NETL-RUA
Regional University Alliance

NETL-Regional University Alliance: A Success in 2012

Cynthia A. Powell
Director, NETL Office of Research & Development
Member, NETL-RUA Executive Committee

NETL Carnegie Mellon PENNSTATE University of Pittsburgh VirginiaTech WestVirginiaUniversity URS

Motivation for the NETL-RUA

- Build an R&D partnership with the combined capability and expertise to be a force in the discovery, development, and deployment of next-generation (energy) technologies.
- Discover and Develop the technology that will launch the next Energy Economy.
- Educate the next generation of energy leaders for the Region and the Nation.

Slide from Powell Presentation at NETL-RUA's First Spring Meeting; March, 2011

NETL-RUA

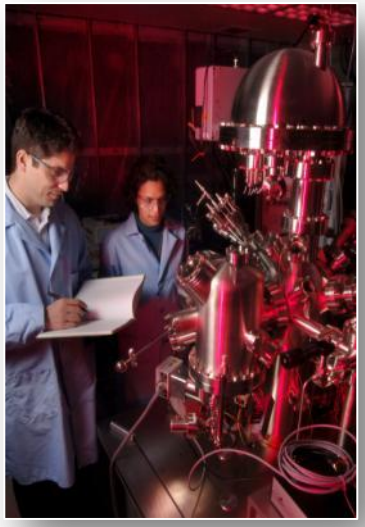
Philosophy behind the NETL-RUA

Partnership and collaboration to create and enable the right Research Teams to do the right research that effectively meets emerging National need for science and technology.

NETL-RUA
Regional University Alliance

Carnegie Mellon

URS



Shared Resources

Shared Intellect

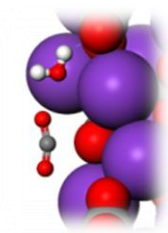
Technology Innovation

NETL-RUA

Slide from Powell Presentation at NETL-RUA's Spring Meeting; March, 2011

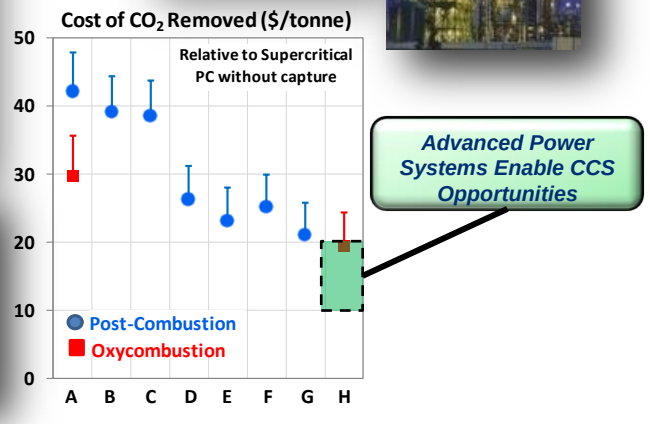
Primary Research Focus: Making Fossil Energy an Affordable, Sustainable Domestic Resource

- **Reducing Environmental Impact of Coal Utilization**
  - Increased Efficiencies
  - Affordable Carbon Capture
  - CO_2 Utilization
  - CO_2 Storage with 99% Permanence
- **Unconventional Fossil Fuel Resources**
  - Shale Gas
  - Ultra-deep Resources
  - Methane Hydrates







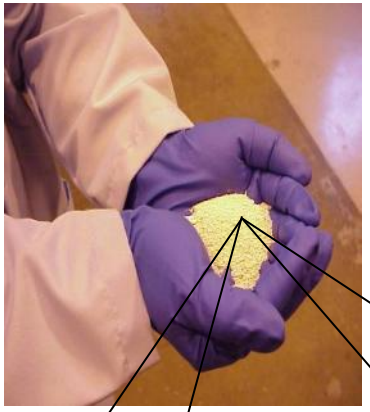



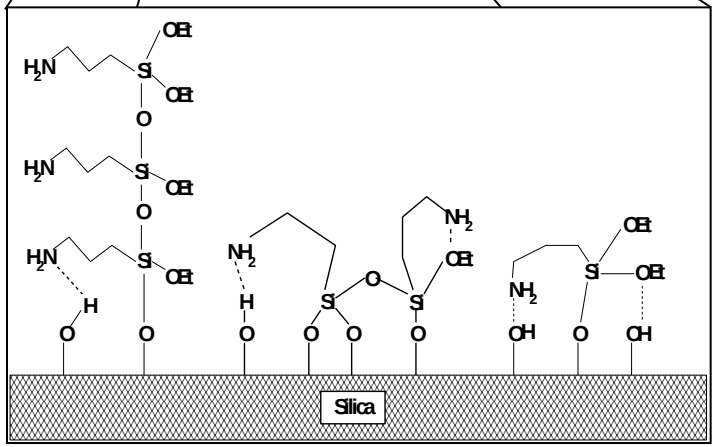
2012

NETL-RUA SUCCESS STORIES

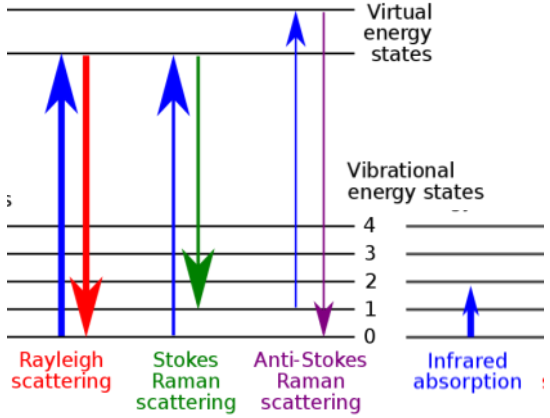
Developed sorbents for a new approach to carbon capture in flue gas.

