PROGRAM facts

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

Power Systems Advanced Research

05/2007

2006 UNIVERSITY COAL RESEARCH PROGRAM

Description

Funded by the U.S. Department of Energy (DOE) Office of Fossil Energy (FE), the University Coal Research (UCR) Program provides grants to U.S. colleges and universities to support fundamental research and to develop efficient and environmentally responsible fossil energy technologies. UCR's primary purpose is to improve basic scientific and technical understanding of the chemical and physical processes involved in conversion and utilization of coal and coal by-products. Through the dedicated involvement of professors and students, the academic environment is conducive to generating fresh ideas and approaches and holds great promise for yielding fundamental advancements in energy science and engineering.

The program also seeks to maintain U.S. leadership in a competitive global economy by strengthening vital educational and research capabilities of the Nation's universities and training the next generation of coal scientists and engineers by introducing them to coal technology research while advancing the science of clean energy. Since 1979 when these grants first became available, more than 1,700 students have worked alongside their professors in over 700 federally funded projects, acquiring and applying valuable experience in understanding the science and technology of coal, the Nation's most abundant fossil energy resource.

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Advanced Research — To support coal and power systems development, NETL's Advanced Research Program conducts a range of pre-competitive research focused on breakthroughs in materials and processes, coal utilization science, sensors and controls, computational energy science, and bioprocessing — opening new avenues to gains in power plant efficiency, reliability, and environmental quality. NETL also sponsors cooperative educational initiatives in University Coal Research, Historically Black Colleges and Universities, and Other Minority Institutions.

PROGRAM PARTICIPANTS

Auburn University

Case Western Reserve University

Clarkson University

Georgia Tech University

Illinois Institute of Technology

Mississippi State University

Pennsylvania State University

Princeton University

Southern Illinois University

Tennessee Technological University

Texas A&M University

University of Cincinnati

University of Connecticut

"Tapping the creativity and talents of America's young scientists to investigate long-term solutions for clean and efficient use of our Nation's abundant coal resources reiterates the Department's commitment to overall basic science."
- Jeffrey D. Jarrett, Assistant Secretary for Fossil Energy

Program Areas

In FY2006, DOE/FE's UCR Program allocated almost $3 million for 26 coal-related research projects at 23 universities in 18 states. These projects will investigate technologies to improve the use of fossil energy for producing electricity, fuels, chemicals, and other high-value products. Selected projects fall under three categories: (1) the Core Program provides funds for projects that complement ongoing applied research in DOE's FE programs; (2) the Innovative Concepts Phase I Program targets unique ideas that might lead to future breakthroughs; and (3) the Innovative Concepts Phase II Program provides funds for projects that augment research previously supported with Phase I funding.

Core Research Projects

Descriptions of projects selected in FY2006 are as follows:

Mercury and Other Trace Metals within Coal-Fired Processes

Gaining an understanding of mercury chemistry is necessary to develop mercury-removal processes for advanced power systems. Research conducted under this topic will investigate partitioning and chemistry of mercury, other trace metals, and organic substances in coal-fired systems.

- The University of Dayton will investigate how fly ash and flue gas composition affects mercury under the full range of post-combustion conditions
  (DOE award: $199,673; cost share: $5,000; duration: 36 months)
- The University of Utah will attempt to understand the fundamental chemistry of bromine and mercury that leads to the formation of mercury bromide
  (DOE award: $199,935; duration: 36 months)

Water Usage in Future Power Generation Systems

The water used for cooling power plants can cause thermal pollution and other environmental impacts. This project aims to reduce the amount of freshwater used for coal-fired power generation.

- Texas A&M University will evaluate the ability of adsorbents and reactants to remove arsenic, selenium, and mercury from wastewater so it can be used for plant cooling
  (DOE award: $199,987; duration: 36 months)

Materials for Advanced Coal-Based Energy Systems

New materials are required to improve performance and reduce costs of existing power systems. Such materials also are needed to support development of new systems for coal combustion and gasification, gas separation, hydrogen storage, high-temperature fuel cells, and advanced turbine systems.

