# Appendix B

# The Energy Policy Act of 1992

## *TITLE XIII—COAL*

### *Subtitle A—Research, Development, Demonstration, and Commercial Application*

*SEC. 1301. COAL RESEARCH, DEVELOPMENT, DEMONSTRATION, AND COMMERCIAL APPLICATION PROGRAMS.*

*(a) ESTABLISHMENT.—The Secretary shall, in accordance with section 3001 and 3002 of this Act, conduct programs for research, development, demonstration, and commercial application on coal-based technologies. Such research, development, demonstration, and commercial application programs shall include the programs established under this subtitle, and shall have the goals and objectives of—*

*(1) ensuring a reliable electricity supply;*

*(2) complying with applicable environmental requirements;*

*(3) achieving the control of sulfur oxides, oxides of nitrogen, air toxics, solid and liquid wastes, greenhouse gases, or other emissions resulting from coal use or conversion at levels of proficiency greater than or equal to applicable currently available commercial technology;*

*(4) achieving the cost competitive conversion of coal into energy forms usable in the transportation sector;*

*(5) demonstrating the conversion of coal to synthetic gaseous, liquid, and solid fuels;*

*(6) demonstrating, in cooperation with other Federal and State agencies, the use of coal-derived fuels in mobile equipment, with opportunities for industrial cost sharing participation;*

*(7) ensuring the timely commercial application of cost-effective technologies or energy production processes or systems utilizing coal which achieve—*

*(A) greater efficiency in the conversion of coal to useful energy when compared to currently available commercial technology for the use of coal; and*

*(B) the control of emissions from the utilization of coal; and*

*(8) ensuring the availability for commercial use of such technologies by the year 2010.*

*(b) DEMONSTRATION AND COMMERCIAL APPLICATION PROGRAMS.—(1) In selecting either a demonstration project or a commercial application project for financial assistance under this subtitle, the Secretary shall seek to ensure that, relative to otherwise comparable commercially available technologies or products, the selected project will meet one or more of the following criteria:*

*(A) It will reduce environmental emissions to an extent greater than required by applicable provisions of law.*

*(B) It will increase the overall efficiency of the utilization of coal, including energy conversion efficiency and, where applicable, production of products derived from coal.*

*(C) It will be a more cost-effective technological alternative, based on life cycle capital and operating costs per unit of energy produced and, where applicable, costs per unit of product produced.*

*Priority in selection shall be given to those projects which, in the judgment of the Secretary, best meet one or more of these criteria.*

*(2) In administering demonstration and commercial application programs authorized by this subtitle, the Secretary shall establish accounting and project management controls that will be adequate to control costs.*

*(3)(A) Not later than 180 days after the date of enactment of this Act, the Secretary shall establish procedures and criteria for the recoupment of the Federal share of each cost shared demonstration and commercial application project authorized pursuant to this subtitle. Such recoupment shall occur within a reasonable period of time following the date of completion of such project, but not later than 20 years following such date, taking into account the effect of recoupment on—*

*(i) the commercial competitiveness of the entity carrying out the project;*

*(ii) the profitability of the project; and*

*(iii) the commercial viability of the coal-based technology utilized.*

*(B) The Secretary may at any time waive or defer all or some portion of the recoupment requirement as necessary for the commercial viability of the project.*

*(4) Projects selected by the Secretary under this subtitle for demonstration or commercial application of a technology shall, in the judgment of the Secretary, be capable of enhancing the state of the art for such technology.*

*(c) REPORT.—Within 240 days after the date of enactment of this Act, the Secretary shall transmit to the Committee on Energy and Commerce and the Committee on Science, Space, and Technolo-*

*gy of the House of Representatives and to the Committee on Energy and Natural Resources of the Senate a report which shall include each of the following:*

*(1) A detailed description of ongoing research, development, demonstration, and commercial application activities regarding coal-based technologies undertaken by the Department of Energy, other Federal or State government departments or agencies and, to the extent such information is publicly available, other public or private organizations in the United States and other countries.*

*(2) A listing and analysis of current Federal and State government regulatory and financial incentives that could further the goals of the programs established under this subtitle.*

*(3) Recommendations regarding the manner in which any ongoing coal-based demonstration and commercial application program might be modified and extended in order to ensure the timely demonstrations of advanced coal-based technologies so as to ensure that the goals established under this section are achieved and that such demonstrated technologies are available for commercial use by the year 2010.*

*(4) Recommendations, if any, regarding the manner in which the cost sharing demonstrations conducted pursuant to the Clean Coal Program established by Public Law 98-473 might be modified and extended in order to ensure the timely demonstration of advanced coal-based technologies.*

*(5) A detailed plan for conducting the research, development, demonstration, and commercial application programs to achieve the goals and objectives of subsection (a) of this section, which plan shall include a description of—*

*(A) the program elements and management structure to be utilized;*

*(B) the technical milestones to be achieved with respect to each of the advanced coal-based technologies included in the plan; and*

*(C) the dates at which further deadlines for additional cost sharing demonstrations shall be established.*

*(d) STATUS REPORTS.—Within one year after transmittal of the report described in subsection (c), and every 2 years thereafter for a period of 6 years, the Secretary shall transmit to the Congress a report that provides a detailed description of the status of development of the advanced coal-based technologies and the research, development, demonstration, and commercial application activities undertaken to carry out the programs required by this subtitle.*

*(e) CONSULTATION.—In carrying out research, development, demonstration, and commercial application activities under this subtitle, the Secretary shall consult with the National Coal Council and other representatives of the public and private sectors as the Secretary considers appropriate.*

***SEC. 1302. COAL-FIRED DIESEL ENGINES.***

*The Secretary shall conduct a program of research, development, demonstration, and commercial application for utilizing coal-derived liquid or gaseous fuels, including ultra-clean coal-water slurries, in diesel engines. The program shall address—*

*(1) required engine retrofit technology;*
*(2) coal-fuel production technology;*
*(3) emission control requirements;*
*(4) the testing of low-Btu highly reactive fuels;*
*(5) fuel delivery and storage systems requirements; and*
*(6) other infrastructure required to support commercial deployment.*

*SEC. 1303. CLEAN COAL, WASTE-TO-ENERGY.*

*The Secretary shall establish a program of research, development, demonstration, and commercial application with respect to the use of solid waste combined with coal as a fuel source for clean coal combustion technologies. The program shall address—*

*(1) the feasibility of cofiring coal and used vehicle tires in fluidized bed combustion units;*
*(2) the combined gasification of coal and municipal sludge using integrated gasification combined cycle technology;*
*(3) the creation of fuel pellets combining coal and material reclaimed from solid waste;*
*(4) the feasibility of cofiring, in fluidized bed combustion units, waste methane from coal mines, including ventilation air, together with coal or coal wastes; and*
*(5) other sources of waste and coal mixtures in other applications that the Secretary considers appropriate.*

*SEC. 1304. NONFUEL USE OF COAL.*

*(a) PROGRAM.—The Secretary shall prepare a plan for and carry out a program of research, development, demonstration, and commercial application with respect to technologies for the nonfuel use of coal, including—*

*(1) production of coke and other carbon products derived from coal;*
*(2) production of coal-derived, carbon-based chemical intermediates that are precursors of value-added chemicals and polymers;*
*(3) production of chemicals from coal-derived synthesis gas;*
*(4) coal treatment processes, including methodologies such as solvent-extraction techniques that produce low ash, low sulfur, coal-based chemical feedstocks; and*
*(5) waste utilization, including recovery, processing, and marketing of products derived from sulfur, carbon dioxide, nitrogen, and ash from coal.*

*(b) PLAN CONTENTS.—The plan described in subsection (a) shall address and evaluate—*

*(1) the known and potential processes for using coal in the creation of products in the chemical, utility, fuel, and carbon-based materials industries;*
*(2) the costs, benefits, and economic feasibility of using coal products in the chemical and materials industries, including value-added chemicals, carbon-based products, coke, and waste derived from coal;*
*(3) the economics of coproduction of products from coal in conjunction with the production of electric power, thermal energy, and fuel;*

*(4) the economics of the refining of coal and coal byproducts to produce nonfuel products;*

*(5) the economics of coal utilization in comparison with other feedstocks that might be used for the same purposes;*

*(6) the steps that can be taken by the public and private sectors to bring about commercialization of technologies developed under the program recommended; and*

*(7) the past development, current status, and future potential of coal products and processes associated with nonfuel uses of coal.*

***SEC. 1305. COAL REFINERY PROGRAM.***

*(a) PROGRAM.—The Secretary shall conduct a program of research, development, demonstration, and commercial application for coal refining technologies.*

*(b) OBJECTIVES.—The program shall include technologies for refining high sulfur coals, low sulfur coals, sub-bituminous coals, and lignites to produce clean-burning transportation fuels, compliance boiler fuels, fuel additives, lubricants, chemical feedstocks, and carbon-based manufactured products, either alone or in conjunction with the generation of electricity or process heat, or the manufacture of a variety of products from coal. The objectives of such program shall be to achieve—*

*(1) the timely commercial application of technologies, including mild gasification, hydrocracking and other hydropyrolysis processes, and other energy production processes or systems to produce coal-derived fuels and coproducts, which achieve greater efficiency and economy in the conversion of coal to electrical energy and coproducts than currently available technology;*

*(2) the production of energy, fuels, and products which, on a complete energy system basis, will result in environmental emissions no greater than those produced by existing comparable energy systems utilized for the same purpose;*

*(3) the capability to produce a range of coal-derived transportation fuels, including oxygenated hydrocarbons, boiler fuels, turbine fuels, and coproducts, which can reduce dependence on imported oil by displacing conventional petroleum in the transportation sector and other sectors of the economy;*

*(4) reduction in the cost of producing such coal-derived fuels and coproducts;*

*(5) the control of emissions from the combustion of coal-derived fuels; and*

*(6) the availability for commercial use of such technologies by the year 2000.*

***SEC. 1306. COALBED METHANE RECOVERY.***

*(a) STUDY OF BARRIERS AND ENVIRONMENTAL AND SAFETY ASPECTS.—The Secretary, in consultation with the Administrator of the Environmental Protection Agency and the Secretary of the Interior, shall conduct a study of—*

*(1) technical, economic, financial, legal, regulatory, institutional, or other barriers to coalbed methane recovery, and of policy options for eliminating such barriers; and*

*(2) the environmental and safety aspects of flaring coalbed methane liberated from coal mines.*

*Within two years after the date of enactment of this Act, the Secretary shall submit a report to the Congress detailing the results of such study.*

*(b) INFORMATION DISSEMINATION.—Beginning one year after the date of enactment of this Act, the Secretary, in consultation with the Administrator of the Environmental Protection Agency and the Secretary of the Interior, shall disseminate to the public information on state-of-the-art coalbed methane recovery techniques, including information on costs and benefits.*

*(c) DEMONSTRATION AND COMMERCIAL APPLICATION PROGRAM.—The Secretary, in consultation with the Administrator of the Environmental Protection Agency and the Secretary of the Interior, shall establish a coalbed methane recovery demonstration and commercial application program, which shall emphasize gas enrichment technology. Such program shall address—*

*(1) gas enrichment technologies for enriching medium-quality methane recovered from coal mines to pipeline quality;*

*(2) technologies to use mine ventilation air in nearby power generation facilities, including gas turbines, internal combustion engines, or other coal fired powerplants;*

*(3) technologies for cofiring methane recovered from mines, including methane from ventilation systems and degasification systems, together with coal in conventional or clean coal technology boilers; and*

*(4) other technologies for producing and using methane from coal mines that the Secretary considers appropriate.*

*SEC. 1307. METALLURGICAL COAL DEVELOPMENT.*

*(a) The Secretary shall establish a research, development, demonstration, and commercial application program on metallurgical coal utilization for the purpose of developing techniques that will lead to the greater and more efficient utilization of the Nation's metallurgical coal resources.*

*(b) The program referred to in subsection (a) shall include the use of metallurgical coal—*