BIAS Supported Amine Sorbents





Characterization



John Kitchin, CMU

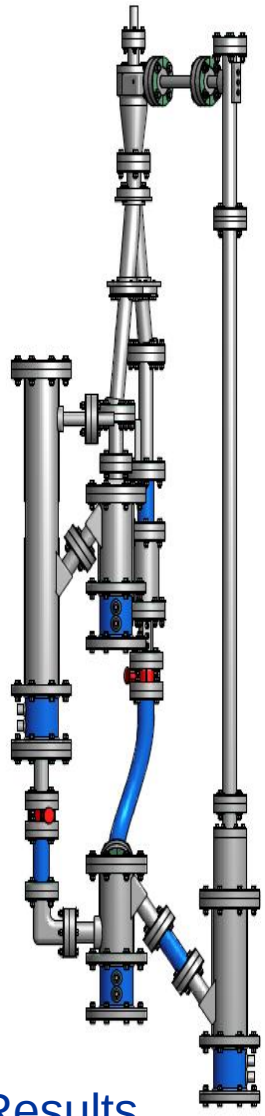
Angela Goodman, DOE

Damodaran Krishnan, Pitt

Scale-up

Larry Shadle, DOE

Scott Chen, CCS



McMahan Gray, DOE

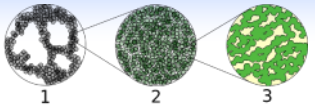
Bingyun Li, WVU

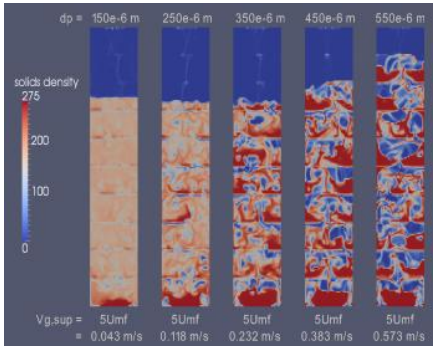
Validation Results Generated for CCSI

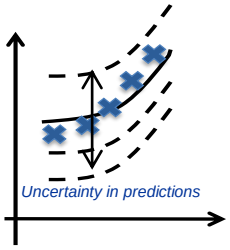
CCSI
Carbon Capture Simulation Initiative

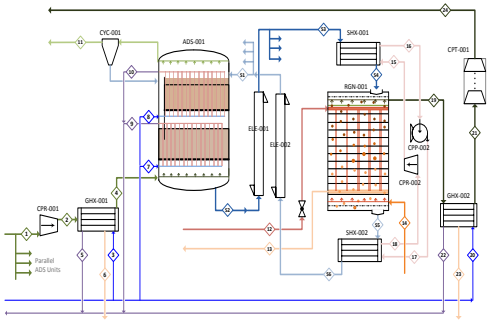
Deploys Initial Toolset

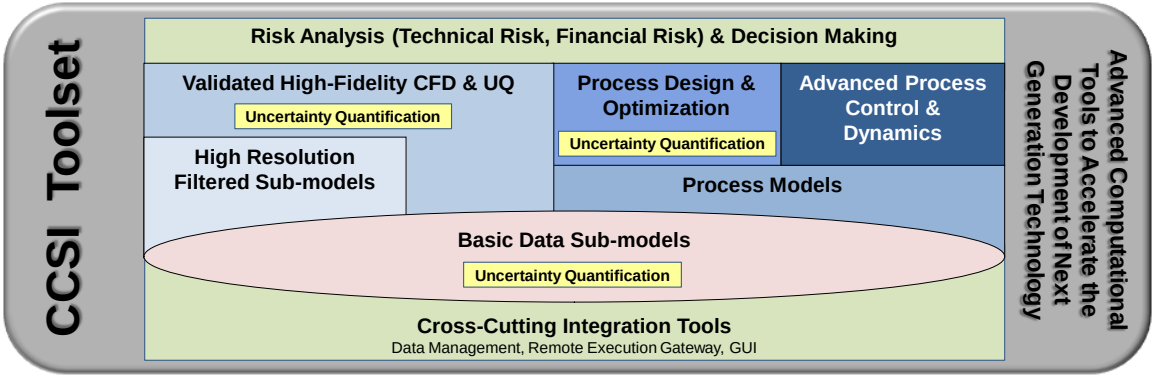
- **Will accelerate CO_2 capture technology development**
- **Released 21 Toolset components**
  - Reaction kinetics model of solid sorbents
  - CFD models of 1 MW adsorber & regenerator
  - Process models of solid-sorbent capture, membrane, and compression systems
  - New optimization tools (ALAMO, superstructure, framework)
  - Advanced dynamic & control models (adsorber, compression
  - New integration tools (REVEAL, Turbine, Sinter)
  - Uncertainty Quantification Framework
  - Financial Risk Tool

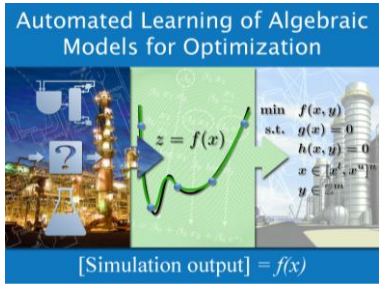


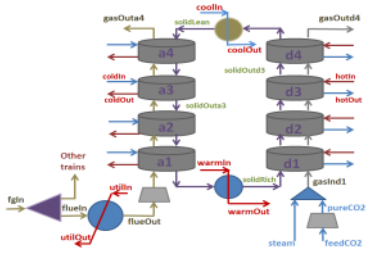












NETL · Berkeley Lab · Lawrence Livermore National Laboratory · Los Alamos National Laboratory · Pacific Northwest National Laboratory · Carnegie Mellon · West Virginia University · Princeton University · Boston University