- Texas A&M University will develop a computational methodology to aid in the design of a wide variety of high-temperature materials
  (DOE award: $199,866; duration: 36 months)
- The University of Tennessee will work collaboratively with Northwestern University and the University of California to develop a new class of "superalloy" steels for use in advanced coal-based energy systems
  (DOE award: $399,794; cost share: $269,399; duration: 36 months)
- Tennessee Technological University proposes to overcome the oxidation problems of key components in ultra-supercritical boilers by developing a low-cost alumina-forming coating
  (DOE award: $200,000; cost share: $54,446; duration: 36 months)

Hydrogen Storage Materials

Development of hydrogen storage materials is necessary for the eventual implementation of a hydrogen economy. This project will aid in developing materials that provide high hydrogen-storage density, and stability at commercially relevant conditions.

- The Pennsylvania State University will employ a combination of analytical techniques to enhance the understanding of materials suitable for hydrogen storage
  (DOE award: $200,000; cost share: $34,006; duration: 36 months)

PROGRAM PARTICIPANTS (cont.)

University of Dayton

University of Houston

University of Iowa

University of Maryland

University of Southern California

University of Tennessee

University of Tulsa

University of Utah

University of Wisconsin

Virginia Polytechnic Institute and State University

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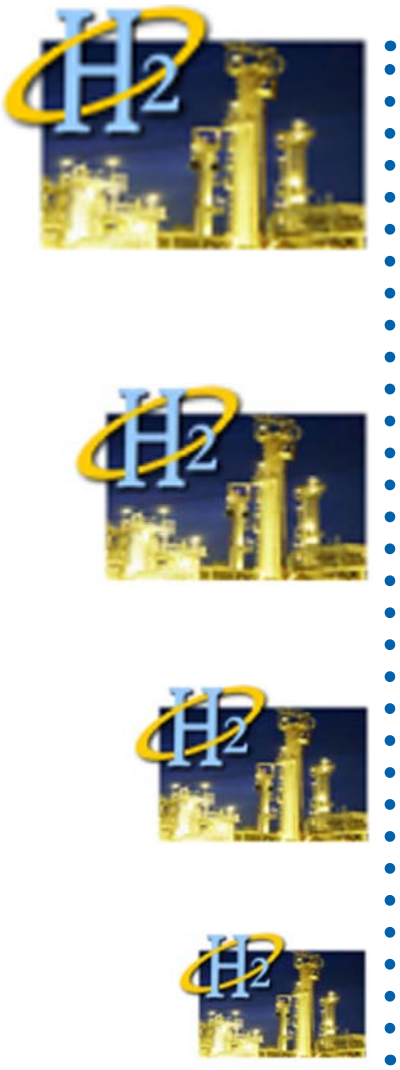
Advancements in Assessment of Geological Reservoirs for CO_2 Sequestration

Carbon dioxide (CO_2) is the major greenhouse gas associated with human activity, and a major factor in global climate change. Selected projects will improve the understanding of physical and chemical processes involved in geologic storage of CO_2 — one method of reducing the amount of CO_2 released into the atmosphere from fossil fuel generating facilities.

- Mississippi State University will determine the extent to which microorganisms isolated from oil-bearing formations can convert CO_2 into methane or cellular components (DOE award: $200,000; duration: 36 months)
- The University of Houston, along with the University of Kansas and Continental Resources of Illinois, will develop an innovative seismic technology to assess geologic reservoirs for CO_2 sequestration (DOE award: $400,000; cost share: $133,333; duration: 36 months)



Syngas and Hydrogen Combustion Reduced-Order Reactions and Rate Constants

The projects selected under this topic will provide experimental data and use validated numerical models to design synthesis gas (syngas) and hydrogen fuel combustors.

- Case Western Reserve University, in conjunction with the University of Southern California and the University of Michigan, will use experiments and numerical modeling to develop tools to aid in designing future syngas and hydrogen-fueled combustion turbines (DOE award: $400,000; duration: 36 months)
- Princeton University will investigate how laminar and turbulent flame speeds and flammability limits affect mixtures of hydrogen, carbon monoxide, air, and water at elevated pressures and temperatures (DOE award: $200,000; duration: 36 months)

Characterization of Atomic and Electronic Structure of Electrochemically Active Solid Oxide Fuel Cell Cathode Surfaces

Solid oxide fuel cells (SOFCs) provide a high degree of fuel flexibility and are the cleanest, most efficient chemical-to-electrical energy conversion systems available. Studies are needed to examine the relationship between atomic structure and electron states at the cathode surface of fuel cells

- Georgia Tech University will use advanced calculations to better understand the detailed mechanisms necessary for oxygen reduction at the cathode surfaces of SOFCs (DOE award: $200,000; cost share: $51,000; duration: 36 months)

Advanced Gasification Research Studies

Future power generation systems based on coal gasification will require an enhanced understanding of the performance of transport reactors. The projects selected under this topic will provide experimental data on transport properties, and enhance modeling capabilities.

