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Interagency Energy/Environment R&D Program-Status Report III

THE ENERGY/ENVIRONMENT R&D DECISION SERIES

This volume is a part of the Energy/Environment R&D Decision Series. The series presents the key issues and findings of the 17-agency Federal Interagency Energy/Environment Research and Development Program in a format conducive to efficient information transfer. The volumes are of three types: summaries—short synopses of larger research reports; issue papers—concise discussions of major energy/environment technical issues; and executive reports—in-depth discussions of an entire programmatic or technical area.

The Interagency Program was inaugurated in fiscal year 1975. Planned and coordinated by the Environmental Protection Agency (EPA), research projects supported by the program range from the analysis of health and environmental effects of energy systems to the development of environmental control technologies. The works in this series will reflect the full range of program concerns.

The Decision Series is produced for both energy/environment decision-makers and the interested public. If you have any comments or questions please write to Series Editor Richard Laska, Office of Energy, Minerals and Industry, RD-681, U.S. EPA, Washington, D.C. 20460 or call (202) 755-4857. Extra copies are available on request.

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Federal Interagency Energy/Environment R&D Program-Status Report III

United States Environmental Protection Agency
Office of Research and Development
Office of Energy, Minerals and Industry

April 1977

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Overview

In its effort to develop domestic energy resources, the Nation can ill afford a repetition of the widespread environmental damage which often accompanied energy extraction and utilization operations in the past. These impacts range from scarred terrain and acidic or saline drainage at the initial extraction site, to the release of atmospheric pollutants as fuels are burned in power plants and automobile engines. Even greater environmental damage than in the past could easily occur under a crash program of energy development unless accompanied by sound environmental protection measures.

To insure that major environmental problems related to energy resource development were anticipated and evaluated, two Federal Interagency Task Forces representing 23 departments and agencies were convened in 1973-74, during the planning phase of the Federal energy development programs. These Task Forces developed a program structure for a Federal interagency research and development effort that would assess potential environmental effects of accelerated energy development, and would develop pollution control measures to hold those environmental impacts within acceptable limits. In addition to the program structure, the Task Forces also defined specific goals and recommendations for the Interagency Energy/Environmental R&D Program which were incorporated into the December, 1973, report on the Ray Committee (*The Nation's Energy Future*) and which served as a basis for a special Congressional appropriation for environmental R&D related to energy development.

The Interagency Energy/Environment R&D Program is administered and coordinated by EPA's Office of Energy, Minerals, and Industry (OEMI). Research and development activities under this program are performed by more than a dozen Federal agencies (principally ERDA, TVA, and HEW) in addition to EPA. The overall effort is subdivided into two major parts:

- R&D on *effects* of pollutants, including health effects, ecological effects, pollutant transport (dissemination) and fate, and integrated assessment of all types of effects. This effort is termed the *Processes and Effects Program.*
- R&D on technological *measures for controlling* the release of pollutants to the environment, including changes within an energy extraction, conversion or utilization process as well as end-of-system control measures. This effort is called the *Control Technology Program.*

This report describes the Interagency Energy/Environment R&D Program. It does not pretend to address *all* Federally sponsored research in energy/environment matters; only that directly supported by EPA Interagency Program funding. The report is organized into three chapters.

- Chapter 1 presents the philosophy of the Interagency Energy/Environment R&D Program, outlines its history and discusses EPA/OEMI's role as program coordinator, outlines the five-step process for defining specific R&D projects to be performed by each participating agency, and summarizes the program budgets for fiscal years 1975, 1976 and 1977.
- Chapter 2 describes the processes and effects program in detail, outlines individual research projects, presents details of FY 76 funding and compares the FY 75 and FY 76 budgets.
- Chapter 3 provides a similar detailed description of the control technology program.

Following the three chapters is a glossary of technical terms, compiled in one location to avoid the necessity of defining technical terms wherever they occur in the text.

For more information on any of the specific projects or program areas cited in this report, the reader should obtain a copy of Who's Who in the Interagency Energy/Environment R&D Program. That booklet is organized in parallel with this report, and contains the names and telephone numbers of the individuals who are responsible for each particular program.

