NATIONAL ENERGY TECHNOLOGY LABORATORY

Fossil Energy's HBCU Research Activities

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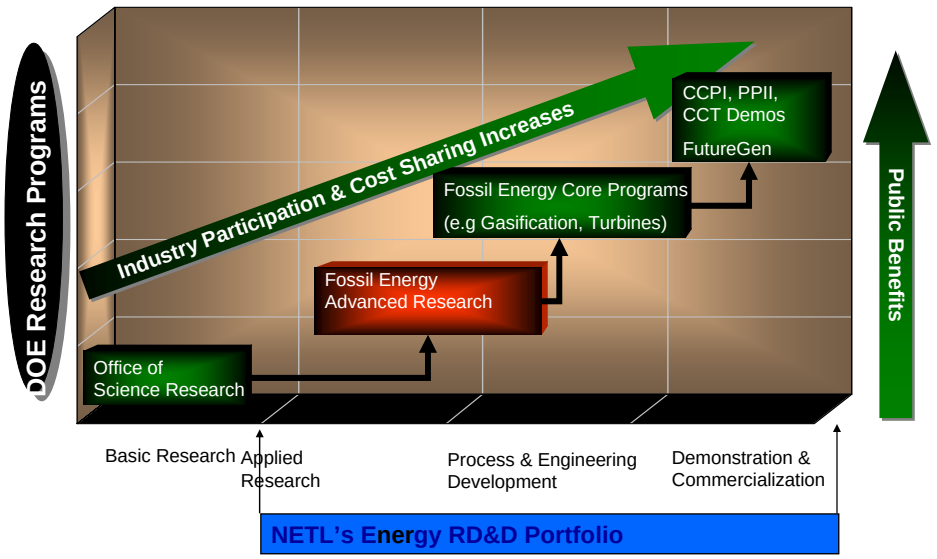
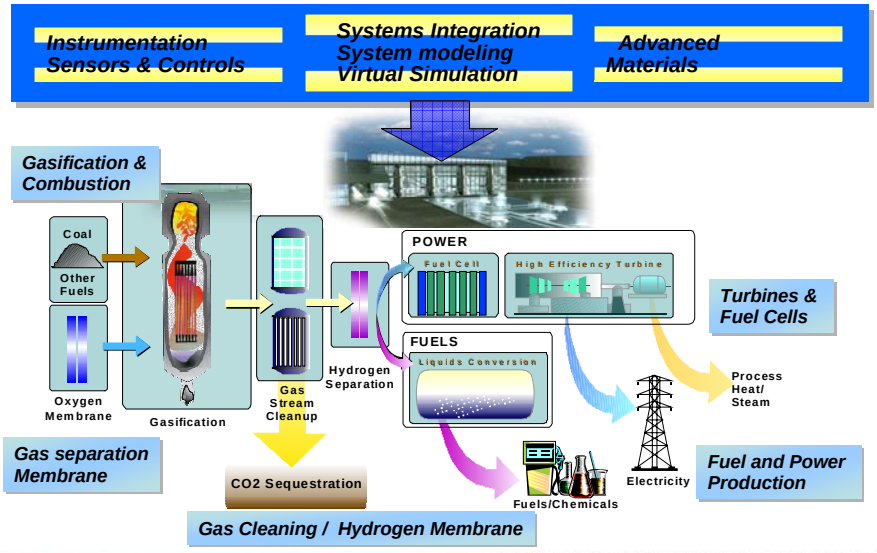
Strategic Center for Coal Program

- **Innovations for Existing Plants**
- **Gasification**
- **Turbines**
- **Fuel Cells**
- **Sequestration**
- **Fuels**
- **Advanced Research**

Fossil Energy Program Outline

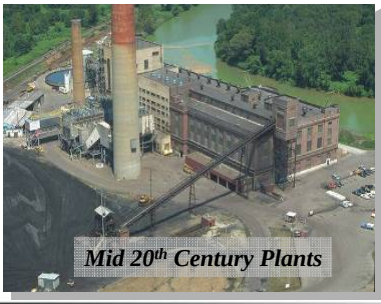


Ultra-Clean Energy Plant



Technology Challenges
Being addressed within Advanced Research

- Zero emissions
- Integrated systems
- Controllable and reliable designs
- Tight tolerances & operating margins
- High temperatures & pressures