NETL-RUA

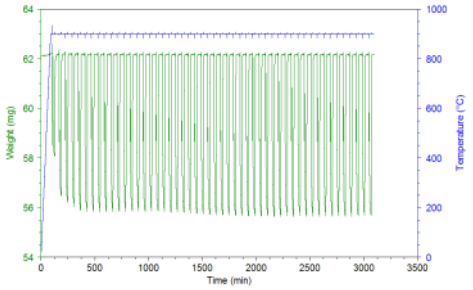
Carbon Capture

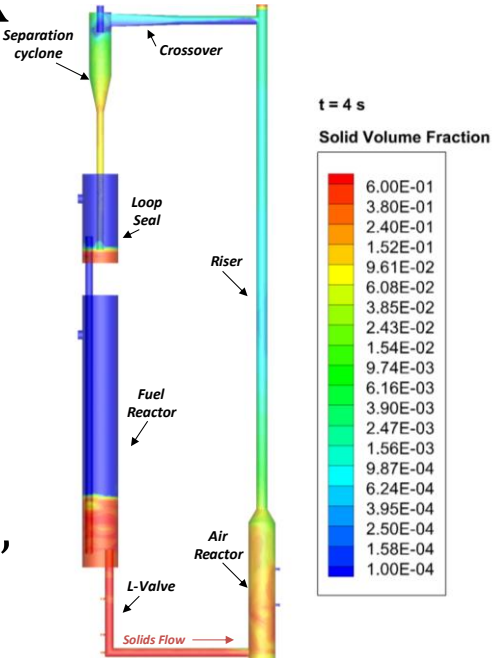
Chemical Looping

Low-cost CO_2 capture potential for coal or natural gas fired boilers in industrial applications.

Recent Accomplishments:

- NETL-developed oxygen carriers are low cost, and attrition-resistant, with 2X the oxygen capacity of other known carriers (patent pending). Pilot-scale demonstration planned with Cenovus Energy.
- Chemical Looping Validation test facility completed at the Morgantown Site, with attrition, cold-flow, high-temperature fluidized-bed reactor units, and a 50kW$_{th}$ chemical looping reactor.





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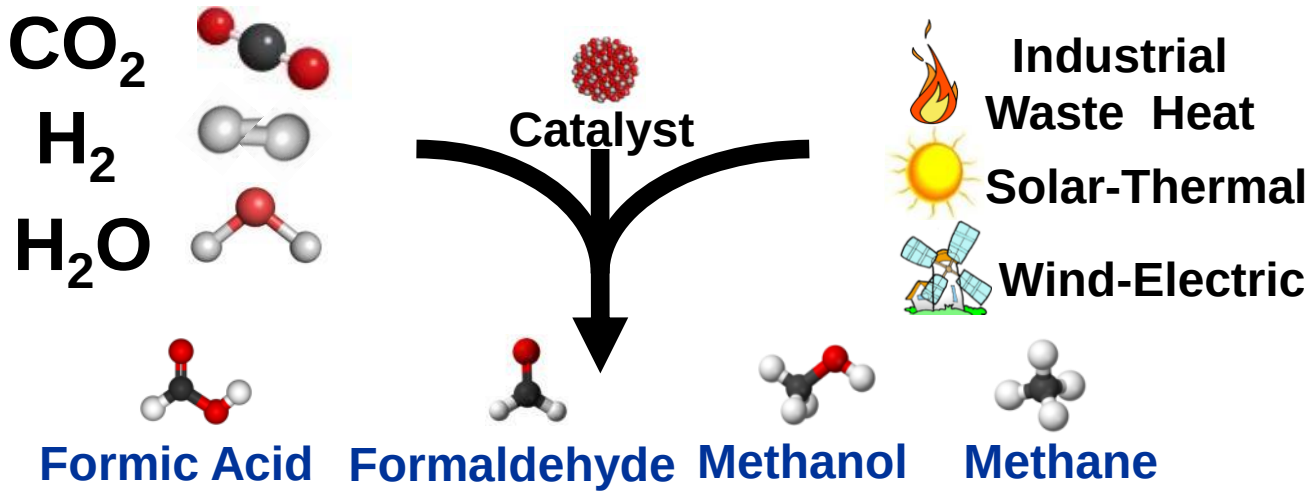
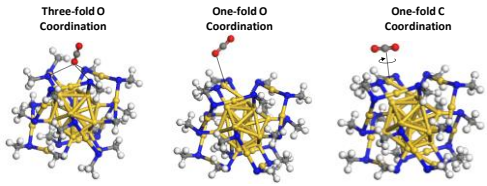
Carbon Utilization

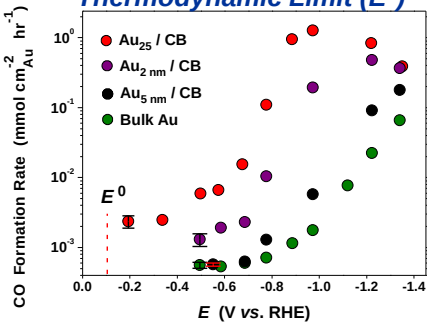


Recent Accomplishments:

- Unique nanostructured copper catalysts outperform commercially available systems
- New heterostructured nanomaterials have 10 fold improvement in catalytic activity
- Novel metal clusters have nearly 100% electrocatalytic efficiency



CO_2 Conversion to CO at the Thermodynamic Limit (E^0)