Introduction

Purpose

As the nation strives to reduce its dependence on foreign sources of energy, increased attention must be given the environmental problems arising from domestic energy resource development. On the Federal level, this need has been recognized by the expansion of energy-related environmental research and development programs and capabilities which are located in a number of departments and agencies.

Centralized coordination of a number of these expanded efforts is provided via the Federal Interagency Energy/Environment Research and Development Program administered by EPA's Office of Energy, Minerals, and Industry (OEMI). The primary purpose of the Interagency Program is to assure that our national energy goals are matched with an effective R&D program in that critical area where energy needs and environmental protection goals overlap.

Since its establishment in 1970, the Environmental Protection Agency (EPA) has been involved in energy-related environmental research efforts, including the development of pollution control technology, as necessary to meet its statutory responsibilities. The Agency has well established programs on flue gas cleaning technology, energy recovery from municipal waste, fluidized bed combustion of oil, physical and chemical coal cleaning, health and ecological effects of energy-related pollutants, and pollutant measurement and monitoring techniques.

The recent national policy emphasis on development of domestic energy supplies stimulated the formation, by EPA, in late 1974, of an Office of Energy Research (OER) within the Office of Research and Development (ORD). Subsequently, reorganization of ORD in June of 1975 combined industrial and mineral extraction pollution control research with energy-related environmental research in a new Office of Energy, Minerals, and Industry (OEMI).

Coordination and Clean Energy

OEMI pursues two basic purposes—to provide a focus for EPA's own environment/energy/industry R&D efforts and to serve as the coordinator of the comprehensive Interagency Energy/Environment R&D Program. The program's goals include environmental protection during every phase of accelerated development and use of energy supplies, with particular emphasis on domestic resources, as well as the development of cost-effective pollution control technologies for energy, industry, and mineral extraction and processing systems.

The Interagency Program recognizes that continuity is crucial in a successful R&D effort. Often, the "surge effect" of accelerated R&D in response to a rapidly emerging problem can lead to results of diminished utility. Within the several agencies involved in the program there lies a reservoir of expertise and experience which could not be mobilized by any one agency. This resource can, through the Interagency Program, be used to conduct that portion of the program wherein lies each organization's unique expertise.

OEMI's role as coordinator of the Interagency Program reflects the fact that a sound environmental R&D program must be conducted in parallel with the evolving energy development programs of the Energy Research and Development Administration (ERDA). ERDA's mission is to aggressively pursue new energy sources and to expand existing sources using the best technological, economic, and environmental means available. Because of the pressure to develop new energy sources and technologies, ERDA cannot be expected to focus as intensely on the environmental aspects as it does on its primary energy development responsibilities. EPA's primary mission is environmental protection, and its objective in the energy area is to enable ERDA's efforts to progress as rapidly as possible while assuring that national environmental goals are maintained.

Congress was cognizant of these two complementary roles when it enacted the Energy Reorganization Act of 1974, under which ERDA was established. This Act calls on the directors of EPA and ERDA to formulate interagency agreements to promote cooperative Federal Energy/Environment R&D efforts. This diversity established by Congress helps to ensure balanced, objective, and carefully weighed judgments. Greater protection of the public interest result-

ing from such a balancing process should foster public trust and increase confidence in national energy and environmental policy decisions.

The philosophy of our program asserts that timing is crucial in the overall relationship between energy and environmental R&D. Through the 1970's and 1980's use of domestic coal resources is expected to increase dramatically. This will occur chiefly through direct combustion of coal in power plant and industrial boilers, but only if technologies to control emissions of sulfur oxides and other pollutants are successfully applied.

Thus, environmental R&D on near-term coal use is focussed on EPA's continuing program to advance environmentally acceptable ways to extract and utilize coal. To the degree that these control technologies can be implemented rapidly, there will be early environmental, economic, and social benefits from such R&D efforts. For this reason, funds are weighted heavily in the FY 1975 and FY 1976 budgets towards facilitating near-term coal use- development of flue gas desulfurization systems (stack gas scrubbers) and coal-cleaning techniques, analysis of environmental effects of coal extraction, characterization and monitoring of resultant pollutants, determination of health effects of coal conversion, and other related programs.

Anticipatory R&D

Another feature of the Interagency Program is anticipatory R&D. Many of the new energy technologies will require attendant pollution control measures. Sufficient lead time is essential to ensure that appropriate controls are available in advance—preferably when a new energy technology is ready for initial demonstration.