*(1) as a boiler fuel for the purpose of generating steam to produce electricity, including blending metallurgical coal with other coals in order to enhance its efficient application as a boiler fuel;*

*(2) as an ingredient in the manufacturing of steel; and*

*(3) as a source of pipeline quality coalbed methane.*

*SEC. 1308. UTILIZATION OF COAL WASTES.*

*(a) COAL WASTE UTILIZATION PROGRAM.—The Secretary, in consultation with the Secretary of the Interior, shall establish a research, development, demonstration, and commercial application program on coal waste utilization for the purpose of developing techniques that will lead to the greater and more efficient utilization of coal wastes from mining and processing, other than coal ash.*

*(b) USE AS BOILER FUEL.—The program referred to in subsection (a) shall include projects to facilitate the use of coal wastes from mining and processing as a boiler fuel for the purpose of generating steam to produce electricity.*

*SEC. 1309. UNDERGROUND COAL GASIFICATION.*

*(a) PROGRAM.—The Secretary shall conduct a research, development, demonstration, and commercial application program for underground coal gasification technology for in-situ conversion of coal to a cleaner burning, easily transportable gaseous fuel. The goal and objective of this program shall be to accelerate the development and commercialization of underground coal gasification. In carrying out this program, the Secretary shall give equal consideration to all ranks of coal.*

*(b) DEMONSTRATION PROJECTS.—As part of the program authorized in subsection (a), the Secretary may solicit proposals for underground coal gasification technology projects to fulfill the goal and objective of subsection (a).*

*SEC. 1310. LOW-RANK COAL RESEARCH AND DEVELOPMENT.*

*The Secretary shall pursue a program of research and development with respect to the technologies needed to expand the use of low-rank coals which take into account the unique properties of lignites and sub-bituminous coals, including, but not limited to, the following areas—*

*(1) high value-added carbon products;*

*(2) fuel cell applications;*

*(3) emissions control and combustion efficiencies;*

*(4) coal water fuels and underground coal gasification;*

*(5) distillates; and*

*(6) any other technologies which will assist in the development of niche markets for lignites and sub-bituminous coals.*

*SEC. 1311. MAGNETOHYDRODYNAMICS.*

*(a) PROGRAM.—The Secretary shall carry out a research, development, demonstration, and commercial application program in magnetohydrodynamics. The purpose of this program shall be to determine the adequacy of the engineering and design information completed to date under Department of Energy contracts related to magnetohydrodynamics retrofit systems and to determine whether any further Federal investment in this technology is warranted.*

*(b) SOLICITATION OF PROPOSALS.—In order to carry out the program authorized in subsection (a), the Secretary may solicit proposals from the private sector and seek to enter into an agreement with appropriate parties.*

*SEC. 1312. OIL SUBSTITUTION THROUGH COAL LIQUEFACTION.*

*(a) PROGRAM DIRECTION.—The Secretary shall conduct a program of research, development, demonstration, and commercial application for the purpose of developing economically and environmentally acceptable advanced technologies for oil substitution through coal liquefaction.*

*(b) PROGRAM GOALS.—The goals of the program established under subsection (a) shall include—*

*(1) improved resource selection and product quality;*

*(2) the development of technologies to increase net yield of liquid fuel product per ton of coal;*

*(3) an increase in overall thermal efficiency; and*

*(4) a reduction in capital and operating costs through technology improvements.*

*(c) PROPOSALS.—Within 180 days after the date of enactment of this Act, the Secretary shall solicit proposals for conducting activities under this section.*

*SEC. 1313. AUTHORIZATION OF APPROPRIATIONS.*

*There are authorized to be appropriated to the Secretary for carrying out this subtitle $278,139,000 for fiscal year 1993 and such sums as may be necessary for fiscal years 1994 through 1997.*

## *Subtitle B—Clean Coal Technology Program*

*SEC. 1321. ADDITIONAL CLEAN COAL TECHNOLOGY SOLICITATIONS.*

*(a) PROGRAM DESIGN.—Additional clean coal technology solicitations described in subsection (b) shall be designed to ensure the timely development of cost-effective technologies or energy production processes or systems utilizing coal that achieve greater efficiency in the conversion of coal to useful energy when compared to currently commercially available technology for the use of coal and the control of emissions from the combustion of coal. Such program shall be designed to ensure, to the greatest extent possible, the availability for commercial use of such technologies by the year 2010.*

*(b) ADDITIONAL SOLICITATIONS.—In conducting the Clean Coal Program established by Public Law 98-473, the Secretary shall consider the potential benefits of conducting additional solicitations pursuant to such program and, based on the results of that consideration, may carry out such additional solicitations, which shall be similar in scope and percentage of Federal cost sharing as that provided by Public Law 101-121.*

## *Subtitle C—Other Coal Provisions*

*SEC. 1331. CLEAN COAL TECHNOLOGY EXPORT PROMOTION AND INTERAGENCY COORDINATION.*

*(a) ESTABLISHMENT.—There shall be established within the Trade Promotion Coordinating Committee (established by the President on May 23, 1990, a Clean Coal Technology Subgroup (in this subtitle referred to as the "CCT Subgroup") to focus interagency efforts on clean coal technologies. The CCT Subgroup shall seek to expand the export and use of clean coal technologies, particularly in those countries which can benefit from gains in the efficiency of, and the control of environmental emissions from, coal utilization.*

*(b) MEMBERSHIP.—The CCT Subgroup shall include 1 member from each agency represented on the Energy, Environment, and Infrastructure Working Group of the Trade Promotion Coordinating Committee as of the date of enactment of this Act. The Secretary shall serve as chair of the CCT Subgroup and shall be responsible for ensuring that the functions of the CCT Subgroup are carried out through its member agencies.*

*(c) CONSULTATION.—(1) In carrying out this section, the CCT Subgroup shall consult with representatives from the United States coal industry, representatives of railroads and other transportation industries, organizations representing workers, the electric utility industry, manufacturers of equipment utilizing clean coal technology,*

*members of organizations formed to further the goals of environmental protection or to promote the development and use of clean coal technologies that are developed, manufactured, or controlled by United States firms, and other appropriate interested members of the public.*

*(2) The CCT Subgroup shall maintain ongoing liaison with other elements of the Trade Promotion Coordinating Committee relating to clean coal technologies or regions where these technologies could be important, including Eastern Europe, Asia, and the Pacific.*

*(d) DUTIES.—The Secretary, acting through the CCT Subgroup, shall—*

*(1) facilitate the establishment of technical training for the consideration, planning, construction, and operation of clean coal technologies by end users and international development personnel;*

*(2) facilitate the establishment of and, where practicable, cause to be established, consistent with the goals and objectives stated in section 1301(a), within existing departments and agencies—*

*(A) financial assistance programs (including grants, loan guarantees, and no interest and low interest loans) to support prefeasibility and feasibility studies for projects that will utilize clean coal technologies; and*

*(B) loan guarantee programs, grants, and no interest and low interest loans designed to facilitate access to capital and credit in order to finance such clean coal technology projects;*

*(3) develop and ensure the execution of programs, including the establishment of financial incentives, to encourage and support private sector efforts in exports of clean coal technologies that are developed, manufactured, or controlled by United States firms;*

*(4) encourage the training in, and understanding of, clean coal technologies by representatives of foreign companies or countries intending to use coal or clean coal technologies by providing technical or financial support for training programs, workshops, and other educational programs sponsored by United States firms;*

*(5) educate loan officers and other officers of international lending institutions, commercial and energy attachés of the United States, and such other personnel as the CCT Subgroup considers appropriate, for the purposes of providing information about clean coal technologies to foreign governments or potential project sponsors of clean coal technology projects;*

*(6) develop policies and practices to be conducted by commercial and energy attachés of the United States, and such other personnel as the CCT Subgroup considers appropriate, in order to promote the exports of clean coal technologies to those countries interested in or intending to utilize coal resources;*

*(7) augment budgets for trade and development programs supported by Federal agencies for the purpose of financially supporting prefeasibility or feasibility studies for projects in foreign countries that will utilize clean coal technologies;*

*(8) review ongoing clean coal technology projects and review and advise Federal agencies on the approval of planned clean coal technology projects which are sponsored abroad by any Federal agency to determine whether such projects are consistent with the overall goals and objectives of this section;*

*(9) coordinate the activities of the appropriate Federal agencies in order to ensure that Federal clean coal technology export promotion policies are implemented in a timely fashion;*

*(10) work with CCT Subgroup member agencies to develop an overall strategy for promoting clean coal technology exports, including setting goals and allocating specific responsibilities among member agencies, consistent with applicable statutes; and*

*(11) coordinate with multilateral institutions to ensure that United States technologies are properly represented in their projects.*

*(e) DATA AND INFORMATION.—(1) The CCT Subgroup, consistent with other applicable provisions of law, shall ensure the development of a comprehensive data base and information dissemination system, using the National Trade Data Bank and the Commercial Information Management System of the Department of Commerce, relating to the availability of clean coal technologies and the potential need for such technologies, particularly in developing countries and countries making the transition from nonmarket to market economies.*

*(2) The Secretary, acting through the CCT Subgroup, shall assess and prioritize foreign markets that have the most potential for the export of clean coal technologies that are developed, manufactured, or controlled by United States firms. Such assessment shall include—*

*(A) an analysis of the financing requirements for clean coal technology projects in foreign countries and whether such projects are dependent upon financial assistance from foreign countries or multilateral institutions;*

*(B) the availability of other fuel or energy resources that may be available to meet the energy requirements intended to be met by the clean coal technology projects;*

*(C) the priority of environmental considerations in the selection of such projects;*

*(D) the technical competence of those entities likely to be involved in the planning and operation of such projects;*

*(E) an objective comparison of the environmental, energy, and economic performance of each clean coal technology relative to conventional technologies;*

*(F) a list of United States vendors of clean coal technologies; and*

*(G) answers to commonly asked questions about clean coal technologies,*

*The Secretary, acting through the CCT Subgroup, shall make such information available to the House of Representatives and the Senate, and to the appropriate committees of each House of Congress, industry, Federal and international financing organizations, nongovernmental organizations, potential customers abroad, govern-*

*ments of countries where such clean coal technologies might be used, and such others as the CCT Subgroup considers appropriate.*

*(f) REPORT.—Within 180 days after the Secretary submits the report to the Congress as required by section 409 of Public Law 101-549, the Secretary, acting through the CCT Subgroup, shall provide to the appropriate committees of the House of Representatives and the Committee on Energy and Natural Resources of the Senate, a plan which details actions to be taken in order to address those recommendations and findings made in the report submitted pursuant to section 409 of Public Law 101-549. As a part of the plan required by this subsection, the Secretary, acting through the CCT Subgroup, shall specifically address the adequacy of financial assistance available from Federal departments and agencies and international financing organizations to aid in the financing of prefeasibility and feasibility studies and projects that would use a clean coal technology in developing countries and countries making the transition from nonmarket to market economies.*

*SEC. 1332. INNOVATIVE CLEAN COAL TECHNOLOGY TRANSFER PROGRAM.*

*(a) ESTABLISHMENT OF PROGRAM.—The Secretary, through the Agency for International Development, and in consultation with the other members of the CCT Subgroup, shall establish a clean coal technology transfer program to carry out the purposes described in subsection (b). Within 150 days after the date of enactment of this Act, the Secretary and the Administrator of the Agency for International Development shall enter into a written agreement to carry out this section. The agreement shall establish a procedure for resolving any disputes between the Secretary and the Administrator regarding the implementation of specific projects. With respect to countries not assisted by the Agency for International Development, the Secretary may enter into agreements with other appropriate United States agencies. If the Secretary and the Administrator, or the Secretary and an agency described in the previous sentence, are unable to reach an agreement, each shall send a memorandum to the President outlining an appropriate agreement. Within 90 days after receipt of either memorandum, the President shall determine which version of the agreement shall be in effect. Any agreement entered into under this subsection shall be provided to the appropriate committees of the Congress and made available to the public.*