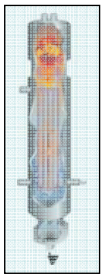


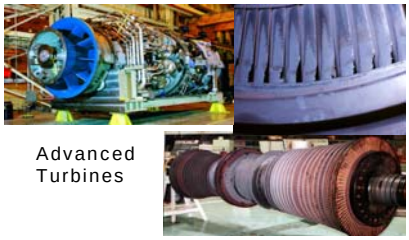
- Plant design
- Process modeling and control
- Operations monitoring (efficiency, emission, equipment)
- Dynamic & transient mode management
- Materials for harsh environments

Fossil Energy Key Material Research Areas

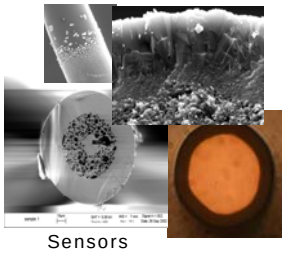
USC Boilers/Turbines

Gasifier

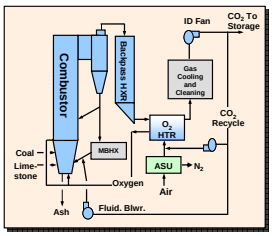




Advanced Turbines



Sensors



Oxy-Firing

Fuel Cells

HBCU Program

•In 1984, the Office of Fossil Energy took another step to expand university participation in its research program. It initiated the Historically Black Colleges and Universities Education

•Training program to expand learning opportunities for university students and increase collaborative efforts between the Nation's minority students and the fossil fuel industry.

•Research proposals can span virtually the entire spectrum of fossil fuel topics, from advanced ways to use coal cleanly to new methods for recovering and processing oil and natural gas, and innovations in fuel cell technology.

•The goal of the HBCU/OMI Program is to enhance research methods and capabilities of minority institutions that can help expand diversity for future generations of energy scientists and engineers.

Advanced Research UCR/HBCU

Fiscal Year Activity

Program Funding ($K)

Program	FY08	FY09	FY10
HBCU	805	813	850

Projects Awarded

Projects	FY08	FY09	FY10
HBCU	4	4	est 4

University of Texas, El Paso

Goal: to develop sensors based on pure and doped tungsten oxide (WO_3) for on-line monitoring and detection of hydrogen sulfide (H_2S) in corrosive environments and temperatures of 500°C or above

Method: assess atomic/chemical structure, surface/interface microstructure, stability, electronic structure, and sensor performance of pure and titanium-, gold-, and aluminum-doped WO_3 thin-film nanostructures for utilization in sensor devices

Expected Outcome: reliable, fast, highly sensitive, and selective sensors which can withstand high-temperature and corrosive environments to detect and monitor low concentrations of H_2S

DOE share: $199,546; length of contract: 36 months

University of Texas, San Antonio

Goal: to improve the performance and accuracy of the Multiphase Flow with Interphase eXchanges (MFIX) code frequently used in multiphase flow simulations

Methods: the use of first principles embedded in a validated Direct Number Simulation (DNS) particulate flow program that uses the Immersed Boundary method (IB) to establish, modify, and validate needed energy and boundary conditions for the MFIX code

Expected Outcome: to understand and model gas-solids flow in fossil fuel processes in building highly-efficient, near-zero emission fossil energy plants

DOE Share: $199,884; length of contract: 24 months

Tennessee State University

Goal: to study the electronic structure and bonding of boron carbide for applications in the energy industry

Method: using large supercell models of the crystal structure of boron carbide, X-ray Absorption Near Edge Spectroscopy (XANES), and Energy Loss Near Edge Spectroscopy (ELNES) methods, searching for possible new phases in the configuration space of supercells, which will be categorized based on lattice symmetry searching

Expected Outcome: provide more conclusive answers regarding boron carbon structure-property relationships

DOE Share: $186,763; length of contract 24 months

North Carolina A&T State University

Goal: to investigate steam reforming of methanol (SRM) with more stable catalysts and minimal production of carbon monoxide (CO)

