PARTNERS

Worcester Polytechnic Institute

University of Texas at Dallas

University of California at San Diego

Alfred University

Lehigh University

University of Florida

University of Connecticut

University of Missouri at Rolla

Georgia Tech Research Corporation

Clemson University

University of Southern California

Southern Illinois University

Pennsylvania State University

University of Cincinnati

University of Wyoming

University of Kentucky Research Foundation

University of Mississippi

Iowa State University

University of North Dakota

Research Foundation of SUNY, University of Albany

University of Alabama at Birmingham

Clark Atlanta University

Gas Technology Institute

Southern Research Institute

Southern Company Services

Development of Advanced SCR Catalysts

- **University of Cincinnati**— "Simultaneous Removal of NOx and Mercury in Low Temperature Selective Catalytic and Adsorptive Reactor." Mercury and NOx emissions from coal-fired power plants are being more stringently regulated. The University of Cincinnati will study the combined removal of NO_X and mercury using a newly developed adsorbent in a multi-purpose catalytic device at their research laboratory (DOE: $50,000; duration: 12 months).

- **University of Wyoming**—"Supported, Alkali-Promoted Cobalt Oxide Catalysts for NOx Removal from Coal Combustion Flue Gases." The University of Wyoming will develop a catalyst that will directly decompose nitrogen oxides found in the flue gases of coal-fired power plants into the harmless elements nitrogen and oxygen. Work on improving cobalt oxide to improve its catalytic activity to permit operation at lower temperature with smaller beds will be conducted before the catalyst can be used industrially (DOE: $49,979; duration: 12 months).

- **University of Kentucky Research Foundation**—"Development of Nitric Oxide Oxidation Catalysts for the Fast SCR Reaction." Since the wide acceptance of selective catalytic reduction (SCR) process using ammonia in coal-fired boilers in the 1970s for NOx reduction there is a continuing need to decrease the costs of this technology. The goal of this project is to identify oxidation catalysts that can be used for partial nitric oxide (NO) to nitrogen dioxide (NO_2) oxidation before the introduction of the SCR catalyst. This would improve the NOx reduction rate, allowing the use of smaller SCR reactors with decreased catalyst volumes and, therefore, lower cost (DOE: $49,814; duration: 12 months).

Innovative Concepts Phase-II Projects

Heterogeneous Reburning

- **University of Mississippi**— "Heterogeneous Reburning by Mixed Fuels." This project will conduct pilot-scale tests to demonstrate that heterogeneous reburning is capable of meeting the Phase-I NOx targets of the proposed Clear Skies Act and the Interstate Air Quality Rule at a cost significantly less than today's state-of-the-art technologies (DOE: $200,000; duration: 36 months).

Membranes for CO2 and N2 Separation/Methane Reforming

- **Iowa State University**—"Development of a Catalyst/Sorbent for Methane Reforming." The researchers seek to develop a catalyst to prove the efficiency of steam reforming of methane for the production of hydrogen (DOE: $200,000; duration: 36 months).

Mercury and Other Trace Emissions in Advanced Power Systems

- **University of North Dakota**—"Oxidation of Mercury via Catalytic Barrier Filters. Bag filters are commonly used devices used to capture regulated particulate matter before emitting the flue gas to the atmosphere." The University of North Dakota will investigate coating ~~of~~ various bag filter fabric materials with catalysts and test the performance and durability of coated filter bags using a laboratory-scale furnace and bag filter to further develop mercury removal technology (DOE: $200,000; duration: 30 months).

Smart Sensing and Advanced Artificially Intelligent Control Systems

- **Research Foundation of SUNY, University of Albany**—"Feasibility of a SOFC Stack Integrated Optical Chemical Sensor." Innovative chemical sensors capable of withstanding demanding operating environment of SOFC systems while being directly integrated in the SOFC are needed to provide real-time monitoring of the operating conditions.The project team will be investigating the feasibility of an innovative chemical sensor based on nano-cermet Surface Plasmon Resonance (SPR) bands that could be integrated with a solid oxide fuel cell (SOFC). (DOE: $199,987; duration, 36 months).

PROGRAM **facts**

U.S. DEPARTMENT OF ENERGY
OFFICE OF FOSSIL ENERGY
NATIONAL ENERGY TECHNOLOGY LABORATORY

Power Systems Advanced Research

01/2005

2004 UNIVERSITY COAL RESEARCH PROGRAM

Description

The primary purpose of the University Coal Research (UCR) Program is to improve our fundamental scientific and technical understanding of the chemical and physical processes involved in the conversion and utilization of coal and coal by-products. The academic environment is well-suited to fundamental research of high payoff potential. Involvement of professors and students is conducive to the generation of fresh ideas. As the secondary purpose of this program, student involvement ensures continuing availability of scientists and technologists with appropriate expertise for the U.S. Energy Industry. The program also maintains and upgrades the vital educational, training and research capabilities of our universities, and provides the talent for utilizing our nation's abundant coal resources.

