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Task 7.1 - Strategic Planning

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By:
Daniel J. Daly
Everett A. Sondreal

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For
U.S. Department of Energy
Office of Fossil Energy
Federal Energy Technology Center
P.O. Box 880
Morgantown, West Virginia 26507-0880

By
Energy & Environmental Research Center
University of North Dakota
P. O. Box 9018
Grand Forks, North Dakota 58202-9018

DISCLAIMER

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1.0 INTRODUCTION

Energy industry decisions on resources, utilization technologies, and environmental control measures are made in reference to changing patterns of fuel cost and availability, emerging technological choices, externality impacts, and governmental policies, statutes, and regulations. Energy and environmental research that makes a difference must be performed with an awareness of the forces that shape these future trends and should anticipate needs in advance to compensate for developmental lead time. Research relevance begins with the appropriate selection of research thrust and topical content and ends with integration, interpretation, and application of results in real-world commercial development. The Energy & Environmental Research Center (EERC) has endeavored to maintain a highly relevant research focus through activities dating back to the benchmark 1980 Low-Rank Coal Study, 1983 defederalization plans, and the 1991 comprehensive white paper on energy policy and technologies. Work was completed in FY94 on an energy and environmental profile for selected East Central European nations.

2.0 OBJECTIVES

Task 7.0 continues a limited effort devoted to strategic studies under the base Cooperative Agreement. The objective of this activity is to understand the potentialities, limitations, and status of competing energy technologies in terms of scientific basis, state of development, technical barriers, cost, efficiency, policy treatment, and environmental performance for the purpose of planning and evaluating research activities under the Cooperative Agreement. This work is performed under the direction of the EERC Director and Associate Directors to provide guidance in planning the broad outline for future research under the Cooperative Agreement in keeping with industry needs and national goals. This is being accomplished through the combination of directed studies and technical oversight described below.

3.0 ACCOMPLISHMENTS

Accomplishments during this reporting period are in the following areas.

3.1 Planning and Technical Oversight

Current research was reviewed in planning for the 1998–2002 renewal of the Cooperative Agreement. Research for 1998 will be proposed based on the following priorities:

- Air toxic metals, emphasis on mercury: occurrence, measurement, transformations, and control.

- Fine respirable particulates: measurement of composition by size for primary and secondary particulates from combustion sources and avoidance/control methods.

- Assessment of past climate change and options for reducing greenhouse gas emissions: climate markers in the geological record, barriers to high-efficiency power systems, integration of fossil energy with renewable energy resources, and CO_2 sequestering.

- Waste management: mercury measurement and stabilization in solid wastes, economic treatment and remediation of liquid and solid wastes from oil and gas production and processing.

3.2 Technical Assessment

Technical and economic assessments were performed to evaluate 1) the feasibility of producing improved carbon sorbents for control of mercury emissions at moderately elevated gas temperatures (e.g., 600°F) and 2) the design features required to provide small power systems for remote Alaska Native villages in Alaska.

The commercial potential of improved sorbents developed by the EERC for capturing elemental mercury from flue gases depends on their sorptive capacity, range of temperature effectiveness, regenerability, strength and stability in a flue gas atmosphere, and cost. Strategic assessment of technical and economic potential and patent opportunity based on laboratory experiments and systems analysis is directed toward finding an industrial partner to support commercial development.

Small power systems operating on indigenous solid fuels (local coal, biomass, and municipal solid wastes) are needed to provide electricity and/or heat in remote areas in Alaska, as well as in overseas markets. Technical assessment of steam–electric and hot-air gas turbine systems utilizing fluidized-bed combustion has indicated that different design criteria will need to be applied depending on the system size and function. Solid fuel systems cannot compete with diesel electric generators in sizes below 1-MW electrical output, but they may be competitive at 1–2 MW or larger depending on the relative cost of the local solid fuel in relation to the delivered price of diesel oil. Distributed hot-water heat has the potential to be competitive in smaller-size units, but simplified designs are needed that can be integrated with the cooling water system of diesel electric generators.