*(b) PURPOSES OF THE PROGRAM.—The purposes of the technology transfer program under this section are to—*

*(1) reduce the United States balance of trade deficit through the export of United States energy technologies and technological expertise;*

*(2) retain and create manufacturing and related service jobs in the United States;*

*(3) encourage the export of United States technologies, including services related thereto, to those countries that have a need for developmentally sound facilities to provide energy derived from coal resources;*

*(4) develop markets for United States technologies and, where appropriate, United States coal resources to be utilized in meeting the energy and environmental requirements of foreign countries;*

*(5) better ensure that United States participation in energy-related projects in foreign countries includes participation by United States firms as well as utilization of United States technologies that have been developed or demonstrated in the United States through publicly or privately funded demonstration programs;*

*(6) provide for the accelerated deployment of United States technologies that will serve to introduce into foreign countries United States technologies intended to use coal resources in a more efficient, cost-effective, and environmentally acceptable manner;*

*(7) serve to ensure the introduction of United States firms and expertise in foreign countries;*

*(8) provide financial assistance by the Federal Government to foster greater participation by United States firms in the financing, ownership, design, construction, or operation of clean coal technology projects in foreign countries;*

*(9) assist foreign countries in meeting their energy needs through the use of coal in an environmentally acceptable manner, consistent with sustainable development policies; and*

*(10) assist United States firms, especially firms that are in competition with firms in foreign countries, to obtain opportunities to transfer technologies to, or undertake projects in, foreign countries.*

*(c) IDENTIFICATION.—Pursuant to the agreements required by subsection (a), the Secretary, through the Agency for International Development, and after consultation with the CCT Subgroup, United States firms, and representatives from foreign countries, shall develop mechanisms to identify potential energy projects in host countries, and shall identify a list of such projects within 240 days after the date of enactment of this Act, and periodically thereafter.*

*(d) FINANCIAL MECHANISMS.—(1) Pursuant to the agreements under subsection (a), the Secretary, through the Agency for International Development, shall—*

*(A) establish appropriate financial mechanisms to increase the participation of United States firms in energy projects utilizing United States clean coal technologies, and services related thereto, in developing countries and countries making the transition from nonmarket to market economies;*

*(B) utilize available financial assistance authorized by this section to counterbalance assistance provided by foreign governments to non-United States firms; and*

*(C) provide financial assistance to support projects, including—*

*(i) financing the incremental costs of a clean coal technology project attributable only to expenditures to prevent or abate emissions;*

*(ii) providing the difference between the costs of a conventional energy project in the host country and a comparable project that would utilize a clean coal technology capable of achieving greater efficiency of energy products and improved environmental emissions compared to such conventional project; and*

*(iii) such other forms of financial assistance as the Secretary, through the Agency for International Development, considers appropriate.*

*(2) The financial assistance authorized by this section may be—*

*(A) provided in combination with other forms of financial assistance, including non-United States funding that is available to the project; and*

*(B) utilized to assist United States firms to develop innovative financing packages for clean coal technology projects that seek to utilize other financial assistance programs available through other Federal agencies.*

*(3) United States obligations under the Arrangement on Guidelines for Officially Supported Export Credits established through the Organization for Economic Cooperation and Development shall be applicable to this section.*

*(e) SOLICITATIONS FOR PROJECT PROPOSALS.—(1) Pursuant to the agreements under subsection (a), the Secretary, through the Agency for International Development, within one year after the date of enactment of this Act, and subsequently as appropriate thereafter, shall solicit proposals from United States firms for the design, construction, testing, and operation of the project or projects identified under subsection (c) which propose to utilize a United States technology. Each solicitation under this section shall establish a closing date for receipt of proposals.*

*(2) The solicitation under this subsection shall, to the extent appropriate, be modeled after the RFP No. DE-PS01-90FE62271 Clean Coal Technology IV as administered by the Department of Energy.*

*(3) Any solicitation made under this subsection shall include the following requirements:*

*(A) The United States firm that submits a proposal in response to the solicitation shall have an equity interest in the proposed project.*

*(B) The project shall utilize a United States clean coal technology, including services related thereto, and, where appropriate, United States coal resources, in meeting the applicable energy and environmental requirements of the host country.*

*(C) Proposals for projects shall be submitted by and undertaken with a United States firm, although a joint venture or other teaming arrangement with a non-United States manufacturer or other non-United States entity is permissible.*

*(f) ASSISTANCE TO UNITED STATES FIRMS.—Pursuant to the agreements under subsection (a), the Secretary, through the Agency for International Development, and in consultation with the CCT Subgroup, shall establish a procedure to provide financial assistance to United States firms under this section for a project identified under subsection (c) where solicitations for the project are being conducted by the host country or by a multilateral lending institution.*

*(g) OTHER PROGRAM REQUIREMENTS.—Pursuant to the agreements under subsection (a), the Secretary, through the Agency for International Development, and in consultation with the CCT Subgroup, shall—*

*(1) establish eligibility criteria for countries that will host projects;*

*(2) periodically review the energy needs of such countries and export opportunities for United States firms for the development of projects in such countries;*

*(3) consult with government officials in host countries and, as appropriate, with representatives of utilities or other entities in host countries, to determine interest in and support for potential projects; and*

*(4) determine whether each project selected under this section is developmentally sound, as determined under the criteria developed by the Development Assistance Committee of the Organization for Economic Cooperation and Development.*

*(h) SELECTION OF PROJECTS.—(1) Pursuant to the agreements under subsection (a), the Secretary, through the Agency for International Development, shall, not later than 120 days after receipt of proposals in response to a solicitation under subsection (e), select one or more proposals under this section.*

*(2) In selecting a proposal under this section, the Secretary, through the Agency for International Development, shall consider—*

*(A) the ability of the United States firm, in cooperation with the host country, to undertake and complete the project;*

*(B) the degree to which the equipment to be included in the project is designed and manufactured in the United States;*

*(C) the long-term technical and competitive viability of the United States technology, and services related thereto, and the ability of the United States firm to compete in the development of additional energy projects using such technology in the host country and in other foreign countries;*

*(D) the extent of technical and financial involvement of the host country in the project;*

*(E) the extent to which the proposed project meets the goals and objectives stated in section 1301(a);*

*(F) the extent of technical, financial, management, and marketing capabilities of the participants in the project, and the commitment of the participants to completion of a successful project in a manner that will facilitate acceptance of the United States technology for future application; and*

*(G) such other criteria as may be appropriate.*

*(3) In selecting among proposed projects, the Secretary shall seek to ensure that, relative to otherwise comparable projects in the host country, a selected project will meet 1 or more of the following criteria:*

*(A) It will reduce environmental emissions to an extent greater than required by applicable provisions of law.*

*(B) It will increase the overall efficiency of the utilization of coal, including energy conversion efficiency and, where applicable, production of products derived from coal.*

*(C) It will be a more cost-effective technological alternative, based on life cycle capital and operating costs per unit of energy produced and, where applicable, costs per unit of product produced.*

*Priority in selection shall be given to those projects which, in the judgment of the Secretary, best meet one or more of these criteria.*

*(i) UNITED STATES-ASIA ENVIRONMENTAL PARTNERSHIP.—Activities carried out under this section shall be coordinated with the United States-Asia Environmental Partnership.*

*(j) BUY AMERICA.—In carrying out this section, the Secretary, through the Agency for International Development, and pursuant to the agreements under subsection (a), shall ensure—*

*(1) the maximum percentage, but in no case less than 50 percent, of the cost of any equipment furnished in connection with a project authorized under this section shall be attributable to the manufactured United States components of such equipment; and*

*(2) the maximum participation of United States firms.*

*In determining whether the cost of United States components equals or exceeds 50 percent, the cost of assembly of such United States components in the host country shall not be considered a part of the cost of such United States component.*

*(k) REPORTS TO CONGRESS.—The Secretary and the Administrator of the Agency for International Development shall report annually to the Committee on Energy and Natural Resources of the Senate and the appropriate committees of the House of Representatives on the progress being made to introduce clean coal technologies into foreign countries.*

*(l) DEFINITION.—For purposes of this section, the term "host country" means a foreign country which is—*

*(1) the participant in or the site of the proposed clean coal technology project; and*

*(2) either—*

*(A) classified as a country eligible to participate in development assistance programs of the Agency for International Development pursuant to applicable law or regulation; or*

*(B) a developing country or country with an economy in transition from a nonmarket to a market economy.*

*(m) AUTHORIZATION FOR PROGRAM.—There are authorized to be appropriated to the Secretary to carry out the program required by this section, $100,000,000 for each of the fiscal years 1993, 1994, 1995, 1996, 1997, and 1998.*

***SEC. 1333. CONVENTIONAL COAL TECHNOLOGY TRANSFER.***

*If the Secretary determines that the utilization of a clean coal technology is not practicable for a proposed project and that a United States conventional coal technology would constitute a substantial improvement in efficiency, costs, and environmental performance relative to the technology being used in a developing country or country making the transition from nonmarket to market economies, with significant indigenous coal resources, such technology shall. for purposes of sections 1321 and 1322, be considered a clean coal technology. In the case of combustion technologies, only the retrofit, repowering, or replacement of a conventional technology shall constitute a substantial improvement for purposes of this section. In carrying out this section, the Secretary shall give highest priority to promoting the most environmentally sound and energy efficient technologies.*

*SEC. 1334. STUDY OF UTILIZATION OF COAL COMBUSTION BYPRODUCTS.*

*(a) DEFINITION.—As used in this section, the term "coal combustion byproducts" means the residues from the combustion of coal including ash, slag, and flue gas desulfurization materials.*

*(b) STUDY AND REPORT TO CONGRESS.—(1) The Secretary shall conduct a detailed and comprehensive study on the institutional, legal, and regulatory barriers to increased utilization of coal combustion byproducts by potential governmental and commercial users. Such study shall identify and investigate barriers found to exist at the Federal, State, or local level, which may have limited or may have the foreseeable effect of limiting the quantities of coal combustion byproducts that are utilized. In conducting this study, the Secretary shall consult with other departments and agencies of the Federal Government, appropriate State and local governments, and the private sector.*

*(2) Not later than one year after the date of enactment of this Act, the Secretary shall submit a report to the Congress containing the results of the study required by paragraph (1) and the Secretary's recommendations for action to be taken to increase the utilization of coal combustion byproducts. At a minimum, such report shall identify actions that would increase the utilization of coal combustion byproducts in—*

*(A) bridge and highway construction;*

*(B) stabilizing wastes;*

*(C) procurement by departments and agencies of the Federal Government and State and local governments; and*

*(D) federally funded or federally subsidized procurement by the private sector.*

*SEC. 1335. CALCULATION OF AVOIDED COST.*

*Nothing in section 210 of the Public Utility Regulatory Policies Act of 1978 (Public Law 95-617) requires a State regulatory authority or nonregulated electric utility to treat a cost reasonably identified to be incurred or to have been incurred in the construction or operation of a facility or a project which has been selected by the Department of Energy and provided Federal funding pursuant to the Clean Coal Program authorized by Public Law 98-473 as an incremental cost of alternative electric energy.*

*SEC. 1336. COAL FUEL MIXTURES.*

*Within one year following the date of enactment of this Act, the Secretary shall submit a report to the Committee on Energy and Commerce and the Committee on Science, Space, and Technology of the House of Representatives and the Committee on Energy and Natural Resources of the Senate on the status of technologies for combining coal with other materials, such as oil or water fuel mixtures. The report shall include—*

*(1) a technical and economic feasibility assessment of such technologies;*

*(2) projected developments in such technologies;*

*(3) an assessment of the market potential of such technologies, including the potential to displace imported crude oil and refined petroleum products;*

*(4) identification of barriers to commercialization of such technologies; and*

*(5) recommendations for addressing barriers to commercialization.*

*SEC. 1337. NATIONAL CLEARINGHOUSE.*

*(a) FEASIBILITY.—(1) The Secretary shall assess the feasibility of establishing a national clearinghouse for the exchange and dissemination of technical information on technology relating to coal and coal-derived fuels.*