In addition, basic information on pollutant characterization, measurement, and effects on human health and the environment should be established at an early date to ensure full consideration of all relevant factors in development decisions. Under the auspices of the Interagency Program, EPA and ERDA are cooperating in the environmental testing of several new energy technologies.

Thus, the mid-term and long-term emphasis of the program shifts toward anticipatory R&D. Overall environmental considerations have to be integrated into the planning of energy technology development. A scientifically valid knowledge of the health, ecological, and welfare implications of an energy technology ought to play a key role in the decision-making process whereby that technology is implemented. Otherwise we risk either unacceptable environmental damage or costly retrofit of controls. At present a major part of EPA's research is in support of its regulatory role (scrubber development, for example). The anticipatory research, emphasizing the *prevention* of environmentally adverse effects, is in its early stages. It will expand as the need for R&D to answer regulatory needs diminishes. In this effort, EPA/OEMI will work closely with ERDA and with the other participating agencies as new energy sources are developed. The rationale behind such a cooperative approach is clear—it is far more cost-effective to provide adequate environmental protection as a part of new technologies than to retrofit controls in operational systems or to clean up wastes once they have been discharged. The nation will be best served if, through cooperative planning and programming, new environmentally compatible energy systems are ready when needed.

Program History

The Office of Energy, Minerals, and Industry has developed a program based upon the goals stated in the report on *The Nation's Energy Future* (often referred to as the Ray Report), and upon two interagency task force reports commissioned by the Office of Management and Budget and the Council on Environmental Quality to recommend how Federal R&D funds in energy and environment could be allocated most effectively. The specific recommendations of the task forces form the foundation for OEMI's role and for the entire R&D program.

The Ray Report

In the summer of 1973, the President directed the Chairperson of the Atomic Energy Commission to prepare a comprehensive and integrated national energy research and development plan. The result, entitled *The Nation's Energy Future*, was completed in December 1973. Drawing upon the efforts of 37 Federal departments and agencies as well as the private sector, it recommended a five-year, $10 billion energy research and development program. Proposed funding for, and brief descriptions of, the environmental control technology R&D required to exploit these resources were incorporated into the report, which also recommended a supporting environmental effects research program.

Fiscal Year 1975 Program Budget

The Ray Report helped shape the Federal budget requests for FY 1975. These requests contained a substantial increase in R&D in the environmental aspects of this major national energy research and development program. The Administration, through EPA's budget, requested $191 million in FY 1975 for the Energy/Environment R&D Program. Congress authorized $134 million. The non-EPA portion of the interagency program was approximately $53 million, or nearly 40 percent.

Fiscal Year 1976 Program Budget

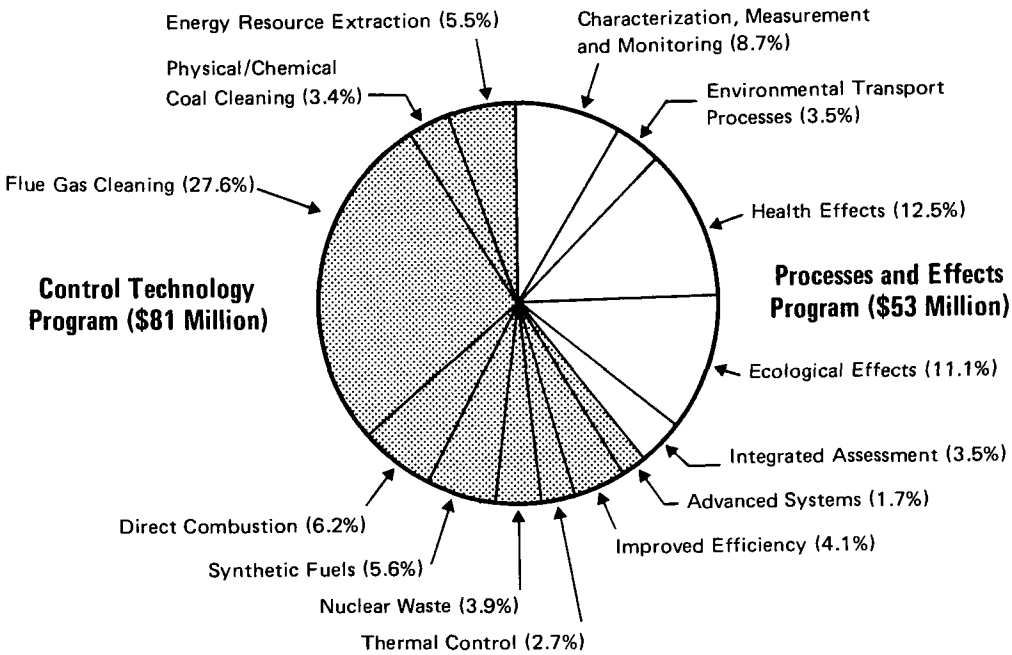
For FY 1976, the Administration, again through EPA's budget, requested $112 million for the Energy/Environmental R&D Program. Congress appropriated $100 million. The interagency portion of the program is about $32 million. Part of the reduction was associated with direct appropriation to ERDA of approximately $6 million of their Interagency Program allocation. Another part is associated with the full funding, in FY 1975, by EPA of two large flue gas desulfurization demonstrations.