During 2004, the Department of Energy made nearly $3 million dollars available for projects that explore ways to use coal while protecting the environment.

Program Areas

In FY2004, a major focus of the program was to carry out research that could benefit several of President Bush's initiatives such as, the FutureGen initiative - the world's first integrated sequestration and hydrogen production research power plant and the Global Climate Change Initiative, an aggressive strategy to cut U.S. greenhouse gas intensity by 18 percent by 2012. The UCR Program was divided into three component areas and academic institutions could submit proposals in one of these three categories:

University Coal Research (UCR) Core Program This program provides financial support for exploratory projects that complement ongoing applied research in the Fossil Energy (FE) Department.

University Coal Research (UCR) Innovative Concepts Phase-I Program This program will support projects that encourage "out-of-the-box" ideas that might lead to future breakthroughs.

University Coal Research (UCR) Innovative Concepts Phase-II Program This program will provide additional funding to promising projects that were supported previously with Phase I funding.

Core Research Projects

Material for Advanced Fossil Energy Systems

- **University of Florida**— "Computer-Aided Design of Advanced Turbine Airfoil Alloys for Industrial Gas Turbines in Coal-Fired Environments." The development and evaluation of high temperature turbine materials is of great interest to gas turbine

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Additional details on each of the projects can be found on the Department of Energy's fossil energy website at

http://www.fe.doe.gov/techline/techlines/2004/tl_ucrsolicit_04.html

manufacturers and utilizes generating electric power. In this project, the High Temperature Turbine Materials Research Center at the University of Florida, a recognized leader in this technology, will use a computational approach to further improve alloy design, thereby permitting more efficient power generation and less release of carbon dioxide and other greenhouse gases (DOE share: $200,000; duration: 30 months).

- **Lehigh University** (Pennsylvania)— "Enhanced High Temperature Corrosion Resistance in Advanced Fossil Energy Systems by Nano-Passive Layer Formation." Materials with improved corrosion resistance are needed for advanced power systems deriving electricity from fossil resources. Improved corrosion resistance is achieved by high temperature coatings that serve as a passive film between underlying alloy and corrosive envirnonments. This project will design new coatings with improved corrosion resistance using sophisticated experimental techniques that include advanced electron imaging to characterize the coatings. Matching funds for the project will be provided by Pennsylvania Power and Electric Company (DOE share: $200,000; duration: 30 months).

- **Alfred University** (New York)— **"**A Radically New Method for Hydrogen Storage in Hollow Glass Microspheres." Vehicles powered by fuel cells will require a safe, lightweight, and cost-competitive method of storing the hydrogen fuel. This project will investigate the use of "photo-enhanced" (light-activated) glass spheres for the storage of hydrogen. These spheres hold great promise as they are made from silica, which is plentiful, lightweight, inexpensive, and recyclable (DOE share: $199,172; duration: 36 months).

Sensors and Controls

- **University of Kentucky Research Foundation**— "Novel Carbon Nanotube-Based Nanostructures for High-Temperature Gas Sensing." Carbon nanotubes that are grown are difficult to engineer from as they resemble wire mess scrub sponges. For this project, researchers will create vertically aligned carbon nanotubes to serve as a basis for new high-temperature microsensors. These nanotubes—arranged like bristles on a brush—will be easy to manipulate and to develop useful products. The researchers will fabricate the nanotube structures and characterize them for their ability to function as ultra-sensitive detection devices (DOE share: $200,000; duration: 36 months).

Measurement Technology for Gasification Systems

- **University of California at San Diego**—**"**Multiplexed Sensor for Synthesis Gas Composition and Temperature." This project comprises both laboratory development and field testing of a "plug-and-play" style optical absorption sensor. The products of this research are expected to have a direct impact on gasifier technology and the production of high-quality syngas, with substantial broader application to sensing in coal and other energy systems (DOE share: $199,746; duration: 25 months).

Novel CO_2 and/or H_2 Separation Technologies

- **University of Texas at Dallas**—**"**Mixed-Matrix Membranes for CO_2 and H_2 Gas Separations Using Metal-Organic Frameworks and Mesoporous Hybrid Silica's." The objective of the project is to develop and test various novel membranes for separating carbon dioxide and hydrogen from a number of process and waste gas streams. Application of this research cover several technology areas, such as, cleanup of waste gas streams from refineries, purification of natural gas produced from gas wells, and preparation of clean gas feed for hydrogen fuel cells. (DOE: $200,000; duration: 36 months).