*(2) In assessing the feasibility, the Secretary shall consider whether such a clearinghouse would be appropriate for purposes of—*

*(A) collecting information and data on technology relating to coal, and coal-derived fuels, which can be utilized to improve environmental quality and increase energy independence;*

*(B) disseminating to appropriate individuals, governmental departments, agencies, and instrumentalities, institutions of higher education, and other entities, information and data collected pursuant to this section;*

*(C) maintaining a library of technology publications and treatises relating to technology information and data collected pursuant to this section;*

*(D) organizing and conducting seminars for government officials, utilities, coal companies, and other entities or institutions relating to technology using coal and coal-derived fuels that will improve environmental quality and increase energy independence;*

*(E) gathering information on research grants made for the purpose of improving or enhancing technology relating to the use of coal, and coal-derived fuels, which will improve environmental quality and increase energy independence;*

*(F) translating into English foreign research papers, articles, seminar proceedings, test results that affect, or could affect, clean coal use technology, and other documents;*

*(G) encouraging, during the testing of technologies, the use of coal from a variety of domestic sources, and collecting or developing, or both, complete listings of test results using coals from all sources;*

*(H) establishing and maintaining an index or compilation of research projects relating to clean coal technology carried out throughout the world; and*

*(I) conducting economic modeling for feasibility of projects.*

*(b) AUTHORITY TO ESTABLISH CLEARINGHOUSE.—Based upon the assessment under subsection (a), the Secretary may establish a clearinghouse.*

*SEC. 1338. COAL EXPORTS.*

*(a) PLAN.—Within 180 days after the date of enactment of this Act, the Secretary of Commerce, in cooperation with the Secretary and other appropriate Federal agencies, shall submit to the appropriate committees of the House of Representatives and the Committee on Energy and Natural Resources of the Senate a plan for expanding exports of coal mined in the United States.*

*(b) PLAN CONTENTS.—The plan submitted under subsection (a) shall include—*

# TITLE XX—GENERAL PROVISIONS; REDUCTION OF OIL VULNERABILITY

## Subtitle A—Oil and Gas Supply Enhancement

SEC. 2013. NATURAL GAS SUPPLY.

(a) PROGRAM DIRECTION.—The Secretary shall conduct a 5-year program, in accordance with section 3001 and 3002 of this Act, to increase the recoverable natural gas resource base including, but not limited to—

(1) more intensive recovery of natural gas from discovered conventional resources;

(2) the extraction of natural gas from tight gas sands and devonian shales or other unconventional sources;

(3) surface gasification of coal; and

(4) recovery of methane from biofuels including municipal solid waste.

(b) PROPOSALS.—Within 1 year after the date of enactment of this Act, the Secretary shall solicit proposals for conducting activities under this section.

(c) COFIRING OF NATURAL GAS AND COAL.—

(1) PROGRAM.—The Secretary shall establish and carry out a 5-year program, in accordance with sections 3001 and 3002 of this Act, on cofiring natural gas with coal in utility and large industrial boilers in order to determine optimal natural gas injection levels for both environmental and operational benefits.

(2) FINANCIAL ASSISTANCE.—The Secretary shall enter into agreements with, and provide financial assistance to, appropriate parties for application of cofiring technologies to boilers to demonstrate this technology.

(3) REPORT TO CONGRESS.—The Secretary shall, before December 31, 1995, submit to the Congress a report on the progress made in carrying out this subsection.

(d) AUTHORIZATION OF APPROPRIATIONS.—There are authorized to be appropriated to the Secretary for carrying out this section and sections 2014 and 2015, $29,745,000 for fiscal year 1993 and $45,000,000 for fiscal year 1994.

# Appendix C

# DOE Budget Data

DOE Fossil Energy Coal R&D Budget, FY 1976 through FY 1994

| Activity | FY 1976 | FY 1977 | FY 1978 | FY 1979 |
|---|---|---|---|---|
| Coal | 310,598 | | | |
| Coal Liquefaction | | 103,000 | 107,400 | 197,426 |
| Surface Coal Gasification | | 94,506 | 193,900 | 164,598 |
| Advanced Power Systems | | 22,500 | 25,700 | 26,900 |
| Direct Combustion | | 51,916 | 60,400 | 51,701 |
| Advanced Research and Technology Development | | 44,135 | 49,900 | 64,551 |
| Demonstration Plants | | 53,000 | 44,900 | |
| Magnetohydrodynamics | | 40,000 | 70,500 | 80,000 |
| In Situ Gasification | | 8,236 | 12,600 | |
| Mining R&D | | | | 75,836 |
| Advanced Environmental Control Technologies | | | | 7,000 |
| TOTAL | $310,598 | $417,293 | $565,300 | $668,012 |

| Activity | FY 1980 | FY 1981 | FY 1982 | FY 1983 | FY 1984 |
|---|---|---|---|---|---|
| Control Technologies and Coal Preparation | 38,250 | 37,500 | 21,984 | 27,900[a] | 26,000 |
| Advanced Research and Technology Development | 56,150 | 58,261 | 56,256 | 35,950 | 45,790 |
| Coal Liquefaction | 250,306 | 521,400 | 98,784 | 37,600 | 28,900 |
| Combustion Systems | 50,850 | 56,500 | 30,544 | 24,200 | 18,200 |
| Fuel Cells | 26,500 | 32,000 | 34,464 | 30,050 | 42,600 |
| Heat Engines | 50,500 | 36,400 | 15,408 | 5,000 | 6,500 |
| Underground Coal Gasification | 10,000 | 10,000 | 8,256 | 6,000 | 6,000 |
| Magnetohydrodynamics | 75,000 | 67,000 | 21,840 | 29,000 | 30,000 |
| Mining R&D | 68,850 | 49,500 | 14,160 | | |
| Surface Coal Gasification | 115,850 | 164,900 | 53,088 | 39,000 | 35,790 |
| TOTAL | $742,256 | $1,033,461 | $354,784 | $234,700 | $239,780 |

[a]In FY 1983, coal preparation was transferred from the Mining R&D activity to a new activity, Control Technologies and Coal Preparation, which also incorporated the earlier Advanced Environment Control Technologies activity. The new Mining R&D activity was transferred to the U.S. Bureau of Mines.

| Activity | FY 1985 | FY 1986 | FY 1987 | FY 1988 | FY 1989 |
|---|---|---|---|---|---|
| Control Technologies and Coal Preparation | 35,083 | 33,256 | 37,826 | 41,578 | 48,927 |
| Advanced Research and Technology Development | 40,011 | 35,233 | 32,387 | 31,877 | 25,564 |
| Coal Liquefaction | 25,815 | 32,912 | 24,107 | 27,129 | 32,389 |
| Combustion Systems | 30,218 | 30,302 | 15,142 | 21,816 | 26,696 |
| Fuel Cells | 40,811 | 35,449 | 28,084 | 32,653 | 26,534 |
| Heat Engines | 11,948 | 12,817 | 12,146 | 17,945 | 22,832 |
| Underground Coal Gasification | 5,753 | 4,238 | 2,370 | 2,777 | 1,371 |
| Magnetohydrodynamics | 30,977 | 28,850 | 26,500 | 35,000 | 37,000 |
| Surface Coal Gasification | 32,011 | 43,011 | 24,655 | 22,993 | 21,557 |
| TOTAL | $252,627 | $256,068 | $203,217 | $233,768 | $242,870 |

| Activity | FY 1990 | FY 1991 | FY 1992 | FY 1993 | FY 1994 |
|---|---|---|---|---|---|
| Control Technology and Coal Preparation | 58,376 | 55,724 | 51,063 | 42,574 | 46,081 |
| Advanced Research and Technology Development | 26,738 | 31,376 | 30,227 | 26,520 | 29,021 |
| Coal Liquefaction | 34,982 | 42,677 | 39,463 | 37,357 | 34,204 |
| Combustion Systems | 33,615 | 36,909 | 37,680 | 36,676 | 46,434 |
| Fuel Cells | 38,501 | 42,890 | 51,305 | 51,128 | [b] |
| Heat Engines | 21,219 | 23,615 | 18,184 | 4,330 | |
| Underground Coal Gasification | 826 | 790 | | | |
| Magnetohydrodynamics | 40,900 | 40,039 | 40,286 | 30,325 | 4,822 |
| Surface Coal Gasification | 23,737 | 15,046 | 11,109 | 10,871 | 15,700 |
| TOTAL | $278,894 | $289,066 | $279,317 | $239,781 | $176,262 |

[b]In FY 1994 the fuel cells activity was transferred to the natural gas program.
Source: DOE budget archives.

# Appendix D

# Environmental Issues Affecting Coal Use

Future coal use in the United States will be strongly influenced by environmental concerns. In this appendix, recent trends in U.S. regulatory policy and technology development to address environmental issues are reviewed.

## Air Quality Standards

National ambient air quality standards for particulate matter, sulfur dioxide ($SO_2$), nitrogen dioxide ($NO_2$), and photochemical ozone were promulgated under the 1970 Clean Air Act to protect human health and welfare throughout the country. In some regions of the country, additional air quality standards for the "prevention of significant deterioration" of superior air quality also apply. To achieve air quality standards and to speed the deployment of lower-emission technologies, emission standards for new and existing air pollution sources have been promulgated by federal and state governments over the past two decades. These pollutant-specific emission standards, together with environmental quality standards, have been the primary forces of technology innovation for environmental control. Recent developments in air quality and emission standards for coal-based systems are discussed below.

### *Sulfur Dioxide*

Ambient air quality standards for $SO_2$, together with federal New Source Performance Standards (NSPS) promulgated in 1971 and 1979, have brought about a profound change in the design of modern coal-fired power plants. Today, $SO_2$ control systems are a necessary component of new coal-based power generation. While air quality standards for $SO_2$ now have been achieved in most regions of the United States, state and local regulations for "best-available control technology," plus new federal regulations to control acid deposition, have given further impetus to $SO_2$ controls.

The trend in $SO_2$ emissions from a new coal-fired power plant is illustrated in Figure 3-2a for an eastern U.S. plant burning medium-sulfur coal similar to the U.S. average. The original NSPS limited emissions to 1.2 lb $SO_2/10^6$ Btu. For the illustrative plant in Figure 3-2, that corresponded to an emissions reduction of about 75 percent relative to a pre-NSPS plant with no $SO_2$ controls. That reduction could be achieved either by switching to a low-sulfur coal or

by installing a flue gas desulfurization (FGD) system. Revisions to the NSPS effective in 1979 eliminated the option of compliance through coal switching, requiring instead that all plants continuously reduce $SO_2$ emissions by 70 to 90 percent, depending on the coal burned. For eastern plants burning medium- to high-sulfur coal, this effectively halved the original NSPS emissions to 0.6 lb $SO_2$/million Btu. Western plants burning low-sulfur coal emitted much less. These reductions were achieved using a variety of FGD systems, which are now found on approximately 25 percent (70 GW) of U.S. coal-fired capacity (DOE, 1993). Over the past decade, the efficiency of FGD systems has continued to improve.

An important implication of the trend in $SO_2$ removal capability for conventional coal-fired power plants is the downward pressure on achieving similar levels of emission reductions for advanced coal conversion systems. Fluidized-bed combustion systems, for example, originally were designed to meet the 90 percent $SO_2$ removal requirements of the NSPS but have not yet demonstrated the ability to economically meet the 98 percent or higher reductions now achieved in the United States with commercially available FGD systems. Though such levels of $SO_2$ reduction are not yet required of all new coal-based power generation, continuing pressure from state and local regulators and the possibility of further tightening of the NSPS within the next decade point to the need for sustained efforts to achieve very high levels of $SO_2$ control for advanced coal conversion technologies.