Following the release of the Ray Report and initial formulation of the FY 1975 budget, two interagency task forces were established under the auspices of the Council on Environmental Quality by the Office of Management and Budget to examine ongoing Federal research programs and to recommend allocations of funds which would provide the most effective integrated environment/energy R&D program. Their reports covered two areas:

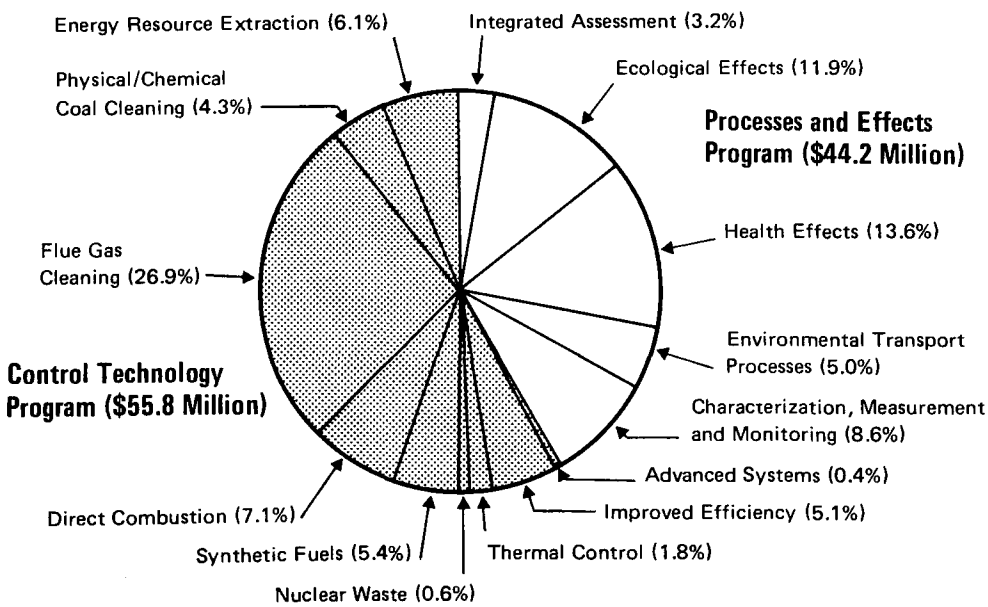
(1) Health and Environmental Effects of Energy Use, and

(2) Environmental Control Technology for Energy Systems

Issued in November 1974, the task force reports were developed by representatives of more than a dozen Federal agencies, departments, and laboratories, all involved in energy-related environmental research. One of the major purposes of the reports was to determine whether serious gaps existed in the overall Federal Energy/Environment R&D Program. By performing a cross-cut review of the entire program, it was possible to identify such gaps, to determine areas where adequate support was available for national energy goals, and to locate target areas for funding via the special energy appropriation to EPA. OEMI, in implementing the Interagency Program based upon the two task force reports, is in an advantageous position to maintain a balanced and coordinated Federal Environment/Energy R&D Program.