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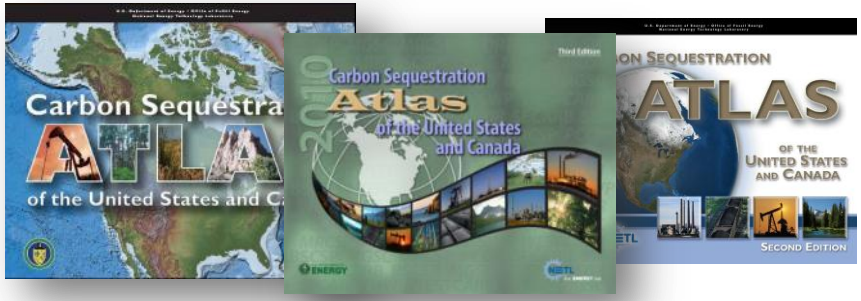
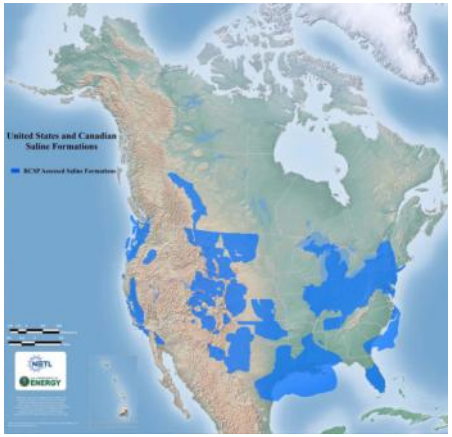
Carbon Storage

Methodologies for Estimating Storage Potential



Atlas III Estimates for Storage Potential in Saline Formations:
1,653 - 20,213 GT CO_2



Goal:

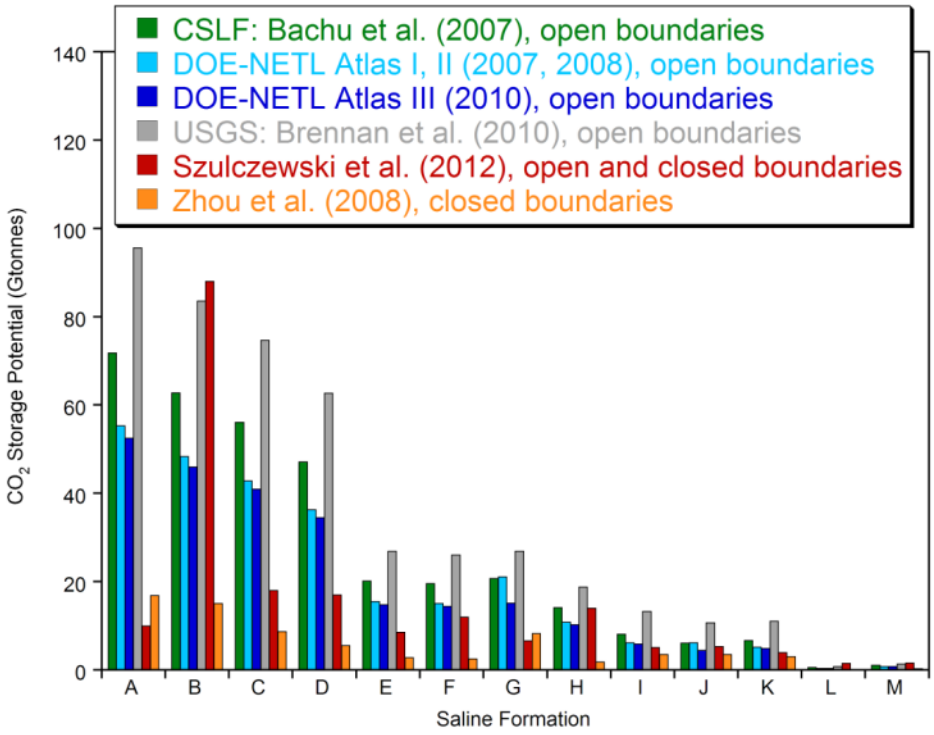
- Build confidence in storage-potential estimates used for decisions related to CCUS by assessing uncertainties due to different methodologies

Approach:

- Compared five widely used CO_2 storage methodologies (including DOE's methodology)
- Applied to 13 synthetic saline formations drawn from data on major US storage formations

Results:

- Methodologies for open-boundary conditions gave comparable estimates (statistically equal)
- Closed-boundary methodologies gave lower estimates (to be expected)
- Provides confidence in Atlas IV estimates

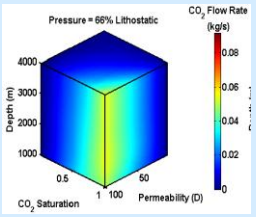


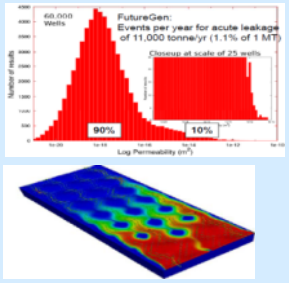
NETL-RUA

First Generation Risk-Profile Protocol

Provides *first* methodology for producing science-based risk relationships based on coupled behavior of reservoirs, potential release pathways, and receptors

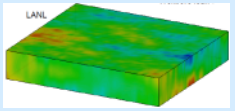
- ✓ Process models & ROMs for open & cemented wells with site-based statistics
- ✓ Process model & ROM for single vertical fault

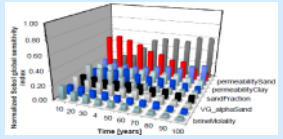


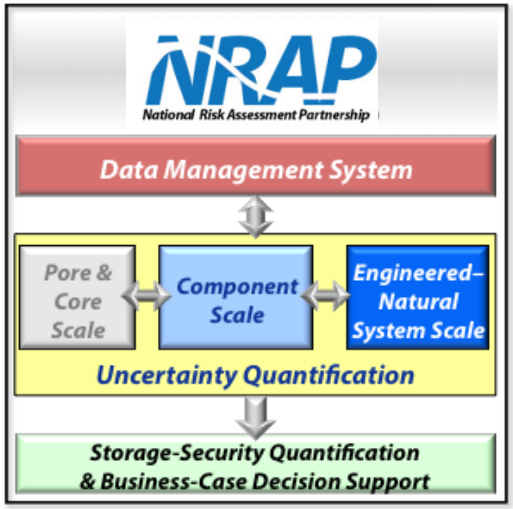


✓Energy Data eXchange (EDX) Initiated (non-NRAP $)

