PROGRAM facts

U.S. Department of Energy
Office of Fossil Energy
National Energy Technology Laboratory

Power Systems
Advanced Research

07/2008

DOE-EERC Fossil Energy Base Program and Jointly Sponsored Research Program

Description

Since 1998, the U.S. Department of Energy (DOE), through the Advanced Research Program of the National Energy Technology Laboratory (NETL), has been providing financial support to the University of North Dakota's Energy and Environmental Research Center (EERC). Within the framework of two cooperative agreements, the EERC performs research, development, and demonstration (RD&D) projects aimed at advancing the deployment of technologies that will improve energy efficiency and environmental performance of fossil energy systems in areas that would otherwise not be adequately addressed by the private sector.

Under a Base agreement, the EERC focuses on new concepts for highly efficient, non-polluting energy systems. The Base Program supports fundamental studies on scientific and engineering foundations for new and improved energy technologies, and solutions to a wide range of environmental issues. The emphasis has been on the EERC's historic work in low-rank coals (LRC), chiefly subbituminous and lignite.

In addition to the Base Program, a Jointly Sponsored Research (JSR) Program provides up to 35 percent co-funding through NETL for follow-on work conducted at the EERC on a larger scale that holds commercial promise. Research under the JSR Program is tailored to critical environmental issues, including water supply and quality, air toxics (e.g., mercury), fine particulate matter (PM2.5), and the goal of net-zero carbon dioxide (CO_2) emissions. Examples of research include the effort to overcome barriers to hot-gas cleaning that are impeding deployment of high-efficiency power systems, and the search for practical ways to capture and store (sequester) CO_2 generated by fossil fuel combustion.

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.

CONTACTS

Richard B. Read
Project Manager
Gasification & Fuels Division
National Energy Technology Laboratory
626 Cochrans Mill Road
P.O. Box 10940
Pittsburgh, PA 15236-0940
412-386-5721
richard.read@netl.doe.gov

Robert R. Romanosky
Technology Manager
Advanced Research
National Energy Technology Laboratory
3610 Collins Ferry Road
P.O. Box 880
Morgantown, WV 26507
304-285-4721
robert.romanosky@netl.doe.gov

Gerald Groenewold
Principal Investigator
University of North Dakota Energy and Environmental Research Center
15 North 23rd Street
P.O. Box 9018
Grand Forks, ND 58202-9018
701-777-5295
ghg@undeerc.org

This combined effort charts a clear pathway from fundamental laboratory research to applied bench- and pilot-scale research. It is a dynamic model for RD&D partnerships among government, industry, and the applied science and engineering communities that can bring cutting-edge technology closer to commercial application.

The EERC is a high-tech, non-profit branch of the university dedicated to moving promising technologies out of the laboratory and into the marketplace. The EERC research portfolio consists of a wide array of strategic energy and environmental solutions, including clean coal technologies, long-term sequestration of CO_2, energy and water sustainability, hydrogen technologies, air toxics and fine particulates, mercury measurement and control, alternative fuels, wind energy, biomass, water management, flood prevention, global climate change, waste utilization, energy-efficient technologies, and contaminant cleanup.

EERC Campus, Grand Forks, North Dakota

Program Areas

Program areas under the Base and JSR cooperative agreements address the following objectives:

Task 1: Resource Characterization and Waste Management

Fuel Resource Characterization — Study of fuel properties in relation to their geological setting and utilization potential; characterization of organic constituents, heteroatoms (e.g., O, S, and N), organically associated elements, and minerals to determine effects on conversion, combustion, and gasification processes; environmental characterization of priority pollutants designated in the Clean Air Act Amendments of 1990, with an emphasis on mercury and other significant toxic metals; and characterization of utilization processes focusing on corrosive and deposit-forming constituents that adversely impact hot-gas cleaning, gas turbines, and other components of high-efficiency power systems.

Waste Management — Investigation of fuel residual and process waste properties, to foster beneficial utilization and safe disposal; development of engineering and environmental reuse criteria for coal combustion and clean coal technology by-products; development of analytical methods for in-situ measurement of priority pollutants; development of remedial methods for extracting mercury from contaminated soils and stabilizing mercury-laden wastes; and advancement of separation processes for concentrating pollutants in fossil-fuel-derived or saline wastewaters.

Task 2: Air Quality Assessment and Control

Air Toxic Metals — Research on analytical methods for measuring trace metal solids and gases, and methods to determine transformations and emissions of air toxics in combustors, gasifiers, and flue gas or hot-gas cleaning control modules; application of validated alternative methods for measuring emissions of mercury and other air toxics from power plants; investigation of interactions of mercury and other air toxic metals with fly ash and sorbent materials in utilization and control processes; and modeling of trace element transformations to cover a range of chemical reactions.

Fine Particulates — Investigation of properties of PM2.5 from conventional and advanced power systems to understand their generation in combustors or gasifiers, their capture in enhanced control devices, and their behavior in the atmosphere; and atmospheric sampling to study source distribution and the atmospheric reactions that form secondary particulates from primary particles, acid gases, organic pollutants, agricultural or industrial chemicals (e.g., ammonia), and background dust.