FY 1975 FUNDING



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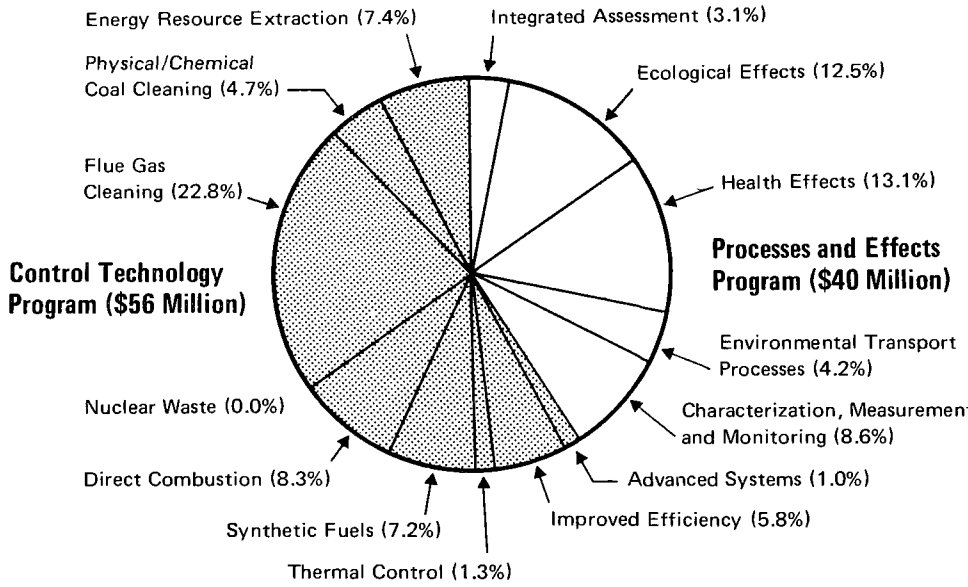
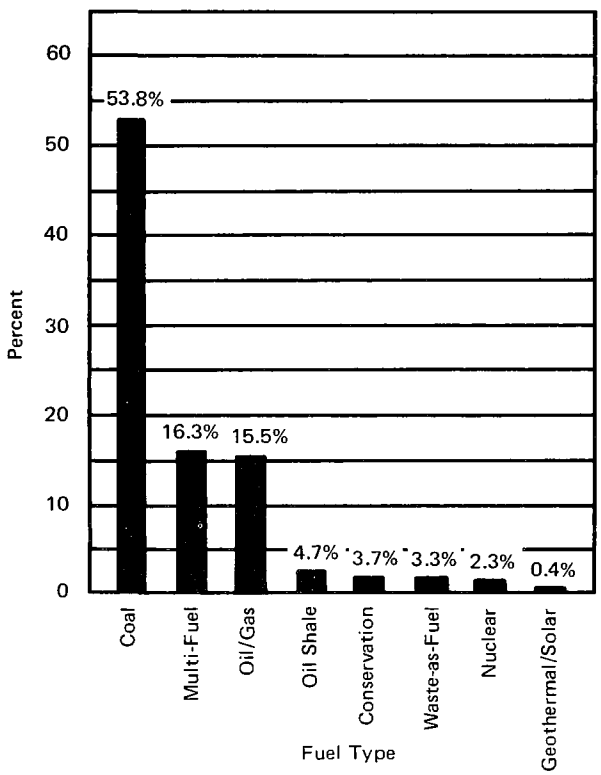
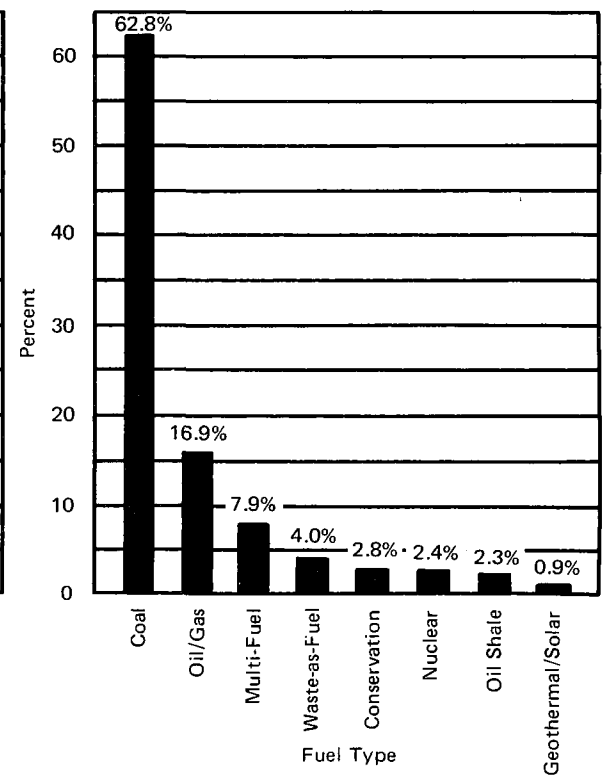


