DOE Selects Nine New University Coal Research Projects to Advance Coal-Based Power Systems

Nine new projects selected by the U.S. Department of Energy (DOE) under the University Coal Research program will seek long-term solutions for the clean and efficient use of our nation's abundant coal resources. The announcement today of the selections marks the 34th round of the Department's longest-running coal program, which began in 1979.

This research continues DOE efforts to improve the understanding of the chemical and physical processes governing coal conversion and utilization, and support the technological development of the advanced coal power systems of the future. These advanced systems include ultra-clean energy plants that could co-produce electric power, fuels, chemicals and other high-value products from coal with near-zero release of emissions and substantial increases in energy conversion and efficiency.

The selected projects will conduct investigations in three topic areas — computational energy sciences, material science, and sensors and controls — and will be funded at a maximum of $300,000 for 36 months. The Office of Fossil Energy National Energy Technology Laboratory (NETL) will manage the projects.

Summaries of the topic areas and the selected projects follow.

Sensors and Controls Topic Area: Advancements in High-Temperature Sensing and Electronic Materials for Novel Wireless Sensor Devices

Projects under this topic area will develop novel materials that can support new designs in integrated high-temperature measurement devices. The materials must be able to hold sensing and electronic capability at temperatures ranging from 600 to 1000 degrees C.

University of Connecticut (Storrs, Conn.) — High-temperature metal-oxide and nitride-based nanomaterials have unique properties, including ultrahigh surface area, low cost, and intrinsic physical and chemical robustness, that make them potential candidates for the construction of highly efficient sensors for advanced power systems. This project aims to design and fabricate a new class of well-defined (size, geometry, interface and orientation) metal oxide/nitride-based heterostructured nanowire array sensing platforms. These platforms could be run under multiple sensing modes at temperatures ranging from 600 to1000 degrees C.

West Virginia University (Morgantown, W.Va.) — The proposed research will investigate the use of graphene-based materials to provide selective sensing of gas species in a mixed-gas environment at temperatures in the range of 600 to 1000 degrees C. The sensors can be readily integrated with wireless communications and will have applications in both low- and warm-temperature as well as high-temperature regimes. The proposed research is highly novel and has the potential to lead to breakthroughs in the surface chemistry, materials properties, and gas-surface chemistry of graphene composites.

Material Science Topic Area: High-Performance Materials for Long-Term Fossil Energy Applications

Operating conditions of advanced boilers and steam turbines are anticipated to be 760 degrees C/5000 psi and higher with advanced gas turbine inlet temperatures above 1700 degrees C. The selected projects will focus on the development of new structural and functional materials and novel and more robust ways to synthesize and process advanced materials for advanced fossil energy applications that offer the potential to reduce manufacturing costs, improve product recovery, reduce product variability, and allow the production of more precisely designed structural and functional materials and coatings.

Auburn University (Auburn University, Ala.) — The proposed project will support development of a thermal barrier coating (TBC)/environmental barrier coating (EBC) system with improved corrosion resistance and increased temperature capabilities. The work will focus on the bond layer between the alloy and ceramic thermal barrier and on identifying prospective pyrochlore materials for the EBC. The objectives are to demonstrate that the EL-Form® process can be used to fabricate iridium/hafnium-based coatings to replace the currently used platinum-based bond coatings that are applied between the alloy and thermal barrier coating and to identify pyrochlore materials with good hot corrosion resistance for environmental barrier coatings.

University of Illinois (Champaign, Ill.) — High-entropy alloys (HEAs) possess remarkable high-temperature softening resistance, high ductility, and excellent wear resistance. A novel statistical model developed at the University of Illinois will be used to predict fracture strength and creep life of HEAs. This new understanding of the deformation mechanisms can be used to design optimal materials for improved fossil energy applications.

North Carolina State University (Raleigh, N.C.) — The project will develop a systematic approach to quantify the relationships among the compositional, structural, and reactive properties of mixed-metal oxide-based oxygen carriers (OCs). This will lead to systematic and quantitative criteria for OC development. Using these criteria, a combination of multi-scale modeling, metaheuristic optimization, and experiments will be used to design optimized OCs for coal chemical looping.

Purdue University (West Lafayette, Ind.) — New developments in high-temperature, corrosion-resistant refractory alloys have shown promise of extended survival in environments that can exceed 1500 degrees C. The effect of grain boundaries (GBs), including quasi-liquid intergranular films (IGFs) formed at high temperatures, is an important limitation of an alloy's applicability in such harsh environments. This project will focus on predicting the creep and associated microstructure evolution of W-based refractory alloys. The researchers will use a new concept, GB diagrams, to establish time-dependent creep resistance and associated microstructure evolution of GBs/IGFs controlled creep as a function of load, environment and temperature.

The University of Tennessee Space Institute (Tullahoma, Tenn.) — Advanced and multifunctional materials with desired transport, electrical and thermal properties, and high durability in oxidizing and reducing environments are critical for improving efficiency and performance in electrical energy storage devices. A polymer electrolyte membrane (PEM) electrolyzer becomes more attractive for electrical energy storage due to its unmatched efficiency, large capacity/energy density, quick startup, and low maintenance. Liquid/gas diffusion layers (LGDLs) in the electrolyzer play key roles with multifunctions to transit reactants, electrons, heat and products. This project proposes to develop a thin and well-tunable multifunctional material with micro/nano fabrication and surface treatment for optimizing multiphase flow, reducing flow/interfacial resistance and promoting thermal/electric conductivities, thus improving electrolyzer efficiency.

Computational Energy Sciences Topic Area: Computational Techniques for Determining Optimal Sensor Deployment in Advanced Power Systems

Next-generation technologies will employ strategically placed, heterogeneous sensors with embedded intelligence that communicate with neighboring sensors to make decisions such as measurement type, duration and actuation. The selected projects will develop computational algorithms that will be used to determine optimal sensor development within an advanced power system. Algorithms will demonstrate improvement in the overall power system, or within a major power system component through the optimization of sensor locations, communications, and values such as pressure, temperature, and strain.

University of Illinois (Chicago, Ill.) — A variety of sensors are available ranging in cost, accuracy, and suitability for the harsh operating conditions encountered in advanced power plants using IGCC. However, incidents of failure of sensors to respond to process upsets due to improper location have occurred. This research will develop new fundamental algorithms and hybrid hardware sensor and virtual sensor architectures for optimization of the location, number, and type of sensors. Sensor placement will be formulated as a large-scale, multi-objective optimization under uncertainty problem, and a new algorithmic framework will be developed which will enable utilities, decision makers, and engineers to find optimal sensor placement in the face of uncertainty.

Oregon State University (Corvallis, Ore.) — The proposed research will provide sensor deployment, coordination and networking algorithms for large numbers of sensors to ensure the safe, reliable, and robust operation of advanced energy systems. Specifically, the research will derive sensor performance metrics for heterogeneous sensor networks and will demonstrate effectiveness, scalability and reconfigurability of heterogeneous sensor networks in advanced power systems.