Sequestering Carbon Dioxide — New approaches to overcome obstacles to storing CO_2 emissions from LRCs (which are higher in relation to heating value than that for other fossil fuels) due to high cost, limited regional application, or environmental uncertainty; exploratory research to identify innovations in separation and adsorption of CO_2 from many sources for use in high-volume applications such as structural materials (concrete or asphalt) or tertiary oil recovery; and use of systems engineering to obtain preliminary indications of the practical feasibility and cost of innovative sequestration concepts.

Task 3: Advanced Power Systems

Fuel Utilization Properties — Investigation of high-temperature chemistry of materials from LRCs and biomass in advanced power systems using bench- and pilot-scale combustion, gasification, and flue gas and hot-gas cleaning facilities to overcome barriers to commercialization; application of advanced analytical methods and thermodynamic/kinetic modeling; study of ash emissivity, ash sintering, and high-range slag viscosity to improve predictive simulations of power systems, including use of artificial intelligence methods; and perfection of fuel quality indices for both conventional and advanced systems to predict utilization properties in relation to fuel analysis and design/operating parameters.

Hot-Gas Filter Blinding — Development of predictive models of ash-related problems in hot-gas particulate filters, which are critical components for commercializing cost-effective, high-efficiency power systems for solid fuels; use of advanced analytical methods and thermodynamic equilibrium modeling to understand mechanisms and failure modes of ash blinding (filter clogging and catalyst masking); and extension of filter blinding models developed for combustion to gasification systems, focusing on distinct mechanisms involving sulfide chemistry, the effect of moisture on high-temperature ash, and the filling of filter pores with high-alkali coal ash.

Hot-Gas Chemical Cleaning — Investigation of removing tars, alkalis, acid gases, and heavy metals from hot gases under both oxidizing and reducing conditions to protect gas turbines, fuel cells, and other components of high-efficiency power systems; development of solutions to unique problems of LRCs and biomass arising from their typically high-alkali ash, which can cause corrosion and deposition and can limit operating temperatures in fluidized beds; and extension of previous research on alkali "getters" or absorbent agents in pressurized fluidized-bed combustion, to include gasification systems.

Additional information about Advanced Research may be found on the Department of Energy's Office of Fossil Energy Web site at:

http://www.fossil.energy.gov/programs/powersystems/advresearch/index.html

PROJECT DURATION

04/15/1998 to 03/31/2008

COST

Base Program:

Total Project Value
$16,743,174

DOE/Non-DOE Share
$16,743,174 / $0

JSR Program:

Total Project Value
$61,619,257

DOE/Non-DOE Share
$24,565,634 / $37,053,623

ADDRESS

National Energy Technology Laboratory

1450 Queen Avenue SW
Albany, OR 97321-2198
541-967-5892

2175 University Avenue South
Suite 201
Fairbanks, AK 99709
907-452-2559

3610 Collins Ferry Road
P.O. Box 880
Morgantown, WV 26507-0880
304-285-4764

626 Cochrans Mill Road
P.O. Box 10940
Pittsburgh, PA 15236-0940
412-386-4687

One West Third Street,
Suite 1400
Tulsa, OK 74103-3519
918-699-2000

CUSTOMER SERVICE

1-800-553-7681

WEBSITE

www.netl.doe.gov

Task 4: Advanced Fuel Forms

Development of improved lower-cost methods for upgrading LRCs and biomass to clean, high-energy solid fuels; development of clean liquid fuels for transportation and slurry feedstocks for advanced power systems; modification of techniques for drying, carbonizing, briquetting, direct liquefaction, and hydrothermal treatment to produce low-rank coal-water fuel; testing of the physical and oxidative stability of upgraded solid fuels; analysis of transportation fuels containing oxygenated additives to assess environmental and operational performance; and conduct of fundamental research into surface properties, wetting, swelling, colloidal dispersion, ion-exchange, and adsorption phenomena that affect LRCs.

Task 5: Value-Added Co-Products

Development of improved activated carbons from coal or biomass combustion and other improved sorbents for environmental applications, with emphasis on the capture of mercury in both elemental and oxidized forms; conduct of fundamental and engineering studies on the catalyzed oxidation of HgO, capacity and kinetics of sorption, strength and stability of the sorbent, and environmental stability of the captured mercury; investigation of the regeneration of sorbents to recover mercury; and evaluation of sorbent applications and costs by systems engineering and with potential commercialization partners.

Task 6: Advanced Materials

Corrosion-Resistant Materials — Study of the corrosion resistance, durability, embrittlement, and fatigue characteristics of advanced alloy and ceramic materials; performance of corrosion tests in a novel dynamic slag corrosion test apparatus; development of methods to improve the corrosion resistance of ceramics; study of interfacial mass transport mechanisms that adversely affect the performance of composite materials; and development of improved methods for joining silicon carbide refractories by joule heating.

Gas Separation Membranes — Continuing research to develop and test superior ceramic membranes for hydrogen separation from coal gas, using an electron beam to vaporize and deposit coatings in various oxidation states on ceramic substrates; and testing membranes to determine the stability of their coating, permeability, and selectivity for hydrogen.

Task 7: Strategic Studies

Performance of strategic studies to provide technical and policy guidance for planning future research under the agreements. These activities establish a basis for technical oversight to ensure that the research performed meets strategic goals within the framework of a market-driven program.

Program Accomplishments

More than 150 projects have been successfully completed under the EERC Base and JSR agreements since 1998. Twenty-four projects are currently active.