FY 1977 FUNDING



FY 1975 FUNDING BY FUEL TYPE ($134 MILLION)



FY 1976 FUNDING BY FUEL TYPE ($100 MILLION)

Task Force on Environmental Effects

This group reviewed current work and future research needs for health and environmental effects which result from the following energy technologies: coal and synthetic fuels, natural gas and oil, energy efficiency, oil shale, nuclear, solar, geothermal, and hydroelectric.

Two criteria were required for areas selected for study: (1) the research areas had to be energy-related and (2) they had to take into account *existing* research bases in the various agencies. In further identifying its task, the group identified the research required at each of the major stages of any energy cycle—extraction, processing or conversion, and utilization. The following areas were used to assess health and environmental information needs for *each* stage of *each* energy cycle.

Pollutant characterization, measurement and monitoring—identification, measurement, and monitoring instrumentation and methods.

Environmental transport processes—the transmission in air, water, and soil of pollutants and heat emitted from energy operations. The review traced these pollutants from their source to their ultimate destination (fate) in man and the environment, including any physical and chemical transformations occurring during transport.

Health effects—the quantitative and qualitative effects of energy-related agents in terms of the risks they pose to human health, and health cost information to aid in occupational and general standard setting for energy-related hazardous substances.

Ecological effects—the environmental effects of increased energy development on fresh surface and ground water, marine and estuarine, and atmospheric/terrestrial ecosystems.

Integrated Assessment—The entire range of consequences of alternative energy/environment policies, including health, ecological, socio-economic, and welfare impacts. Attention is directed toward identifying environmentally and economically acceptable alternatives . . . to assist in selection of 'optimum' policies for attainment of environmental quality goals. The report called for the initiation of assessments integrating information from the following areas:

environmental research,
social and welfare effects,
total environmental impact,
cost/risk/benefit, and
implementation alternatives.

For an explanation of how these functional areas fit into the overall planning structure, see the OEMI program description in Chapter 2. The FY 1976 health and environmental effects program, totalling $40-million, follows essentially the same distribution pattern as $53-million FY 1976 program. The FY 1977 program is set at $40-million.

Task Force on Control Technology

The task force report on Federal R&D Programs for environmental control technology recommends where programs should be expanded, maintained, or revised. Because of the goal of increasing the use of domestic energy resources, this task force's report concentrates on the following nine programs.

Energy Resource Extraction—Measures to reduce the environmental impacts of extracting coal, oil and gas, and oil shale with special emphasis on Western surface mining of coal and oil shale.

Coal Cleaning—Processes for chemical and physical cleaning of coal to remove ash and sulfur prior to combustion.

Flue Gas Cleaning—A major near-term priority item for the Interagency Program is to complete demonstration of the current generation of flue gas desulfurization (FGD) systems and to advance the state of the art of regenerable (producing a useful byproduct) FGD systems. The report also recommended that processes be developed for removal of fine particulates, nitrogen oxides, and hazardous materials. It also directed attention towards environmentally acceptable disposal techniques for flue gas cleaning wastes.

Direct Combustion—Processes to develop high-efficiency, low-pollutant combustion systems were reviewed, with particular emphasis on fluidized bed combustors.

Synthetic Fuel—Coal gasification and liquefaction technoligies appear to be promising, but little is now known about emissions and residuals released to the environment from such conversion process. The report concluded that appropriate control technology will have to be developed before commercial-scale operations can begin.

Nuclear Fuel Cycle—Work is needed on nuclear waste control. The report focused on reduction of the environmental impacts from processing and disposal of waste at critical points in the nuclear fuel chain—particularly mining and milling wastes.