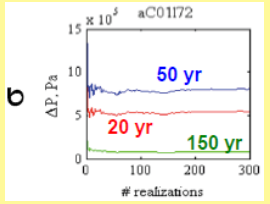
- ✓ ROMs for two aquifer classes for pH & TDS
- ✓ Sensitivity analysis to identify key risk variables



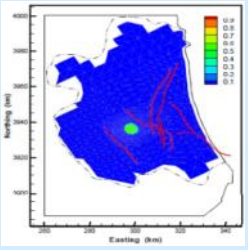


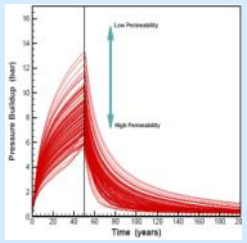


- ✓ Component-model UQ for reservoirs, wells, aquifers



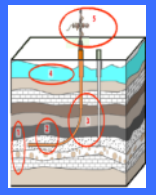
- ✓ ROMs for P & saturation for two reservoirs & two commonly used simulators
- ✓ Sensitivity analysis to identify key risk variables

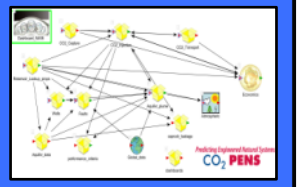




✓Preliminary evaluation of storage retention goals (>99%)

- ✓ Integrated Assessment Models (IAMs) for atmospheric release & groundwater impact
- ✓ Component models& IAM for ground motion



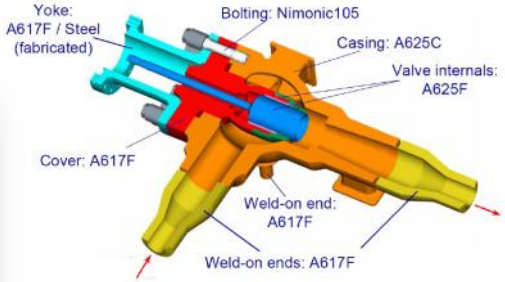


NETL-RUA

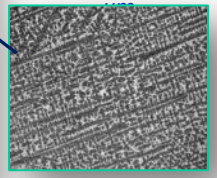
Improved Efficiencies

Large Ni-base Casting for Steam Turbine Casings

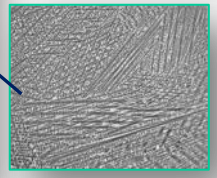
Casting large-scale nickel parts for use at 760 ℃ for steam turbine rotor casing or valve chest.

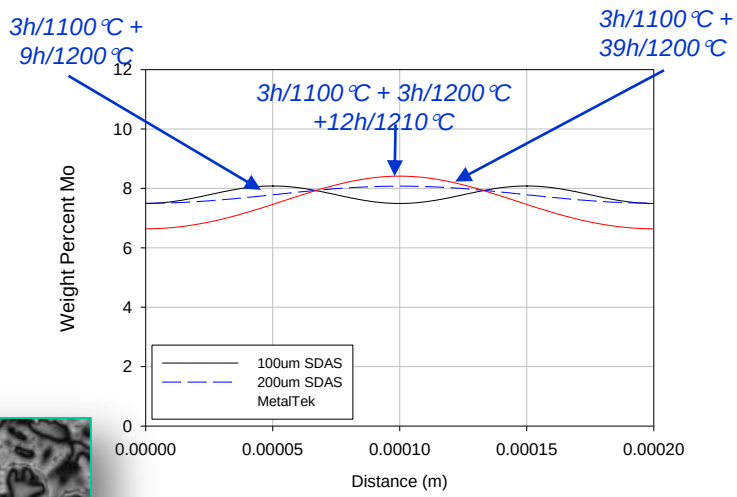


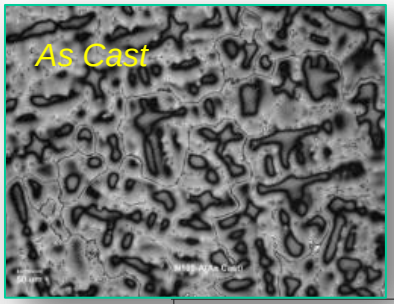
Riser Pad SDAS: 154-188

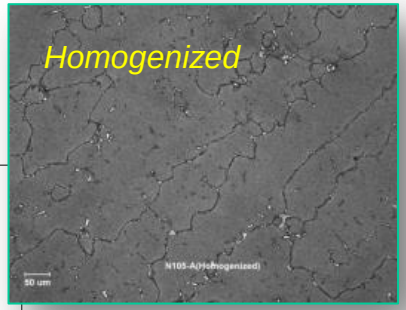


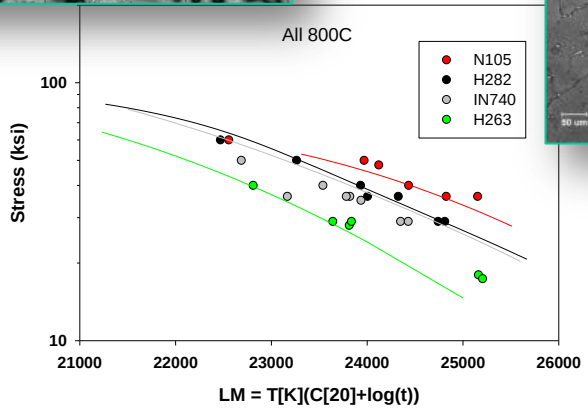
Keel Block SDAS: 57-67











Accomplishments to date:

Heat treatment optimized for alloy homogeneity.

Creep capability equivalent to forged version of alloy.

Castings produced to date: 300 lbs, 1000 lbs, 10,000lbs.