### *Particulate Matter*

In 1987 the original ambient air quality standards for total suspended particulates were augmented by a standard based on fine (respirable) particulates less than 10 microns in size. The EPA (U.S. Environmental Protection Agency) has indicated that another revision to the health-based fine particulate standard, possibly an air quality standard for fine particles of 2 to 3 microns, is likely before the end of the decade (Bachman, 1994). The implication of that change could be a further tightening of particulate emissions from coal combustion sources in the near- to mid-term period. Restrictions on fine particulates also could require control of gaseous sulfates and nitrates, which condense in the atmosphere to form micron-sized particles.

The federal NSPS for particulate emissions from coal-fired power plants has been tightened by a factor of three since standards were first promulgated in 1971 (see Figure 3-2b). Modern electrostatic precipitators and fabric filters routinely achieve emission levels significantly below the federal standard, with commercial designs today achieving one-third the NSPS level (Sloat et al., 1993). Some baghouses now in use achieve particulate emission levels of 0.005 lb/million Btu, or one-sixth the NSPS requirement (EPRI, 1992). With the likelihood of a new air quality standard for fine particles, the potential exists for future emission limits based on particle size as well as total mass.

### *Nitrogen Dioxide*

The health-based ambient air quality standard for $NO_2$ has not been a major forcing function for power plant control technology development. However, the federal NSPS for

nitrogen oxides ($NO_x$, a mix of NO and $NO_2$) has brought about a number of changes in the design of new coal-fired boilers. The 1971 NSPS of 0.7 lb $NO_x$/million Btu led to the extinction of new cyclone-fired boilers, which have high $NO_x$ emissions, and stimulated a variety of low-$NO_x$ burner designs. In 1979 the NSPS was tightened slightly, reflecting improvements in combustion-based controls (see Figure 3-2c). The overall level of $NO_x$ reduction now being achieved at new coal-fired plants is roughly 50 percent of uncontrolled pre-NSPS levels. As noted earlier, the environmental issues of acid deposition, fine particles, and urban ozone are likely to push requirements for greater $NO_x$ controls in the near future.

### *Ozone*

Attainment of the health-related national air quality standard for tropospheric ozone, the major constituent of photochemical smog, poses some of the most difficult environmental challenges in the United States. Though this problem traditionally has been associated with Los Angeles and the automobile, evidence shows the problem to be far more widespread, with many metropolitan areas throughout the country exceeding the national standard (EPA, 1990). Photochemical ozone is formed from emissions of volatile organic compounds and $NO_x$ via a complex series of chemical reactions fueled by sunlight. To date, reductions in ozone have been sought primarily by reducing emissions of volatile organic compounds. Improved understanding of photochemical smog formation, however, now indicates that $NO_x$ controls must be a more significant component of ozone reduction strategies (NRC, 1991).

Federal standards for new automobiles already have reduced mobile source $NO_x$ emissions significantly in the past two decades. As a result, power plants today account for about half the total U.S. $NO_x$ emissions. After the further reductions in automotive and power plant $NO_x$ mandated by the 1990 CAAAs (Clean Air Act amendments), $NO_x$ emissions from power plants will be twice as great as automobiles and the largest source of $NO_x$ emissions nationally around the turn of the century (Bachman, 1994). Therefore, it can be expected that ozone reduction strategies in the Northeast and other parts of the United States will focus increasingly on $NO_x$ emissions from new and existing fossil-fueled power plants. A tightening of the ambient ozone standard also is under consideration by EPA based on recent health studies (Bachman, 1994). Though the timing and magnitude of $NO_x$ reduction requirements to achieve ambient ozone standards is highly uncertain, the implication of current trends in regulation and technology development is that stringent $NO_x$ controls of coal-based technologies could well emerge within the next decade.

## Acid Deposition

The acid deposition provisions of the 1990 CAAAs established for the first time an absolute cap on total U.S. $SO_2$ emissions. In contrast to ambient air quality standards, which primarily protect human health, acid deposition regulations primarily guard against a host of cultural and ecological concerns, including damage to aquatic systems, forests, visibility, and materials. The regional nature of acid deposition and the role of long-range transport of

pollutants require reductions in $SO_2$ and $NO_x$ emissions over a broad geographical area, primarily the eastern half of the United States. The $SO_2$ cap of 10 million tons per year established by the 1990 amendments will require a reduction of roughly 40 percent in current $SO_2$ emissions from electric power plants, to be phased in by the turn of the century. A smaller reduction of 2 million tons per year in $NO_x$ emissions, about 10 percent of 1980 levels, also is mandated for acid deposition control. There is no cap on total $NO_x$ emissions, however.

The anticipation of acid rain controls was the prime factor motivating $SO_2$ and $NO_x$ control technology development during the 1980s. The longer-term implications of acid rain regulations for coal technology development are somewhat speculative. The absolute cap on $SO_2$ emissions could provide incentives to seek high levels of $SO_2$ control in order to accommodate long-term growth. Some scenarios, however, suggest that future $SO_2$ emissions will continue to decline using power generation technologies that are currently available or will become available commercially in the near-term period, especially integrated gasification combined-cycle systems (NAPAP, 1991). Other factors also could affect future developments. For example, a new air quality standard for fine particulates, discussed earlier, could require additional $SO_2$ controls to reduce particulate sulfate emissions.

## Air Toxics

Title III of the 1990 CAAAs lists 189 substances as "air toxics" subject to "maximum-achievable control technology" when emitted at rates of 10 to 25 tons per year from designated industrial and other sources. The air toxic provisions represented a major expansion in the number of air pollutant species of regulatory concern. Emissions from fossil-fueled power plants, however, were exempted from the provision of the amendments, pending further study by EPA. Extensive efforts currently are under way to characterize trace species emissions from coal-fired power plants as a basis for federal decisionmaking expected in late 1995 or soon thereafter. Air toxics concerns for utilities center primarily around 10 to 20 trace substances commonly found in coal, including arsenic, mercury, selenium, nickel, cadmium, and other heavy metals. The basis for regulating these species under the air toxics provisions would be a finding by EPA of an unacceptable health risk or an ecological risk to one or more regions of the country named in the 1990 CAAAs (Zeugin, 1992).

Individual states, however, could regulate on other grounds. Some states such as Wisconsin already are considering trace emission limitations for coal-burning plants based on trace substance concentrations in coal.[1] The Electric Power Research Institute has compiled an extensive database of published information on trace substances, including extensive characterizations of U.S. coals. The data for bituminous, subbituminous, and lignite coals show large variability, often an order of magnitude or more, in trace species concentrations (Rubin et al., 1993). Detailed trace species data at the mine and seam levels, however, are not generally available, though a number of U.S. coal companies do possess proprietary information of that

[1]Personal communication from B.T. O'Neil, Electric Power Research Institute, to E.S. Rubin, Vice Chair, Committee on the Strategic Assessment of DOE's Coal Program, February 1994.

type. EPRI and DOE currently are conducting extensive testing programs to characterize trace species emissions from conventional and advanced power plants.

## Global Warming

Of all the environmental issues facing the future use of coal, none is as potentially far reaching as the worldwide concern over global climate change. For coal, emissions of carbon dioxide ($CO_2$) from combustion and methane from coal mining are the two greenhouse gases of primary concern. While it is likely to be at least a decade or more before the magnitude and consequences of global warming can be measured or predicted with reasonable scientific certainty, international concern over the potential effects of global warming has prompted recommendations and policy measures to curtail the growth in greenhouse gas emissions, primarily $CO_2$ (e.g., NRC, 1992). As a result of the 1992 United Nations Conference on the Environment, the United States is signatory to an international accord to limit $CO_2$ emissions to 1990 levels by the turn of the century. Recently, the Clinton administration put forth a program of largely voluntary measures to achieve that objective (Clinton and Gore, 1993).

Since coal combustion emits 20 to 75 percent more $CO_2$ per unit of energy than other fossil fuels, it has been a major focus of attention and a key target for greenhouse gas reductions. Coal presently accounts for about 35 percent of total $CO_2$ emissions globally. Emissions are projected to increase significantly in the next century, especially in developing countries such as China. Based on current estimates of natural resources, coal is the only fossil fuel with carbon reserves sufficient to dramatically increase the current carbon content of the atmosphere if burned on a widespread scale (Edmonds, 1994). Thus, there is substantial interest in the long-term trend in $CO_2$ emissions from coal combustion and other conversion processes. Various studies have examined the potential to reduce coal-related greenhouse gas emissions (e.g., NRC, 1992).

## Water Quality Standards

Coal-fired electric power plants and fuel conversion processes are subject to state and federal regulations to protect the quality of surface waters, ground water, and drinking water. Stream quality standards for specific receiving waters are established by state and local jurisdictions, while the NSPS are the primary federal vehicle limiting aqueous discharges. The principal environmental concerns are thermal discharges to waterways (which are prohibited for new plants) and various chemical emissions, including heavy metals, organics, suspended solids, and other aqueous constituents found in power plant waste streams. In recent years there has been increasing attention to a large number of hazardous or toxic trace chemical species and a general tightening of effluent emission standards at existing as well as new facilities (Rubin, 1989).

Reauthorization of the Clean Water Act is expected soon, with the potential for more stringent effluent standards for coal-based electric power plants. While water-related environmental controls have not had the visibility or economic impact of air pollution controls,

future restrictions could nonetheless have significant consequences for power plant siting and cost. Some advanced power generation and fuel conversion technologies, which produce a variety of aqueous discharges not found in conventional pulverized coal plants, may merit special scrutiny. Overall, the research and development (R&D) implication of current trends is that water-related environmental issues also may require additional attention to preserve or increase options and lower the cost of complying with current and future restrictions.

Water quality issues also affect other parts of the coal fuel cycle, especially coal mining and beneficiation. Acid mine drainage from coal extraction and effluents from coal preparation plants have historically been among the most serious water-related environmental problems associated with coal use. Research needs on advanced treatment technologies and improved process design to minimize or eliminate water-borne pollutants thus extend across the fuel cycle.

## Solid and Hazardous Wastes

High-volume solid wastes from electric power plants, including fly ash, bottom ash, and FGD sludge, have been classified as nonhazardous under the Resource Conservation and Recovery Act of 1976. Thus, coal-fired power plants are largely exempt from the rigorous treatment requirements and high costs of dealing with hazardous wastes, although some low-volume wastes such as boiler cleaning sludges may still fall under the "hazardous" category. Methods for cleaning coal and for meeting stringent air emission regulations often transform gaseous emissions to solid waste products. These waste products must then be used or disposed of in compliance with other regulatory standards that protect land, surface water, and ground water resources.

Nonetheless, the sheer volume of power plant wastes, and their potential to affect ground water and surface water quality, poses a continuing problem that can affect the viability of increased coal use in the future. From a cost viewpoint alone, waste disposal represents an increasing burden, especially for utilities in densely populated areas where land suitable for waste disposal is fast disappearing. This problem will continue to grow as land availability decreases in the next century. These issues also apply across the coal fuel cycle, including the mining and beneficiation stages where significant solid waste generation occurs.

Related to the issue of solid waste disposal are environmental requirements for land reclamation and control of mine subsidence. The latter issue is specifically cited for attention in the 1992 Energy Policy Act. R&D needed to address these issues is likely to be shared between DOE and other federal agencies, such as the U.S. Bureau of Mines.

## Externalities and Siting Issues

To an increasing extent, state and local governments, rather than the federal government, are forcing the most stringent environmental requirements for energy facilities, typically in conjunction with plant siting and operating permits. Thus, federal NSPS levels for power plants no longer set the benchmark for environmental control performance. Rather, state and local determinations of "lowest-achievable emission rates" have become the de facto requirements in

many cases. Similarly, the most stringent requirements for treatment of solid and aqueous wastes often arise from state and local jurisdictions. The implication of this trend is that local and regional concerns will play an increasingly important role in establishing requirements for environmental control technology R&D.