- **Worcester Polytechnic Institute**—**"**Sulfur-Tolerant Palladium-Copper Alloy Membranes for Hydrogen Separation with High-Pressure CO_2 for Sequestration." This project will develop a palladium membrane process with very high engineering life to separate hydrogen from synthesis gas at practical rates, producing high-purity hydrogen at temperatures consistent with downstream applications, and leaving behind high-pressure, sequestration-ready CO_2 streams. The proposed membrane could play a key role in the transition to a hydrogen economy (DOE: $200,000; duration, 36 months).

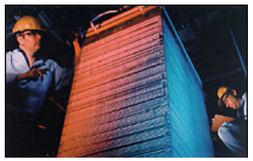
Partitioning and Mechanism Studies for Mercury and Associated Trace Metals within Coal-Fired Systems

- **University of Connecticut**—**"**Homogeneous and Heterogeneous Reaction and Transformation of Hg and Trace Metals in Combustion Systems." The goal of this project is to develop an improved understanding of the chemical and physical transformations of selected trace metals during coal combustion. The metals to be examined include mercury, selenium, arsenic, cadmium, and antimony, those for which our understanding of chemistry and emissions parameters from various systems are poorest (DOE: $199,967; duration: 36 months).

- **University of Alabama at Birmingham**—**"**Oxidation of Mercury During Selective Catalytic Reduction." The University of Alabama at Birmingham will conduct a catalyst reactivity study. Previous research suggests that catalysts used for NO_2 reduction in power plants could possibly oxidized mercury. The objective is to screen 12 candidate catalyst materials looking for maximum mercury oxidation and NO_X reduction with minimum SO_3 production. Following screening, four catalysts will be selected for further research (two high-temperature catalysts and two low-temperature catalysts) in order to identify a catalyst material with the highest mercury oxidation potential (DOE: $399,899; duration: 36 months).

SOFC Sealing Systems

- **University of Missouri at Rolla**—**"**Resilient Sealing Materials for Solid Oxide Fuel Cells." Solid oxide fuel cells (SOFCs) stacks require seals between various stack components for efficient operation and adequate reliability and service life. These seals must separate high temperature (700 to 800°C) fuel and air flows and be electrically insulated. The objective of this project is to develop and evaluate glass-based seals for SOFC applications that are resistant to stress-induced cracking and failure resulting from the large temperature changes experienced by the stack during start-up and shut-down (DOE: $188,600; duration: 24 months).



Turbines Combustion: Flashback

- **Georgia Tech Research Corporation**—**"**Flashback Characteristics of Syngas-Type Fuels Under Steady and Pulsating Conditions." This project will improve the state of the art in understanding and modeling of the phenomenon of flashback in gas turbine combustors. Flashback is a significant issue in low emissions combustors burning fuels containing higher levels of hydrogen. Measurements and analysis will be performed under steady and oscillatory flow conditions. Particular attention is given to coal-derived gaseous fuels while other candidate fuels, such as process gas or other fuels containing hydrogen or higher hydrocarbons will be given consideration as well (DOE: $188,818; duration: 36 months).

Innovative Concepts Phase-I Projects

- **Clemson University**—"Specifically Designed Constructed Wetlands: A Novel Treatment Approach for Scrubber Wastewater." This research will evaluate a pilot-scale constructed wetland to remove harmful constituents which are present at such low concentrations that traditional treatment methods are cost prohibitive. Performance will be tested over various conditions and seasons to demonstrate the robustness of the system (DOE: $49,982; duration: 12 months).

- **University of Southern California**— "Novel Anionic Clay Adsorbents for Boiler-Blow Down Waters Reclaim and Reuse." Electric utilities are large users of water in the United States, and power plant effluents can contain heavy metals such as mercury, arsenic, and selenium in a high-volume low-concentration form that is "too hard to clean. The objective of this investigation is to develop a Novel Anionic Clay Adsorbents and to use this adsorbent in combination with a separation technology, to facilitate recycle and reuse of these waters (DOE: $49,999; duration: 36 months).

Novel Uses of the Calcium Sulfate- and Calcium Sulfite-Based FGD Material

- **Southern Illinois University**— "Value-Added Products from FGD Sulfite-Rich Scrubber Material." Southern Illinois University proposes to combine sulfite-rich flue gas desulfurization (FGD) scrubber materials with renewable agricultural by-products. Developing technologies which will convert such materials will aid in successfully competing with commercially available construction products currently in the marketplace (DOE: $49,997; duration: 12 months).

- **Pennsylvania State University**—"Autoclaved Building Products from FGD Sludges." Flue gas desulfurization solids can be recycled as an ingredient for manufacturing cost-effective building products like masonry blocks and wall panels as solids removed from coal-fired FGD process can be harden in a reaction similar to that of concrete. Penn State will explore the solids curing (hardening) process, physical properties, and performance of various FGD mixtures in their materials laboratory (DOE: $50,000; duration: 12 months).