NETL-RUA

Improved Efficiencies

Advanced Gasification

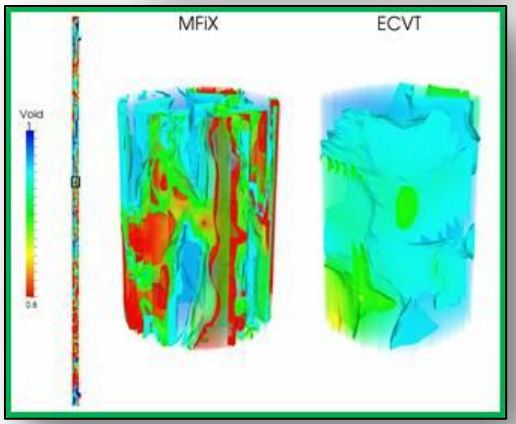
Discover and develop the technologies and materials to enable affordable, reliable Advanced Gasification Systems

Recent Accomplishments:

- NETL releases C3M, the world's largest virtual reaction kinetics laboratory for coal & other carbonaceous materials.
- AVESTAR™ deploys first 3D virtual immersive training system for an IGCC plant with capture.

C3M™
Carbonaceous Chemistry for Computational Modeling

AVESTAR™



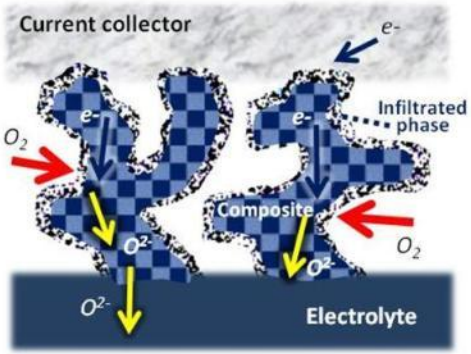
NETL-RUA

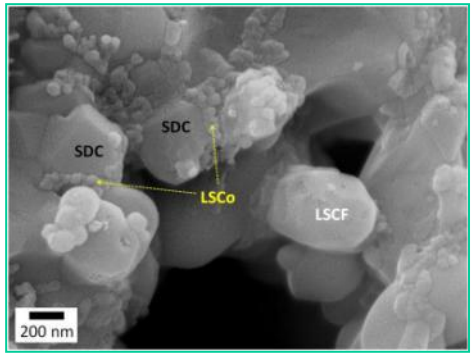
Improved Efficiencies

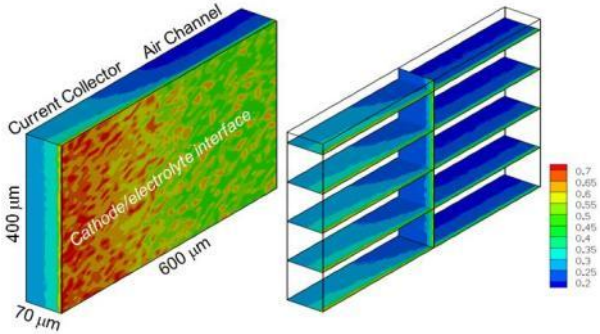
Solid Oxide Fuel Cells (SOFCs)

Support the SECA program to *Reduce* Cell Production/Operation Costs; *Enhance* Cell Activity/Efficiency; and *Improve* Cell lifetime (>40khr)

- **Recent Accomplishments:**
  - NETL-developed SOFC cathode infiltration methodology enhances electrochemical activity, resulting in cathodes that significantly exceed multiple critical performance criteria, with proven stability in lab tests. Now in pilot tests.
  - NETL-developed SOFC degradation models account for impacts resulting from stack exposures to real service environments, and suggest areas where mitigation strategies are needed.



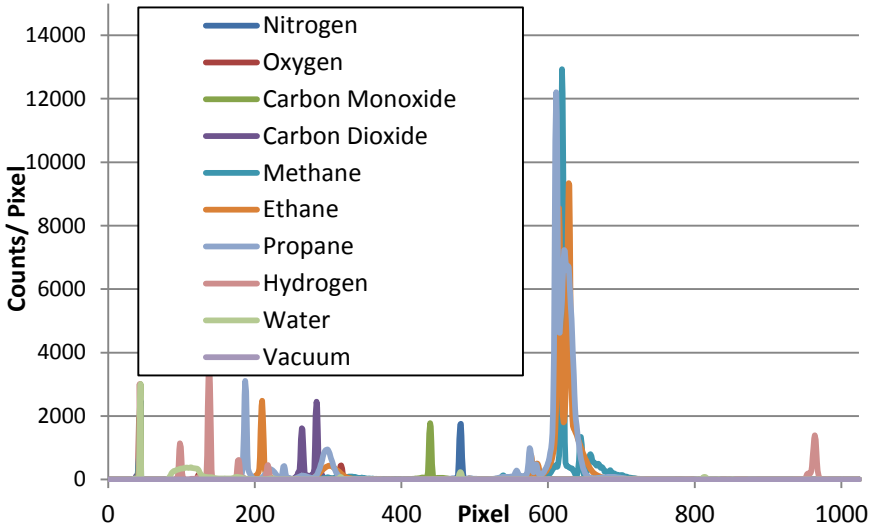




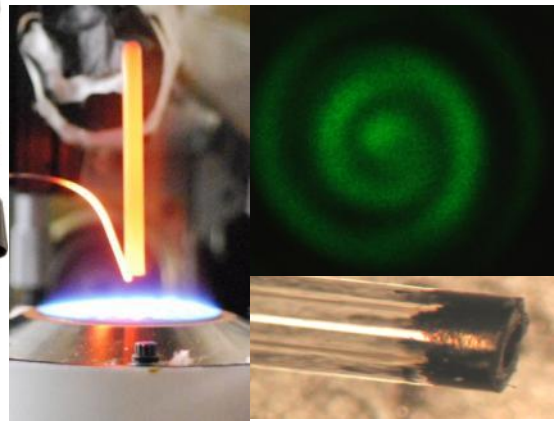
Innovative Process Technologies

- **Raman Gas Composition Sensor**
- *Simultaneously* measures multiple gases:

