonate/bicarbonate solvent, syngas chemical looping, pressure-swing adsorption, pressure-swing Claus
  - Fuel cells
- Additional operation with CO_2 solvents, both on-line and off-line
- Achieved scale-ups and process intensification for several technologies including membranes, catalysts, sorbents
- Major upgrades to infrastructure such as new SCU control room and gas analysis building

G3/G4 Test Campaign Summary

- 1,457 hours of gasifier operation
  - 581 hours on PRB coal, 876 hours on lignite coal
- 9,990 technology developer testing hours

Developer	Technology	Hours
The Ohio State University	Chemical Looping	120
SRI International	Solvent	400
MTR Membrane Technology & Research	Hydrogen Membrane	1,100
Media and Process Technology	Hydrogen Membrane	406
TDA Research	CO2 Sorbent with Integrated WGS	650
Emerson	Temperature Sensors	1,900
PCME	Particulate Monitoring Sensor	1,900
Johnson Matthey	Mercury Sorbent	1,167
Carbon Clean Solutions	Solvent	40
WGS & COS Developer	WGS	1,081
	COS	1,233

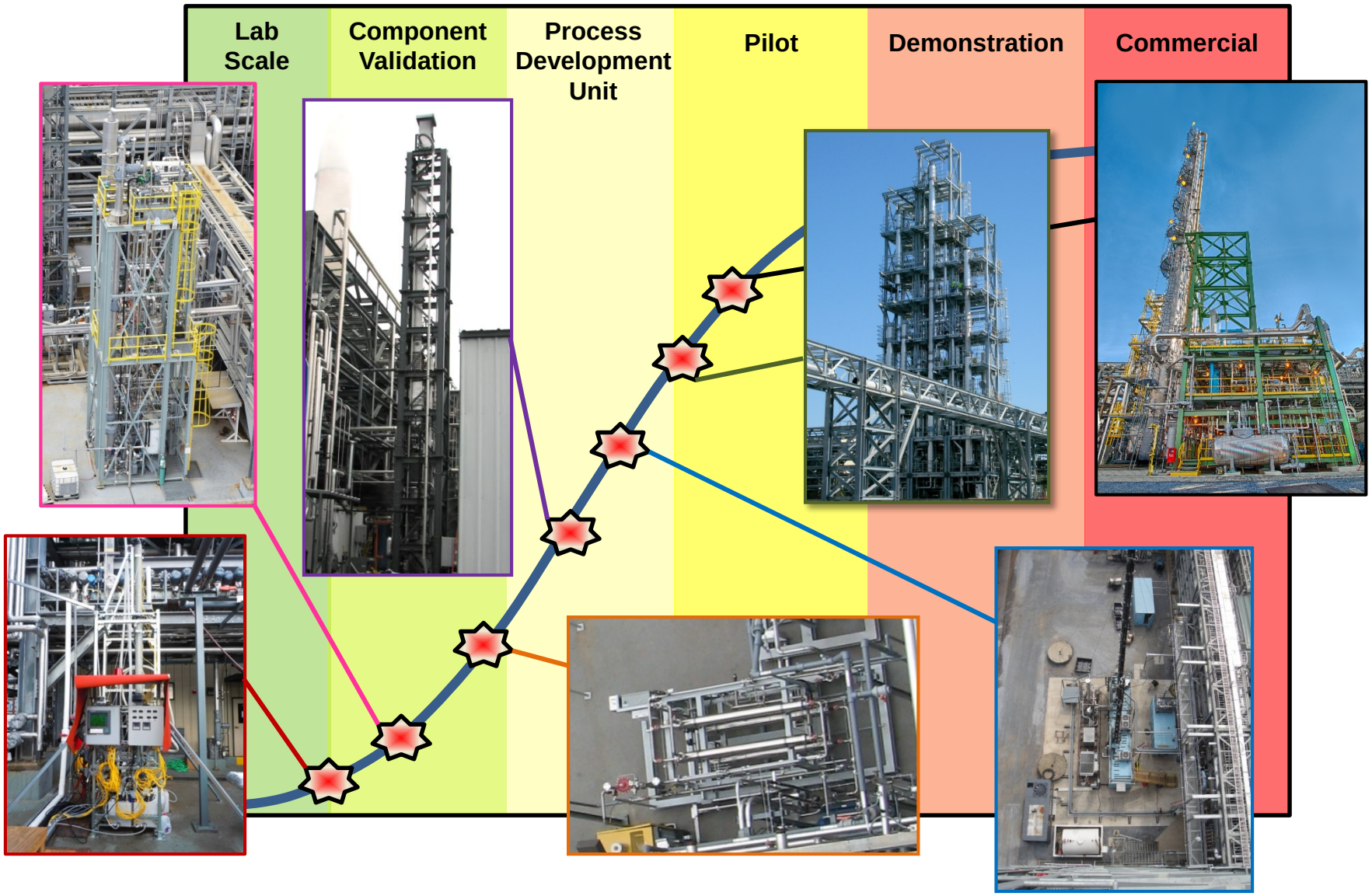


G5 Test Campaign

- 750 hours
  - PRB coal operation

Developer	**Technology**
The Ohio State University	Chemical Looping
MTR Membrane Technology & Research	Hydrogen Membranes
Media and Process Technology	Hydrogen Membrane
SR Southern Research	Coal-To-Liquids
	Syngas Reformer
SRI International	PBI Membrane
TDA Research	CO2 Sorbent with Integrated WGS
	0.1 MWe Sorbent System
JM Johnson Matthey	Mercury Sorbent
Emerson	Temperature Sensors
	3D Level Measurement
WGS & COS Developer	WGS
	COS

Successful Testing and Partnerships



National Carbon Capture Center

International Test Center Network

Share CO_2 Capture Knowledge

to encourage global collaboration and accelerate technology development of cost effective CO_2 capture processes

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