- The Illinois Institute of Technology will improve the correlations that describe mass transport and dispersion of both solids and gases in circulating fluidized beds and transport reactors
  (DOE award: $199,998; cost share: $18,684; duration: 36 months)
- Princeton University will develop more accurate and affordable large-scale simulations of transport gasifiers and other reacting and non-reacting gas-particle flows in a variety of chemical reactors
  (DOE award: $200,000; cost share: $99,756; duration: 36 months)

Innovative Concepts Phase I Projects

Analysis to Quantify the Contribution of Coal-Fired Boiler Emissions to Ambient Fine Particle Concentrations

Studies have shown consistent associations between elevated concentrations of fine particles in the air and adverse health effects, but research is needed to clarify the links between coal-fired utility boiler emissions, ambient particulate concentrations and composition, and specific health impacts.

- The University of Maryland – College Park will develop a method to quantify the contribution of individual coal-fired utility boiler emissions to ambient fine particle concentrations
  (DOE award: $49,999; cost share: $12,500; duration: 12 months)

Advanced NO_x Control

Most coal-fired utilities use selective catalytic reduction to achieve compliance with new, more stringent NO_x control regulations. However, this technology is expensive and has generated plumes of sulfur trioxide. Less-expensive technologies, with fewer negative balance-of-plant issues, are needed for the existing fleet of coal-fired power plants.

- The University of Iowa will evaluate the reactivity of a type of "tailored" catalyst for the selective catalytic reduction of NO_x with ammonia
  (DOE award: $50,000; cost share: $9,000; duration: 12 months)

Computational Chemistry in Support of Hydrogen from Coal

Computational chemistry has the potential to uncover new reaction mechanisms and unique interactions between materials and reaction products. The selected project will employ computational chemistry to develop chemical catalysts for the production of hydrogen from coal.

- University of Wisconsin will identify bimetallic catalysts to produce hydrogen from gasified coal via a chemical reaction called the "water-gas shift" reaction
  (DOE award: $50,000; cost share: $9,245; duration: 12 months)

Solid Oxide Fuel Cell Sealing Materials and Systems

Power generation systems employing SOFCs are being developed for use in future coal-fired power plants. Novel sealing materials and systems are needed to address the needs of these fuel cells.

- Virginia Polytechnic Institute and State University will develop a novel concept for the seals between SOFC components and layers to achieve long-term seal durability under demanding operating conditions
  (DOE award: $50,000; duration: 36 months)

Separation and Handling of Nano-sized Particles

Sub-micron-sized structured materials are becoming more important in the areas of catalysis and materials for energy systems. New, low-cost methods are desired for separating these materials into specific, narrow ranges of sizes so that the properties of the materials can be better studied and utilized.

- Clarkson University will develop advanced wireless controls applicable to the cogeneration of electric power and synthetic fuel
  (DOE award: $50,000; cost share: $10,080; duration: 12 months)
- University of Connecticut will examine the feasibility of optical sensors that use exposed fiber probes that are placed directly in harsh environments
  (DOE award: $50,000; duration: 12 months)
- The University of Tulsa will develop innovative optical sensor networks that couple infrared and ultraviolet spectroscopy
  (DOE award: $49,962; cost share: $29,201; duration: 12 months)

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Innovative Concepts Phase II Projects

The projects chosen under Innovative Concepts Phase II were supported in Phase I and have shown sufficient promise to be selected for additional research.

- Southern Illinois University will develop and test value-added products by combining sulfite-rich materials from power plant exhaust scrubbers with renewable agricultural by-products
  (DOE award: $199,999; cost share: $259,540; duration: 36 months)
- The University of Cincinnati will develop an advanced reactor for the simultaneous removal of NO_x and mercury from coal-fired flue gases.
  (DOE award: $200,000; duration: 36 months)
- The University of Southern California will team with Media & Process Technology Inc. and the Gas Company of Southern California to study special clay sorbents to reduce the amount of water used by utilities during electricity generation
  (DOE award: $199,999; cost share: $35,404 duration: 36 months)