3.3 Policy Review and Preparation of White Papers

Work on white papers concerning environmental issues was continued, focusing principally on updating the previous Policy Assessment on Climate Change and placing it on the EERC internet website at http://www.eerc.und.nodak.edu/960828/envirst.html. This assessment seeks to begin to understand the findings of the United Nations Intergovernmental Panel on Climate Change within the context of boundaries on global warming posed by finite economic fossil fuel reserves and long-term geologic climate variations. The result of this review at the EERC will be to place a higher priority on research activities under the Cooperative Agreement directed toward understanding and mitigating greenhouse gas emissions and climate change, including work on 1) climate markers in the geological record; 2) barriers to higher-efficiency power systems; 3) integration of fossil fuels and renewable resources, applying extensive existing background on high-alkali ash chemistry applicable to biofuels; and 4) new concepts for separating and

sequestering carbon dioxide, including engineered biosystems that can be integrated with power systems.

3.4 New and Improved Tools for Technical Evaluation

A very limited activity was directed toward extending capabilities for evaluating new technologies by using interactive spreadsheets for performing heat and material/elemental balances based on convergent iterative macros. Spreadsheets for calculating combustion stoichiometry and emission factors in relation to fuel analysis were extended to compute 1) theoretical heating values based on the elemental analysis and 2) adiabatic flame temperatures at specified conditions of air preheat and excess air. Spreadsheets for combined-cycle systems were extended to provide capabilities for on-line calculation of steam conditions (enthalpy and entropy) and isentropic expansions.

3.5 Opportunities for International Marketing of U.S. Technologies

A review of ash deposition research devoted to low-rank coals at the EERC was performed as the basis for a paper to be presented at the International Pittsburgh Coal Conference in Taiyuan, China in September 1997. The paper, entitled "Issues in Application of Advanced Power Systems to Low-Rank Coals," traces progress in combustion science and boiler design which has resulted in highly successful utilization of low-rank coals for power production in the United States, where nine of the ten steam electric plants having the lowest average operating cost over the past 5 years were fueled on lignite or subbituminous coal. Problems have been largely resolved in pulverizing and burning high-moisture coals and remediating serious ash fouling and slagging. Serious ash deposition caused by high-temperature reactions of ionically bound sodium and calcium with silicates and sulfur have been remedied through changes in design and operating parameters, including added mill capacity, larger furnaces, lower furnace exit temperatures, wider tube spacings, on-line cleaning, and combustion additives. Current issues in conventional boilers burning low-rank coals are mainly concerned with improving the control of emissions, including acid gases (SO_2 and NO_x), fine respirable particulates, and toxic metals such as volatile mercury and selenium, while maintaining stable operation and high carbon burnout. In a future concerned over possible global warming, the challenge in utilizing low-rank coals will be to achieve substantially higher efficiencies and lower carbon emissions per unit of electricity generated at a cost that competes with inherently cleaner energy sources such as natural gas and nuclear. Emerging advances in power systems based on supercritical steam cycles, combined turbine cycles (PFBC and IGCC [pressurized fluidized-bed combustion and integrated gasification combined-cycle]) and fuel cells offer significantly improved efficiencies, but new issues are raised by the distinctive utilization properties of low-rank coals in these technologies. High moisture content in low-rank coals both reduces the energy density in the coal slurry feed to pressurized systems and increases stack losses unless water can be rejected hydrothermally. The high-sodium ash and low-viscosity slag from some low-rank coals pose special problems of high-temperature corrosion and deposition on heat exchange surfaces, hot-gas filters, and turbine blades made from new ceramic and alloy materials. Fouling and slagging occurring under reducing conditions in gasifiers and hot-gas-cleaning systems are as yet not adequately understood. The very low heating value of fuel gas from air-blown gasifiers operating on coals with high moisture and oxygen contents needs to be considered in relation to the minimum requirements of a gas turbine. The successful integration of various advanced technologies under development into competitive power systems for low-rank

coal in the 21st century will depend on a better understanding of the effect of design parameters affecting coal feeding, carbon conversion, desulfurization, and hot-gas filtration for the distinctive properties of low-rank coals. Different optimum designs will be needed for retrofit and new applications burning either coal alone or in combination with biomass or natural gas and for both large baseload generating stations and small distributed power systems.

4.0 FUTURE WORK

In the coming reporting period, efforts will be focused in the areas of Planning and Technical Oversight, Technical Assessment, Policy Review, Technical Assessment Tools, and Marketing as directed by EERC senior management. In the near term, efforts will be directed toward preparation for the Cooperative Agreement review meeting scheduled to be held at the EERC in August 1997.