A related trend is the adoption by some state public utility commissions of "externality adders" to account for the environmental impacts of power plant emissions that escape control. Externality adders are economic costs added to the nominal cost of power generation, typically for the purpose of comparing different options. In some cases such adders are part of a larger program of "integrated resource planning" approaches used by state regulatory commissions to assess the relative merits and cost of proposed capacity additions by electric utility companies. More than half the states in the country are currently examining the use of externality adders as part of the regulatory decisionmaking process. Several states, including Washington, New York, and Massachusetts, have already adopted or anticipate adoption of externality adders (CECA, 1993). The effect of externality cost adders is to make coal-based power generation less attractive relative to other options having lower air pollutant and solid waste emissions. For coal to be viable, therefore, emissions reductions well below current regulatory requirements may be needed.

A final issue deserving mention is the concern over possible health effects of 60-cycle (Hz) electromagnetic fields. For some years now, there have been suggestions in the scientific and epidemiological literature of a link between the electric and magnetic fields induced by power transmission lines, distribution lines, and electric appliances and an increased risk of certain cancers, particularly childhood leukemia. To date, however, there has been no definitive evidence that such a link exists, nor have fundamental mechanisms been identified by which electromagnetic fields could induce biological effects (CIRRCP, 1992). Nonetheless, public concern has caused public utility commissions in some states to prevent the siting of new transmission and distribution lines near populated areas. As with many complex environmental issues, it will likely be several decades before new scientific evidence can unambiguously shed light on this issue. In the meantime, the principle of "prudent avoidance" has been adopted by many state regulatory agencies and utilities, with the objective of avoiding exposure to 60-Hz fields where options are readily available (Morgan, 1992). The implication of all this for the coal R&D program is to suggest that large central station facilities requiring extensive new transmission and distribution lines to deliver power become more difficult to deploy because of electromagnetic field concerns, thus favoring smaller more distributed systems.

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# Appendix E

# Clean Coal Technology Demonstration Projects

Table E-1 CCT Program: LIST OF PROJECTS ADVANCED ELECTRIC POWER GENERATION SYSTEMS

| PROJECT<br>Sponsor | Solicitation | MW Scale of Project | DOE Obligation (millions of dollars) | Private Obligation (millions of dollars) | Total Provisional Cost Estimate (millions of dollars) |
|---|---|---|---|---|---|
| COMBUSTION ENGINEERING IGCC REPOWERING PROJECT<br>ABB Combustion Engineering, Inc. | CCT-II | 65 | 129.4 (48%) | 141.3 (52%) | 270.7 |
| HEALY CLEAN COAL PROJECT<br>Alaska Industrial Development and Export Authority | CCT-III | 50 | 103.7 (48%) | 111.3 (52%) | 215.0 |
| PCFB DEMONSTRATION PROJECT<br>DMEC-1 Limited Partnership | CCT-III | 80 | 93.3 (46%) | 109.7 (54%) | 203.0 |
| TIDD PFBC DEMONSTRATION PROJECT<br>The Ohio Power Company | CCT-I | 70 | 60.2 (31%) | 133.3 (69%) | 193.5 + cost increase of $26.0 M |
| PINON PINE IGCC POWER PROJECT<br>Sierra Pacific Power Company | CCT-IV | 80 | 135.0 (50%) | 135.0 (50%) | 270.0 |
| TOMS CREEK IGCC DEMONSTRATION PROJECT<br>TAMCO Power Partners | CCT-IV | 190 | 95.0 (48%) | 101.6 (52%) | 196.6 |
| TAMPA ELECTRIC INTEGRATED GASIFICATION COMBINED-CYCLE PROJECT<br>Tampa Electric Company | CCT-III | 260 | 120.7 (50%) | 120.7 (50%) | 241.4 |
| NUCLA CFB DEMONSTRATION PROJECT<br>Tri-State Generation and Transmission Association, Inc. | CCT-I | 110 | 19.9 (37%) | 34.2 (63%) | 54.1[b] Completed |
| WABASH RIVER COAL GASIFICATION REPOWERING PROJECT<br>Wabash River Coal Gasification Repowering Project Joint Venture | CCT-IV | 268 | 198.0 (50%) | 198.0 (50%) | 396.0 |
| YORK COUNTY ENERGY PARTNERS COGENERATION PROJECT<br>York County Energy Partners, L.P. | CCT-I | 227 | 74.7 (20%) | 299.6 (80%) | 374.3 |
| WARREN STATION EXTERNAL FIRED COMBINED CYCLE<br>Penna Electric Company | CCT-V | 62 | 73.0 (50%) | 73.0 (50%) | 146.0 |

| PROJECT<br>Sponsor | Solicitation | MW Scale of Project | DOE Obligation (millions of dollars) | Private Obligation (millions of dollars) | Total Provisional Cost Estimate (millions of dollars) |
|---|---|---|---|---|---|
| CAMDEN IGCC (including fuel cell)<br>Duke Energy Corporation | CCT-V | 480 | 195.0 (25%) | 585 (75%) | 780.0 |
| CALVERT CITY, PCFB DEMONSTRATION PROJECT<br>Air Products & Chemical Company | CCT-V | 95 | 150.0 (40%) | 225.0 (60%) | 375.0 |
| SNOX FLUE GAS CLEANING DEMONSTRATION PROJECT<br>ABB Combustion Engineering, Inc. | CCT-II | 35 | 15.7 (50%) | 15.7 (50%) | 31.4 |
| 10-MW DEMONSTRATION OF GAS SUSPENSION ABSORPTION<br>AirPol, Inc. | CCT-III | 10 | 2.3 (30%) | 5.4 (70%) | 7.7 |
| DEMONSTRATION OF COAL REBURNING FOR CYCLONE BOILER $NO_x$ CONTROL<br>Babcock & Wilcox Company | CCT-II | 100 | 6.2 (48%) | 6.9 (52%) | 13.1 |
| FULL-SCALE DEMONSTRATION OF LOW-$NO_x$ CELL™ BURNER RETROFIT<br>Babcock & Wilcox Company | CCT-III | 605 | 5.4 (48%) | 5.8 (52%) | 11.2 |
| LIMB DEMONSTRATION PROJECT EXTENSION AND COOLSIDE DEMONSTRATION<br>Babcock & Wilcox Company | CCT-I | 105 | 7.6 (39%) | 11.8 (61%) | 19.4[b] Completed |
| SOX-NOX-ROX BOX FLUE GAS CLEANUP DEMONSTRATION PROJECT<br>Babcock & Wilcox Company | CCT-II | 5 equivalent slipstream from a 156 boiler | 6.1 (46%) | 7.2 (54%) | 13.3 |
| CONFINED ZONE DISPERSION FLUE GAS CLEANUP DEMONSTRATION<br>Bechtel Corporation | CCT-III | 73.5 | 5.2 (50%) | 5.2 (50%) | 10.4 |
| ENHANCING THE USE OF COALS BY GAS REBURNING AND SORBENT INJECTION<br>Energy and Environmental Research Corporation | CCT-I | 80-Hennepin 40-Lakeside | 18.7 (50%) | 18.7 (50%) | 37.5 |
| EVALUATION OF GAS REBURNING AND LOW-$NO_x$ BURNERS ON A WALL-FIRED BOILER<br>Energy and Environmental Research Corporation | CCT-III | 172 | 8.1 (50%) | 8.1 (50%) | 16.2 |

| PROJECT<br>Sponsor | Solicitation | MW Scale of Project | DOE Obligation (millions of dollars) | Private Obligation (millions of dollars) | Total Provisional Cost Estimate (millions of dollars) |
|---|---|---|---|---|---|
| LIFAC SORBENT INJECTION DESULFURIZATION DEMONSTRATION PROJECT<br>LIFAC-North America | CCT-III | 60 | 10.6 (50%) | 10.8 (50%) | 21.4 |
| COMMERCIAL DEMONSTRATION OF THE NOXSO $SO_2/NO_x$ REMOVAL FLUE GAS CLEANUP SYSTEM<br>MK-Ferguson Company | CCT-III | 115 | 33.1 (50%) | 33.1 (50%) | 66.3 |
| MILLIKEN CLEAN COAL TECHNOLOGY DEMONSTRATION PROJECT<br>New York State Electric & Gas Corporation | CCT-IV | 300 | 45 (28%) | 113.6 (72%) | 158.6 |
| INTEGRATED DRY $NO_x/SO_2$ EMISSIONS CONTROL SYSTEM<br>Public Service Company of Colorado | CCT-III | 100 | 13.7 (50%) | 13.7 (50%) | 27.4 |
| ADVANCED FLUE GAS DESULFURIZATION DEMONSTRATION PROJECT<br>Pure Air on the Lake, L.P. | CCT-II | 528 | 63.4 (42%) | 87.0 (58%) | 150.5 |
| DEMONSTRATION OF ADVANCED COMBUSTION TECHNIQUES FOR A WALL-FIRED BOILER<br>Southern Company Services, Inc. | CCT-II | 500 | 6.6 (45%) | 8.3 (55%) | 14.7 |
| DEMONSTRATION OF INNOVATIVE APPLICATIONS OF TECHNOLOGY FOR THE CT-121 FGD PROCESS<br>Southern Company Services, Inc. | CCT-II | 100 | 17.5 (49%) | 18.3 (51%) | 35.8 |
| DEMONSTRATION OF SELECTIVE CATALYTIC REDUCTION TECHNOLOGY FOR THE CONTROL OF $NO_x$ EMISSIONS FROM HIGH-SULFUR COAL-FIRED BOILERS<br>Southern Company Services, Inc. | CCT-II | 8.7 | 7.5 (48%) | 8.0 (52%) | 15.6 |

| PROJECT<br>Sponsor | Solicitation | MW Scale of Project | DOE Obligation (millions of dollars) | Private Obligation (millions of dollars) | Total Provisional Cost Estimate (millions of dollars) |
|---|---|---|---|---|---|
| 180-MWe DEMONSTRATION OF ADVANCED TANGENTIALLY FIRED COMBUSTION TECHNIQUES FOR REDUCTION OF $NO_x$ EMISSIONS FROM COAL-FIRED BOILERS<br>Southern Company Services, Inc. | CCT-II | 180 | 4.4 (49%) | 4.6 (51%) | 9.0 |
| MICRONIZED COAL REBURNING DEMONSTRATION FOR $NO_x$ CONTROL ON A 175-MWe WALL-FIRED UNIT<br>Tennessee Valley Authority | CCT-IV | 175 | 3.5 (48%) | 3.8 (52%) | 7.3 |
| DEVELOPMENT OF THE COAL QUALITY EXPERT<br>ABB Combustion Engineering, Inc., and CQ, Inc. | CCT-I | 250–880 | 10.9 (50%) | 10.9 (50%) | 21.7 |
| COMMERCIAL-SCALE DEMONSTRATION OF LIQUID-PHASE METHANOL (LPMEOH™) PROCESS<br>Air Products and Chemicals, Inc. | CCT-III | 150 tons/day of methanol | 92.7 (43%) | 121 (57%) | 213.7 |
| SELF-SCRUBBING COAL™: AN INTEGRATED APPROACH TO CLEAN AIR<br>Custom Coals International | CCT-IV | 350 tons/hour | 38 (47%) | 43.7 (53%) | 81.7 |
| ENCOAL MILD COAL GASIFICATION PROJECT<br>ENCOAL Corporation | CCT-III | 1,000 tons/day of subbituminous coal feed | 36.3 (50%) | 36.3 (50%) | 72.6 |
| ADVANCED COAL CONVERSION PROCESS DEMONSTRATION<br>Rosebud SynCoal Partnership | CCT-I | 45 tons/hour | 34.5 (50%) | 34.5 (50%) | 69.0 |
| BLAST FURNACE GRANULATED COAL INJECTION SYSTEM DEMONSTRATION PROJECT<br>Bethlehem Steel Corporation | CCT-III | 7,000 net tons/day of hot metal | 31.2 (22%) | 112.5 (78%) | 143.8 |
| INNOVATIVE COKE OVEN GAS CLEANING SYSTEM FOR RETROFIT APPLICATIONS<br>Bethlehem Steel Corporation | CCT-II | 74 mil std $ft^3$/day of COG | 13.5 (30%) | 31.7 (70%) | 45.2 |

| PROJECT<br>Sponsor | Solicitation | MW Scale of Project | DOE Obligation (millions of dollars) | Private Obligation (millions of dollars) | Total Provisional Cost Estimate (millions of dollars) |
|---|---|---|---|---|---|
| ADVANCED CYCLONE COMBUSTOR WITH INTERNAL SULFUR, NITROGEN, AND ASH CONTROL<br>Coal Tech Corporation | CCT-I | 23 mil Btu/hour | 0.5 (50%) | 0.5 (50%) | 1.0[b] Completed |
| CEMENT KILN FLUE GAS RECOVERY SCRUBBER<br>Passamaquoddy Tribe | CCT-II | 1,450 tons/day of cement; 250,000 std/ft$^3$ of kiln gas; up to 274 tons/day of coal | 6.0 (36%) | 10.5 (64%) | 16.5 |
| DEMONSTRATION OF PULSE COMBUSTION IN AN APPLICATION FOR STEAM GASIFICATION OF COAL<br>ThermoChem, Inc. | CCT-IV | 161 million Btu/hour of 325 Btu/std ft$^3$ medium-Btu fuel gas plus 40,000 lb/hr of export steam | 18.7 (50%) | 18.7 (50%) | 37.3 |
| INTEGRATED IRON ORE REDUCTION-POWER GENERATION<br>Centerior Energy Corporation | CCT-V | | | | |
| CLEAN COAL DIESEL ENGINE<br>Easton Utility/A.D. Little | CCT-V | | | | |

[a]Projects are ongoing or pending final approval (CCT-V) unless otherwise stated.
[b]Completed projects; figures represent total cost.
Source: DOE (1994).