Method: the synthesis of novel palladium-cobalt (Pd-Co) and palladium-nickel (Pd-Ni) bimetallic nanocatalysts in mesoporous silica using hydrothermal and co-condensation routes in the presence of a surfactant as a structure-directing agent

Expected Outcome: impact the H_2-economy using coal-derived fuels by steam reforming of methanol for hydrogen (H_2) production

DOE Share: $200,000; length of contract: 36 months

HBCU Success Story

An Integrated Hydrogen Production - Carbon Capture Process from Fossil Fuels

CHALLENGE: Separating H_2 and CO_2
SOLUTION: Re-form coal emissions

This innovative project was conducted in conjunction with Clark Atlanta University and Scientific Carbons, Inc., to produce hydrogen and fertilizer from coal and biomass using a pyrolysis-reforming process. The process also incorporated the capture of CO2 from smokestack emissions, producing a carbon fertilizer. The ability to convert char from coal and biomass into both hydrogen and a slow-release fertilizer will facilitate the use of hydrogen as a clean source of energy. It simultaneously provides a way to sequester CO2, a major greenhouse gas that contributes to the challenge of global climate change.

Pilot plant pyrolysis unit with biomass feedstock system.

HBCU Project Information

Fact Sheets

- **North Carolina A&T State University**
  - Development of Palladium-Silver Composite Membranes for Separation of Hydrogen at Elevated Temperature
    http://www.netl.doe.gov/publications/factsheets/project/Proj449.pdf
- **University of Texas – El Paso**
  - Super High-Temperature Alloys and Composites From Nb-W-Cr Systems
    http://www.netl.doe.gov/publications/factsheets/project/Proj448.pdf

HBCU Awards

- **http://fossil.energy.gov/programs/powersystems/advresearch/advresearch-university.html**

Mickey Leland Points of Contact

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Recovery Act: Geologic Sequestration Training and Research (DE-FOA-0000032)

- **Issue Date:** June 29, 2009
- **Application Due Date:** August 11, 2009
- **Objective:** To provide training opportunities for graduate and undergraduate students that will provide the human capital and skills required for implementing and deploying CCS technologies
- **Training accomplished through fundamental research in the following areas:**
  - Simulation and risk assessment
  - Monitoring, Verification and Accounting (MVA)
  - Geological related analytical tools
  - Methods to interpret geophysical models
  - Well completion and integrity for long-term CO_2 storage
  - CO_2 capture

Recovery Act: Geologic Sequestration Training and Research (DE-FOA-0000032)

- **Funding Available $12.93 M**
- **Restricted Eligibility: 2 categories**
  - All universities, colleges, and college-affiliated research institutions ($7.93 M)
  - HBCUs/OMIs ($5.0M)
- **Awards**
  - Grants (cost-share not required, but encouraged)
  - Anticipate approximately 42 awards
  - Period of performance ~ 3 years
  - Estimated Award Size: $300,000 DOE Funding
  - Award Date : 12/23/2009

Recovery Act: Geologic Sequestration Training and Research (DE-FOA-0000032)

- **Benefits**
  - Advance the US in its position as the leader in technology for addressing climate change
  - Make vital contribution to the scientific, technical, and institutional knowledge necessary for commercial CCS projects
  - Produce a trained workforce necessary for the CCS industry with skills and competencies in geology, geophysics, geomechanics, geochemistry and reservoir engineering

- **Access Application:**
  http://fossil.energy.gov/aboutus/budget/stimulus.html

Contact Information

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Sequestration HBCU Solicitation

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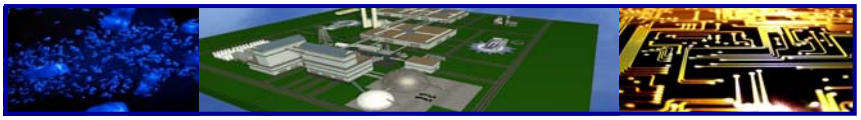
ADDITIONAL SLIDES