Thermal Control—Disposal of waste heat from electric power plants. Emphasis must be placed on improved cooling devices, reduced use of rivers and lakes as heat sinks for discarding thermal effluents, and utilization of waste heat.

Improved Efficiency—Assessment of potential environmental effects of the industrial process changes to apply energy conservation, waste-as-fuel, and advanced power systems.

Advanced Systems—Environmental studies on geothermal and solar energy were reviewed, and future research areas were discussed.

The task force recommended that highest priority be given to R&D on flue gas cleaning and energy resource extraction since both processes can facilitate increased near-term use of coal. Looking further into the future, it stressed that high priority should also be assigned to R&D on ways of using more coal and such physical/chemical cleaning and fluidized bed combustion. Because of the likelihood that successful commercial development of synthetic fuels would guarantee that most domestic coals could be used, the report urged that attention be focused on environmental problems in that area. Finally, research on potential environmental problems arising from increased energy conservation measures was identified as a priority area. For the near term, however, more than 60 percent of the control technology program funds are allocated for coal-related studies.

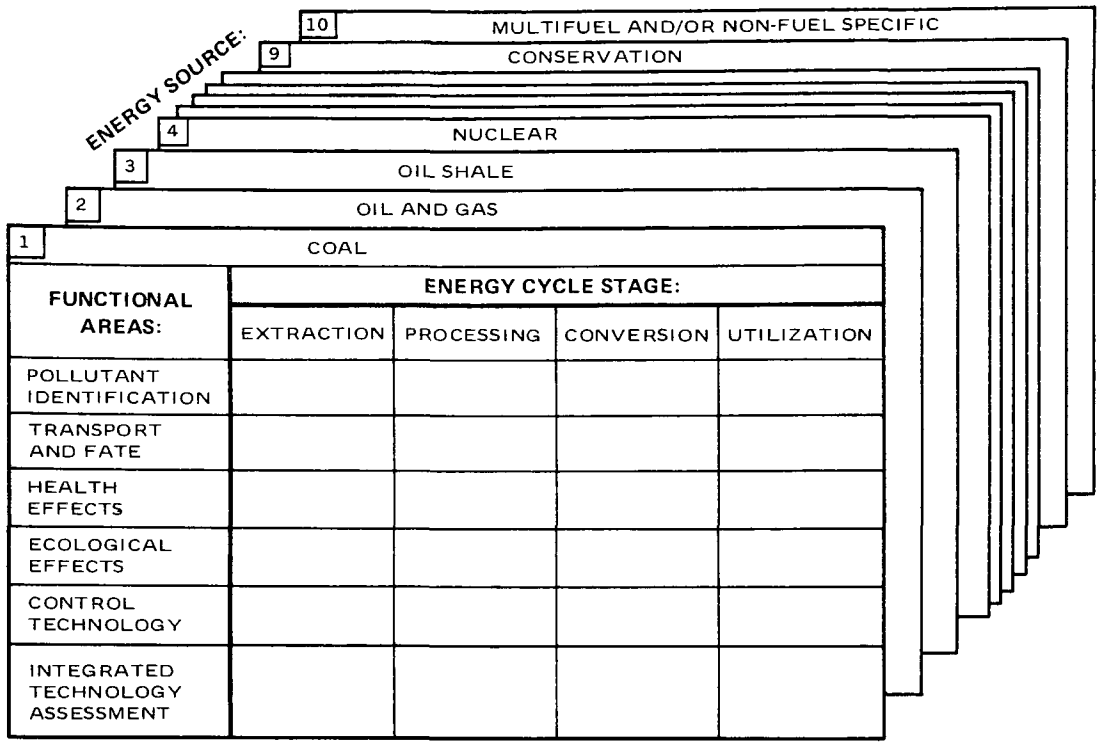
Since the publication of the two task force reports in November of 1974, the R&D program categories used in those reports have become common nomenclature for the Interagency Program's research communications. Not only are these terms of reference used between agencies, but they have also been adopted for portions of internal planning and/or communications by several agencies. Details of EPA's program, including accomplishments for FY 1976 and beyond, both within EPA and in other Federal agencies receiving Interagency Program funds, are contained in Chapter 3.