## REFERENCE

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# Appendix F

## Committee Meetings and Activities

**1. Committee Meeting, November 22–23, 1993, Washington, D.C.**

The following presentations were made to the committee:

**Department of Energy Introduction and Expectations for the Study**
Doug Uthus, Director, Coal Combustion, Coal Preparation, and Control Systems, U.S. Department of Energy

**Scenarios for Coal**
Richard Dye, Manager, Fossil Fuel Utilization Program, U.S. Department of Energy

**Overview of DOE Coal Program**
Howard Feibus, Director, Office of Clean Coal Technology, U.S. Department of Energy

**Summary of Advanced Power Systems Effort**
Howard Feibus, Director, Office of Clean Coal Technology, U.S. Department of Energy

**Summary of Advanced Fuel Systems Effort**
Robert Hamilton, Acting Director, Office of Coal Conversion, U.S. Department of Energy

**Contributing Research Under AR&TD Program**
Dave Beecy, Director, Office of Advanced Research, U.S. Department of Energy

**DOE Perspective on EPACT 1992**
Howard Feibus, Director, Office of Clean Coal Technology, U.S. Department of Energy

**2. Power Generation/Technology Subgroup Meeting, January 13–14, 1994, Washington, D.C.**

The following presentations were made to the committee:

**Projections of Utility Industry Needs**

George Preston, Vice President, Generation and Storage, Electric Power Research Institute

Larry Joseph, Senior Program Manager, Clean Coal Technology Program, U.S. Department of Energy

Gary Styles, Manager, Special Projects, Southern Services Company

Donald Hafer, Manager, Cogeneration and Performance, American Electric Power Company, Inc.

**Advanced Gas Turbines**

Sandy Webb, Product Manager, Heat Engines, Morgantown Energy Technology Center

**Hot Gas Cleanup**

Randy Dellefield, Product Manager, Pressurized Fluidized-Bed Combustion, Morgantown Energy Technology Center

**Fuel Cell Development**

Manville Mayfield, Product Manager, Fuel Cells, Morgantown Energy Technology Center

**Low-Emission Boilers**

Larry Ruth, Division Director, Coal Utilization, Pittsburgh Energy Technology Center

**Assessment of the Role of Government in Clean Coal Technology**

Larry Papay, Vice President and Manager of Research and Development, Bechtel Group, Inc.

**Past, Present, and Future Commercialization Activities in the Office of Fossil Energy**

Douglas Uthus, Director, Coal Combustion, Coal Preparation, and Control Systems, U.S. Department of Energy

**Direct Liquefaction**

Edgar Klunder, Project Coordinator, Direct Liquefaction, Pittsburgh Energy Technology Center

**Indirect Liquefaction**
Gary Stiegel, Project Coordinator, Indirect Liquefaction, Pittsburgh Energy Technology Center

3. **Strategy/Policy Subgroup Meeting, January 27–28, 1994, Washington, D.C.**

The following presentations were made to the committee:

**The DOE Fiscal Year 1995 Budget: DOE/Fossil Energy Strategic Planning Process**
Jack Siegel, Acting Assistant Secretary, Office of Fossil Energy, U.S. Department of Energy
George Rudins, Acting Deputy Assistant Secretary for Coal Technology, U.S. Department of Energy
Jay Braitsch, Acting Director, Office of Planning and Environment, Office of Fossil Energy, U.S. Department of Energy

**The Regulatory Environment for the Utility Industry**
John Bachman, Associate Director, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency

**An Alternative Energy Future**
John Hemphill, Executive Director, Business Council/Alliance to Save Energy

**Projections of Natural Gas Use and Price**
William Burnett, Senior Vice President, Technology Development, Gas Research Institute

**Costs of Greenhouse Gas Reductions**
Jae Edmonds, Battelle Pacific Northwest Laboratories

**The U.S. Coal Resource Base**
Harold J. Gluskoter, U.S. Geological Survey

4. **Committee Meeting, March 3–4, 1994, Washington, D.C.**

5. **Writing Group Meeting, April 21–22, 1994, Irvine, California**

6. **Committee Meeting, May 19–20, 1994, Washington, D.C.**

# Appendix G

## Biographical Sketches of Committee Members

**John P. Longwell** received his B.S. in mechanical engineering from the University of California, Berkeley, and his Sc.D. in chemical engineering from the Massachusetts Institute of Technology (MIT). Dr. Longwell spent 33 years with Exxon Research and Engineering Company, where he was engaged in research and research management activities in the petroleum, petrochemical, and propulsion areas. He subsequently joined MIT as Edward R. Gilliland Professor of Chemical Engineering and is currently professor emeritus in the Department of Chemical Engineering. His research interests include the utilization of fossil energy resources, fuels and combustion systems, and the ecology of Idaho rivers and lakes. Dr. Longwell is a member of the National Academy of Engineering.

**Edward S. Rubin** is the Alumni Professor of Environmental Engineering and Science at Carnegie Mellon University (CMU). He holds joint appointments in the Departments of Engineering and Public Policy and Mechanical Engineering and is director of CMU's Center for Energy and Environmental Studies. He earned a B.E. in mechanical engineering at the City College of New York and an M.S. and Ph.D. in mechanical engineering from Stanford University. His teaching and research interests at CMU are in the areas of environmental control, energy utilization, and technology-policy interactions, with a particular focus on coal-based systems. He has served as a member of technical and advisory committees to the U.S. Environmental Protection Agency and the National Academy of Sciences and is a past chairman of the Environmental Control Division of the American Society of Mechanical Engineers.

**Morrel H. Cohen** received his B.S. from Worcester Polytechnic Institute, his M.A. from Dartmouth College, and his Ph.D. in physics from the University of California, Berkeley. Dr. Cohen held positions at the University of Chicago and the James Franck Institute before joining Exxon Research and Engineering Company as senior science advisor in the corporate research laboratories. He has also held concurrent positions at the Universities of Cambridge and Amsterdam and Argonne National Laboratory. Dr. Cohen's areas of interest include the theoretical physics of condensed matter, developmental biology, and energy policy. He is a member of the National Academy of Sciences.

**A. Denny Ellerman** obtained his A.B. in public and international affairs from Princeton University and his Ph.D. in political economy and government from Harvard University. Following service with the U.S. Marine Corps, Dr. Ellerman held positions with the U.S.

Departments of Defense, State, and Energy and the Office of Management and Budget. Later he was executive vice president of the National Coal Association. Dr. Ellerman is currently executive director of the Center for Energy and Environmental Policy Research and senior lecturer at the Sloan School of Management at the Massachusetts Institute of Technology. His interests are primarily in energy economics and policy analysis.

**Martha W. Gilliland** earned her B.A. from Catawba College, North Carolina; her M.A. from Rice University; and her Ph.D. in environmental engineering and systems ecology from the University of Florida. She has held positions at the Universities of Oklahoma and Nebraska-Lincoln and was executive director of Energy Policy Studies, Inc. Dr. Gilliland is currently vice provost for academic affairs at the University of Arizona. Her research interests are in energy technologies, energy policy, and environmental science and policy.

**Robert D. Hall** received his B.S. in chemical engineering from the University of Illinois. He then joined Sinclair Research Laboratories as a design engineer before taking up a position with Amoco Chemical Company. Mr. Hall served as director of design and economics and director of process research for the Amoco Oil Company, manager of strategic planning for the Information Services Department, and manager of management systems and planning in the Corporate Research Department before assuming his current position as general manager of the Alternative Feedstock Development Department. He has extensive expertise in scientific and engineering aspects of the production of liquid fuels and chemicals from biomass, natural gas, coal, oil shale, tar sands, and organic waste products.

**John W. Larsen** earned his B.S. from Tufts University and his Ph.D. in chemistry from Purdue University. He was professor of chemistry at the University of Tennessee before joining Lehigh University, where he is currently professor of chemistry. His primary research interests are the organic chemistry and macromolecular structure of coal, coal conversion, and pyrolysis. Dr. Larsen is editor of the American Chemical Society journal, *Energy and Fuels.*

**Peter T. Luckie** received his B.S. in fuel engineering, his M.S. in mineral preparation, and his Ph.D. in mineral processing, all from the Pennsylvania State University. Dr. Luckie's industrial experience includes positions with Pitt-Consol Chemical Company, HRB-Singer, Inc., Kennedy Van Saun Corporation, and McNally Pittsburgh Corporation, where he was corporate director for research and development. He is currently associate dean for research in the College of Earth and Mineral Sciences and professor of mineral engineering at the Pennsylvania State University. His principal research interests are in comminution, liberation, solid-solid separation, and circuit analysis.

**Maurice D. McIntosh** received his B.S. in mechanical and nuclear engineering from North Carolina State University. He has 30 years of experience in the electric utility industry, primarily with Duke Power, where he is currently vice president of the Fossil/Hydro Generation Department. He has responsibility for the operation and maintenance of Duke Power's coal-fired and hydro stations and was previously manager of the McGuire Nuclear Station in North Carolina.

**George T. Preston** obtained his B.S. from the California Institute of Technology and his Ph.D. from the University of California, Berkeley, both in chemical engineering. He was technical manager of resource recovery programs for Occidental Research Corporation before joining the Electric Power Research Institute (EPRI). His positions at EPRI have included that of director of environmental control systems and director of fossil power plants. He is currently vice president of generation.

**Eric H. Reichl** received his M.S. in chemical engineering from the Technical University of Vienna. He has spent his entire professional career in the coal, gas, and oil industries, including 24 years with the R&D Division of Consolidation Coal Company. He is the former president of Conoco Coal Development Company. Mr. Reichl chaired the U.S. Department of Energy's Research Advisory Board panel, which issued a 1985 report entitled *Clean Coal Use Technologies*, and served briefly on the board of directors of the Synthetic Fuels Corporation. He has extensive expertise in coal conversion and associated environmental issues. He is a member of the National Academy of Engineering.

**Larry D. Woodfork** earned his B.S. and A.M. degrees in geology from Indiana University. He has conducted extensive geological fieldwork and has been involved in exploration geology throughout the United States for the California Company (now Chevron), the Indiana Geological Survey, and Humble Oil and Refining Company (now Exxon). Mr. Woodfork is currently director and state geologist for the West Virginia Geological and Economic Survey and holds adjunct appointments as professor of geology and petroleum engineering at West Virginia University. His current research interests include the geology of fossil fuels and environmental geology. Mr. Woodfork is an honorary member of the American Association of Petroleum Geologists and a past president of the American Institute of Professional Geologists.