Driver for New Sensing Technology

- **Advanced Power Generation:**
  - Harsh sensing conditions throughout plant
  - Monitoring needed with advanced instrumentation and sensor technology.
  - Existing instrumentation and sensing technology are inadequate
- **Coal Gasifiers and Combustions Turbines:**
  - have the most extreme conditions
    - Gasifier temperatures may extend to 1600 °C and pressures above 800 psi. Slagging coal gasifiers are highly reducing, highly erosive and corrosive.
    - Combustion turbines have a highly oxidizing combustion atmosphere.
- **Targeting development of critical on line measurements**
  - Sensor materials and designs are aimed at up to 1600 °C for temperature measurement and near 500 °C for micro gas sensors.
  - Goal is to enable the coordinated control of advanced power plants followed by improvement of a system's reliability and availability and on line optimization of plant performance.

Technology Gaps and Future Directions

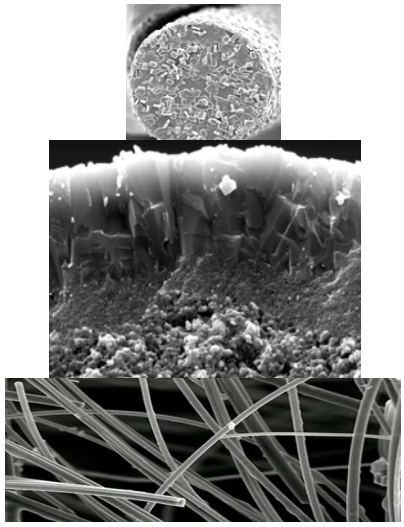
- Sensor Packaging and Testing
- Application of computational intelligence for sensing and control
- Utilization of sensor networks
- Integration with models



Materials for Sensing in Harsh Environments

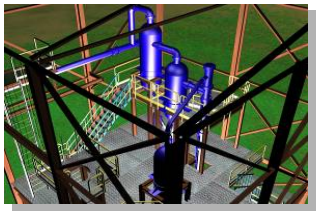
Optical and Micro Sensors

- Sapphire
- Alumina
- Silicon Carbide
- Doped Silicon Carbide Nitride
- Yttria stabilized zirconia
- Fused/doped silica for certain process conditions
- Active/doped coatings
- Nano derived high temperature materials and structures
- Novel materials for high temperatures (1000 °C)

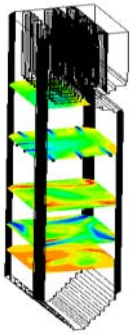


Advanced Control Development

- **Advanced Control**
  - Link to process and component modeling for Model Predictive Control
  - Focus on core control advanced technologies
  - Examine adaptive control for existing combustion and actuation systems
  - Examine novel control architectures



- **Sensor Networks**
  - Pervasive low cost networked sensing for condition monitoring and control including wireless/less wires
  - Permit capture and manipulation of data for process improvement (via advanced control) and enable novel approaches to system integration
  - Explore novel constructs and application to generate and control power

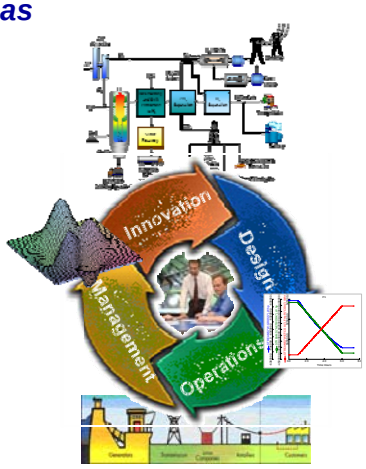


- **Challenge**
  - What data to collect, where to send it, coordinated output….
  - Measuring, modeling, and controlling solids and multiphase reacting flows

NETL Collaboratory
Process & Dynamic Systems Research

R&D Areas

- **Innovation**
  - Process Synthesis
  - Heat Exchanger/Water Networks
- **Design**
  - Process/Equipment Co-Simulation
  - Virtual Plant Simulation
  - Plant-wide Optimization
  - Risk and Uncertainty Analysis
  - Cost Estimation
- **Operations**
  - Dynamic Simulation and Control
  - Real-time Applications
- **Management**
  - Planning and Scheduling
  - Supply Chain Management
  - Enterprise-Wide Optimization



Power Plant Lifecycle