  $CH_4 – C_4H_{10}$, CO, CO_2, H_2, N_2, O_2, H_2O
- *Fast :*1 second measurement time*
- *Accurate* : Better than 1% accuracy
- *Multiple uses possible*: Applicable to real-time process control in power generation, chemical and other industries



- **Progress toward commercialization**
- NETL-RUA Project - US Patent Application number 13300988
- IP Licensed to Kaiser Optical Instruments
- Team awarded Bronze Excellence in Government award from the Pittsburgh Federal Executive Board



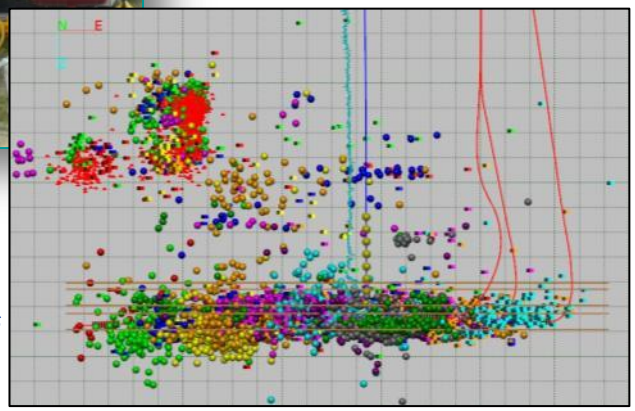
** Existing industrial gas chromatography can require several minutes for similar measurements*

Unconventional Resources

Shale Gas: Predicting Subsurface Phenomena

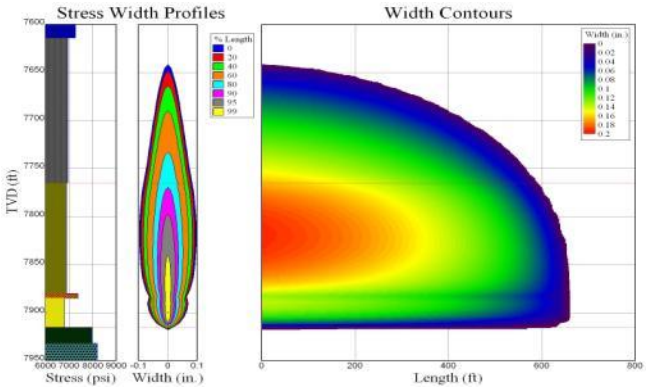
- NETL is collecting µ-seismic data to confirm industry reports that hydraulic fractures do not extend to groundwater resources, and to validate predictive models that can demonstrate relationships across Marcellus diversity
- Microseismic data collected during hydraulic fracturing at an NETL-monitored field site found
  - Maximum fracture heights were 1920 ft above Marcellus Shale
  - Highest fractures are still more than 5,500 ft below drinking water aquifers
- Models predict fracture growth both horizontally and vertically
  - Will help to confirm that out-of-zone events tie to existing fractures (not to generated fractures)

Microseismic data measured during a multistage frac in the Marcellus



µ-seismic events above Marcellus

µ-seismic events in Marcellus



Models predict fracture height and width and are calibrated with field data

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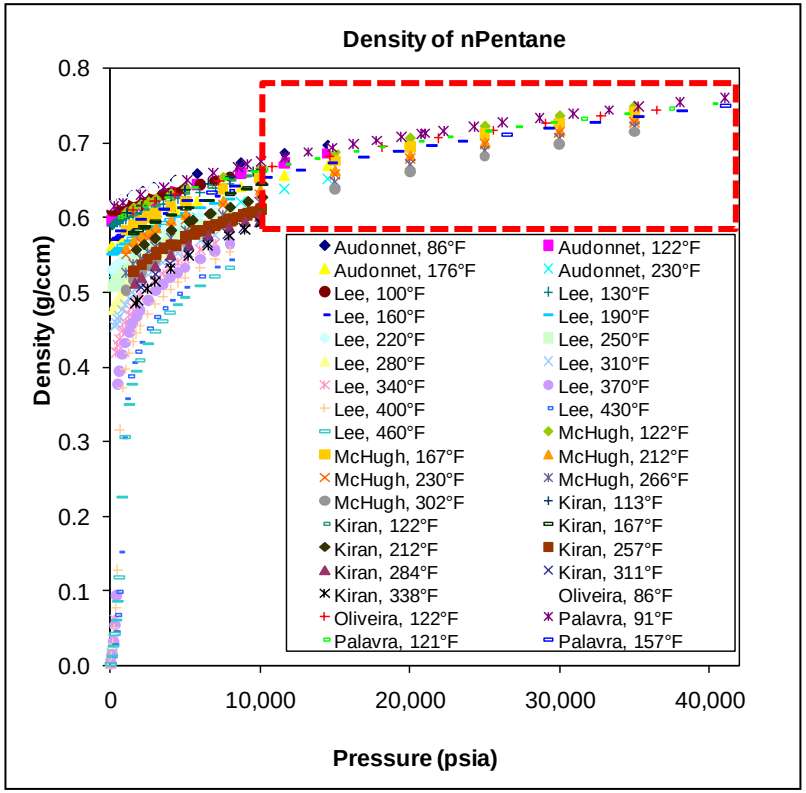
Unconventional Resources

Ultra-Deep Water: HPHT Fluids

Developing critical data for predicting fluid flow under extreme *in situ* conditions in order to assess risks associated with loss of control events in deepwater & ultra-deepwater settings:

- Expanding density and viscosity databases for hydrocarbon compounds to UDW conditions.
- Integrating NETL data with existing lower T and P data for comprehensive database.
- Developing equations of state with greatly improved accuracy.
- Extending modeling and experimental studies into polymer (additives) + hydrocarbon phase, density, and viscosity behavior.