**John M. Wootten** received his B.S. in mechanical engineering and his M.S. in civil engineering, both from the University of Missouri. He has spent most of his professional career with Peabody Holding Company, Inc., the largest producer and marketer of coal in the United States. His positions at Peabody and its subsidiaries have included that of director of environmental services, director of research and technology, vice president for engineering and operations services, and president of Coal Services Corporation (COALSERV). Mr. Wootten is currently vice president of engineering and environmental services for Peabody Holding Company, Inc. His areas of expertise include the environmental and combustion aspects of coal utilization, clean coal technologies, and environmental control technologies for coal combustion.

# Glossary and Conventions

## Cost of Coal Conversion Processes

The cost of producing electricity or clean gaseous and liquid fuels from coal is highly dependent on the level of capital investment and, therefore, on the return required by investors. This return depends on both the prime rate, which reflects the anticipated effects of inflation and the desire of the Federal Reserve Bank to control inflation, and the investors' assessment of risk.

The electric utility industry, with its relatively predictable selling prices for electricity and stable production costs, can attract capital at a lower prime rate than, for example, the oil industry, where future product and feedstock prices are much less certain. Major investments are frequently split between a component with relatively assured, but lower, return and a higher-return component that will incur a larger risk. In the utility industry, a substantially larger component of low-risk borrowed money is more common than in the petroleum industry, where 100 percent equity financing has been more commonly practiced. Hence, the term "utility financing" is frequently used to describe highly leveraged investments, whereas "petroleum financing" describes investments with the smaller component of borrowed money generally employed in that industry.

The costs presented by the U.S. Department of Energy (DOE) and used in this report are based on leveraged financing. Key assumptions are summarized below.[1] It has also been assumed that sufficient plants have been built to reach a stable cost (*n*th plant costs; see Chapter 8).

Key assumptions for capital cost estimation:

| | |
|---|---|
| Bank interest rate (percent) | 8 |
| Percent equity | 25 |
| Percent internal rate of return | 15 |
| Years of construction | 4 |
| Years of operation | 25 |
| Depreciation, years | 10 |

[1]DOE, 1993, Direct Coal Liquefaction Baseline Design and System Analysis: Final Report on Baseline and Improved Baseline, Executive Summary, prepared for the U.S. Department of Energy, Pittsburgh Energy Technology Center, under contract no. DEAC22 90PC89857, DOE, Pittsburgh, Pennsylvania.

| | |
|---|---|
| Maintenance, percent initial capital | 1 |
| Working capital, percent revenue | 10 |
| Working capital, percent liquid | 50 |
| Owner's cost, percent initial capital, first-year operation | 5 |
| Federal income tax rate, percent | 34 |
| General inflation, percent | 3 |
| Raw material price escalation, percent (same as general inflation) | 3 |
| State tax | 0 |

General inflation of 3 percent per year was applied to all costs and selling prices. As mentioned above, an assumed rate of inflation was included in the investment required by investors.

## Economic Conventions

Throughout this report, all costs, prices, and so forth, are given in constant 1992 dollars unless otherwise specified. A Gross Domestic Product Implicit Price Deflator[2] has been used to adjust current dollars to 1992 dollar figures. An exception is DOE budget data, which are quoted in current dollars.

## Thermal Efficiency

Throughout this report all thermal efficiency figures are based on the higher heating value (HHV) of fuel, which is the convention most widely used in the United States for coal-based systems. HHV credits the fuel with the heat of vaporization of water formed in the combustion reaction; that is, water is assumed to exist in the liquid phase after combustion. This is consistent with the standard thermodynamic conditions of 25 °C (77 °F) and 1 atmospheric pressure used to calculate the heat of formation or reaction of any chemical compound (recall that "heating value" is simply the name commonly used for the heat of reaction of a hydrocarbon used as fuel).

In parts of Europe and elsewhere, however, the lower heating value (LHV) is commonly used in reporting thermal efficiencies. In the United States LHV is commonly used to quote efficiencies based on natural gas as a fuel. The LHV assumes that water formed in combustion remains in a vapor state, as in actual combustion systems that discharge flue gases at temperatures of several hundred degrees. Thus, the energy potentially recoverable by condensing water in the flue gas is assumed to be unavailable and not credited to the fuel. Since the LHV

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[2] EIA, 1994, Annual Energy Review 1993, Energy Information Administration, U.S. Department of Energy, DOE/EIA-0384(93), DOE, Washington, D.C.

assumes that fuel delivers less energy input than the HHV, any thermodynamic efficiency, E, based on LHV will be higher than one based on HHV in simple inverse proportion; that is, $E_{LHV}/E_{HHV}$ = HHV/LHV.

The numerical difference between LHV and HHV depends on the fuel. The difference is smallest for coal (where LHV is roughly 4 percent less than HHV) and greatest for natural gas (where LHV is about 10 percent lower). Accordingly, a power plant efficiency of 40 percent based on HHV would be reported as 42 percent based on LHV using coal and about 44 percent based on LHV using natural gas.

**ABB** Asea Brown Boveri

**AFBC** Atmospheric fluidized bed combustion

**Anthracite** Highest rank of economically useable coal, with a heating value of 15,000 Btu per pound, carbon content of 86 to 97 percent, and moisture content of less than 15 percent

**APC** Advanced pulverized coal

**APS** Advanced power system

**AR&ET** Advanced research and environmental technology

**AR&TD** Advanced research and technology development

**ATS** Advanced turbine system

**Baseload** Baseload is the minimum amount of power required during a specified period at a steady state.

**bbl** Barrel

**Bituminous coal** Type of coal most commonly used for electric power generation, with a heating value of 10,500 to 15,000 Btu per pound, carbon content of 45 to 86 percent, and moisture content of less than 20 percent

**Btu** British thermal unit

**CAAA** Clean Air Act Amendments

**CCT** Clean coal technology

**CCTC** Clean Coal Technology Coalition

**CE** Combustion Engineering

**$CH_4$** Methane

**Cl** Chlorine

**CO** Carbon monoxide

**$CO_2$** Carbon dioxide

**COM** Coal-oil mixture

**CWM** Coal-water mixture

**CWS** Coal-water slurry

**DOE** U.S. Department of Energy

**DRB** Demonstrated reserve base

**DSM** Demand-side management; DSM programs are instituted by utilities, such as rebates to customers for installation of energy-efficient appliances or reduced rates

for nonpeak-load use of electricity, to encourage customers to reduce electricity consumption overall or at certain periods.

**ECU** European currency unit

**EFCC** Externally fired combined-cycle

**EIA** Energy Information Administration

**EMF** Electromagnetic fields

**EPA** U.S. Environmental Protection Agency

**EPACT** Energy Policy Act of 1992

**EPRI** Electric Power Research Institute

**ESP** Electrostatic precipitator

**EU** European Union

**FBC** Fluidized-bed combustion

**FE** Fossil energy

**FGD** Flue gas desulfurization

**F-T** Fischer-Tropsch process; catalytic conversion of synthesis gas into a range of hydrocarbons.

**GDP** Gross domestic product

**Greenhouse gases** Gases, such as water vapor, carbon dioxide, tropospheric ozone, nitrous oxide, and methane, that are transparent to solar radiation but opaque to long-wavelength radiation; their action is similar to that of glass in a greenhouse.

**GRI** Gas Research Institute

**GW** Gigawatt ($10^9$ Watts)

**GWh** Gigawatt-hour

**$H_2$** Hydrogen

**Hg** Mercury

**HHV** Higher heating value

**HIPPS** High-performance power system

**IFC** Indirectly fired cycle

**IGCC** Integrated gasification combined-cycle; IGCC power generation systems replace the traditional coal combustor with a gasifier and gas turbine.

**IGFC** Integrated gasification fuel cell

**KRW** Kellogg-Rust-Westinghouse

**kW** Kilowatt

**kWh** Kilowatt-hour

**LEBS** Low-emission boiler system

**LHV** Lower heating value

**Life extension** Life extension is achieved by maintaining or improving the operating status of an electric power plant within acceptable levels of availability and efficiency, beyond the originally anticipated retirement date.

**Lignite** Type of coal with a heating value of 4,000 to 8,300 Btu per pound, a carbon content of 25 to 35 percent, and moisture content up to 45 percent.

**LNG** Liquefied natural gas

**Mcf** Thousand cubic feet

**MCFC** Molten carbonate fuel cell

| | |
|---|---|
| **METC** | Morgantown Energy Technology Center |
| **MHD** | Magnetohydrodynamics |
| **Mild gasification** | See Pyrolysis |
| **MMBtu** | Million ($10^6$) Btu |
| **MW** | Megawatt ($10^6$ Watts) |
| **MWe** | Megawatt electric |
| **MWt** | Megawatt thermal |
| **NCA** | National Coal Association |
| **NCC** | National Coal Council |
| **$NH_3$** | Ammonia |
| **$NO_2$** | Nitrogen dioxide |
| **$NO_x$** | Oxides of nitrogen; a mix of nitrous oxide (NO) and nitrogen dioxide ($NO_2$) |
| **NSPS** | New Source Performance Standards |
| **NUG** | Non-utility generator |
| **$O_3$** | Ozone |
| **OECD** | Organization for Economic Cooperation and Development |
| **OPEC** | Organization of Petroleum Exporting Countries |
| **PAFC** | Phosphoric acid fuel cell |
| **PC** | Pulverized coal |
| **Peak load** | Peak load (usually in reference to electrical load) is the maximum load during a specified period of time. |
| **PETC** | Pittsburgh Energy Technology Center |
| **PFBC** | Pressurized fluidized-bed combustion |
| **ppm** | Parts per million |
| **psi (or psig)** | Pounds per square inch (psig indicates gauge pressure, that is, pressure above atmospheric pressure) |
| **PURPA** | Public Utility Regulatory Policy Act of 1979 |
| **Pyrolysis** | Thermal decomposition of a chemical compound or mixture of chemical compounds. |
| **quad** | Quadrillion ($10^{15}$) Btu |
| **Rank** | Variety of coal; the higher the rank of coal, the greater its carbon content and heating value. |
| **RD&D** | Research, development and demonstration |
| **RDD&C** | Research, development, demonstration and commercialization |
| **Repowering** | Repowering is achieved by investments made in a plant to substantially increase its generating capability, to change generating fuels, or to install a more efficient generating technology at the plant site. |
| **$RO_x$** | Particulate matter |
| **Sasol** | South African Coal, Oil, and Gas Corporation; coal conversion plant in operation at Sasolburg; coal is gasified by the Lurgi process and then converted to liquid hydrocarbons through the Fisher-Tropsch process. |
| **SCCWS** | Super clean cold water slurry |
| **SCR** | Selective catalytic reduction; post-combustion $NO_x$ control with the use of catalysts. |

**SNG** Synthetic natural gas
**$SNO_X$** Combined $SO_2$ and $NO_x$ catalytic advanced flue gas cleanup
**SOFC** Solid oxide fuel cell
**$SO_X$** Sulfur oxide
**$SO_2$** Sulfur dioxide
**Synthesis gas** Mixture of carbon monoxide and hydrogen and other liquid and gaseous products
**Subbituminous coal** Coal with a heating value of 8,300 to 11,500 Btu per pound, a carbon content of 35 to 45 percent, and a moisture content of 20 to 30 percent.
**Synthetic Fuels Corporation** Organization established by the Energy Security Act of 1980 to facilitate the development of domestic nonconventional energy resources.
**TBC** Thermal barrier coatings
**Tcf** Trillion ($10^{12}$) cubic feet
**$UF_6$** Uranium Hexafluoride
**UNDEERC** University of North Dakota Energy and Environmental Research Center
**VOC** Volatile organic compounds