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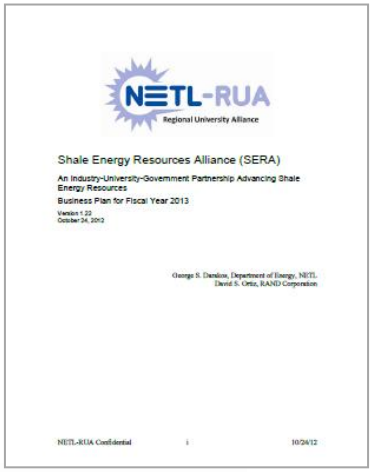
Strategic Growth Area Successes

- **NETL-RUA (led by VT) is finalist for DOE Critical Materials Hub.**
- **Grid Technologies Collaborative completes Phase I research effort, focused on modeling & simulation to develop validated models of system interactions at the grid-converter interface.**
- **SERA takes off!**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Shale Energy Resources Alliance (SERA)

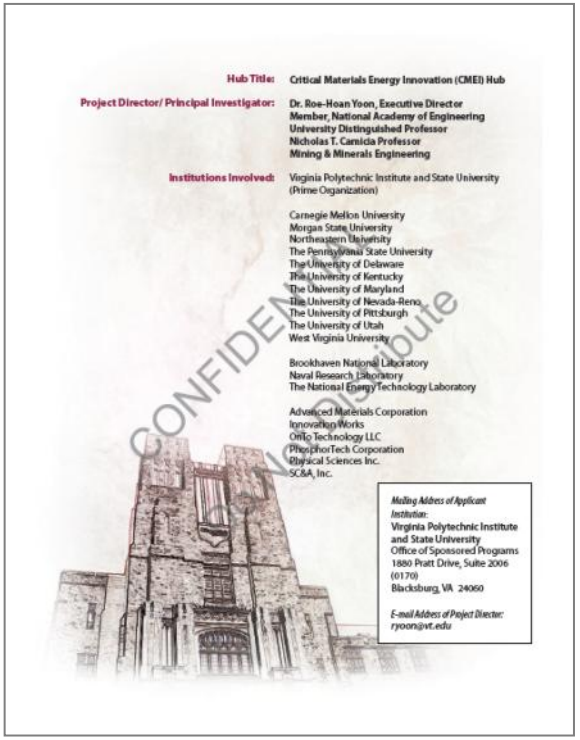
An Industry-University-Government Partnership Advancing Shale Energy Resources

Business Plan for Fiscal Year 2013

Version 1.22
October 24, 2012

George S. Dunlop, Department of Energy, NETL
David S. Ortiz, RAND Corporation

NETL-RUA Confidential 1 10/24/12


Hub Title: Critical Materials Energy Innovation (CMEI) Hub

Project Director/ Principal Investigator: Dr. Roe-Hoan Yoon, Executive Director
Member, National Academy of Engineering
University Distinguished Professor
Nicholas T. Camicia Professor
Mining & Minerals Engineering

Institutions Involved: Virginia Polytechnic Institute and State University (Prime Organization)

Carnegie Mellon University
Morgan State University
Northeastern University
The Pennsylvania State University
The University of Delaware
The University of Kentucky
The University of Maryland
The University of Nevada-Reno
The University of Pittsburgh
The University of Utah
West Virginia University

Brookhaven National Laboratory
Naval Research Laboratory
The National Energy Technology Laboratory

Advanced Materials Corporation
Ignovation Works
Ortho Technology LLC
PhosphorTech Corporation
Physical Sciences Inc.
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ryoon@vt.edu


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Regional University Alliance

The Grid Technologies Collaborative
Next Generation Power Converter Development
2012 Research & Development Report

February 28, 2013

DOE/NETL Contract:
Innovative Process Technologies FWP Award Number:
IPT_FY131415

NETL Carnegie Mellon University of Pittsburgh Virginia Tech URS

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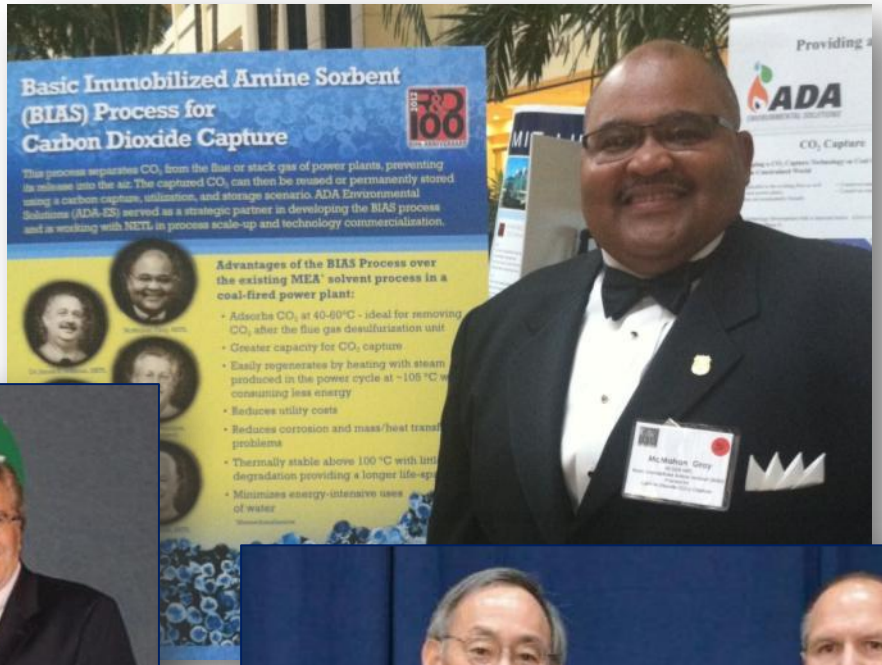
Recognition for Excellence



NETL-RUA

Success

Metrics Snapshot

PRODUCTS		
	FY2011	FY2012
Publications	194	195
Patents	11	12
Licenses	9	4
Students Graduated	20 PhD	23 PhD
	8 MS	19 MS