Program Structure and Operation

The Ray Report and the two interagency task force reports form the basis of the Interagency Program. To implement the report's recommendations, OEMI has established a straightforward, comprehensive plan to ensure that the entire range of energy/environment R&D is woven together into a manageable framework.

A multidimensional matrix concept is employed to classify program content and resources. This format, depicted in Figure 1, provides both a means for classifying ongoing activities and a practical structure for program planning. The structure allows easy identification of the various elements of the program.

An example of how this planning process works is shown in Figure 2 which illustrates typical environmental research areas for each stage of the fuel cycle for coal. Each component of the energy cycle—*extraction* of the resource, physical *processing* or chemical *conversion* to get the resource into a more usable form, and *utilization* or the actual controlled release of energy as power for transmission and consumer end use—calls for specific areas of environmental research. Some of these typical areas are listed.



INTERAGENCY PROGRAM PLANNING STRUCTURE

OEMI'S Role

This planning approach is being used by OEMI in its role as coordinator of the Interagency Energy/Environment R&D Program for EPA's laboratories and for other participating Federal agencies and departments. OEMI, with input from the other participants, concentrates on strategic planning, information assessment and transfer, and overall program balancing. Detailed program execution and management is delegated to the field laboratories of EPA and to the other Federal agencies.

When the strategic planning phase is completed, OEMI's role becomes one of implementing and monitoring the program. The implementation phase is carried out in the following manner:

Step 1: The first step is the identification of necessary tasks. Prior to this, OEMI has reviewed existing, related programs. This process requires extensive consultation with field laboratories, Federal and private research organizations, and other EPA offices.

Step 2: After a necessary task is identified, a short description (an Objective Statement) is transmitted to the appropriate EPA laboratory or other agency for review in terms of that organizations current programs, experience, and potential for contribution.

Step 3: The participating laboratory responds with a concise description (Accomplishment Plan) of a plan for accomplishing the task outlined in the Objective Statement.

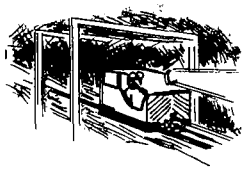
Step 4: Final review is conducted by OEMI headquarters staff, and the OEMI director authorizes expenditure of funds.

Step 5: Upon receiving OEMI approval, the participating laboratory or agency then carries out the plan, including the development of any extramural contracts or grants. OEMI monitors the progress of the task via semi-annual progress reports and periodic interagency program reviews.

In its coordination role, OEMI has three objectives: (1) to establish clear communication between OEMI and the field research laboratories and/or implementing agencies, (2) to provide a high degree of interaction among all participants in a research program, and (3) to eliminate unnecessary paperwork.

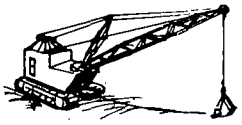
Coal Fuel Cycle—
Typical Environmental Research Areas

EXTRACTION



UNDERGROUND

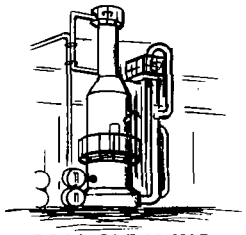
- Acid mine drainage
- Coal mining waste treatment/disposal



SURFACE MINING

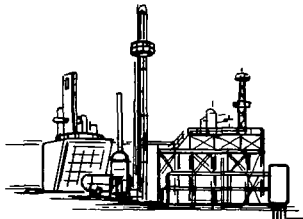
- Revegetation of arid lands
- Disruption of aquifers and natural drainage contours
- Pollutant discharges and effects
- Site selection
- Surface & ground water monitoring

PROCESSING OR CONVERSION



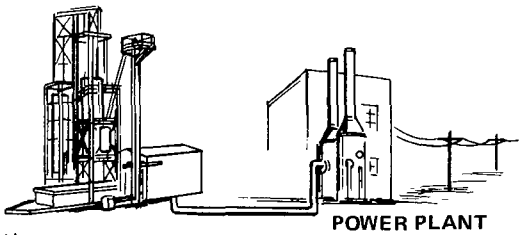
COAL CLEANING
COAL LIQUEFACTION

- Identification & treatment of hazardous pollutants
- Health effects of hazardous pollutants
- Waste disposal and reclamation
- Resource recovery



HIGH-BTU GASIFICATION

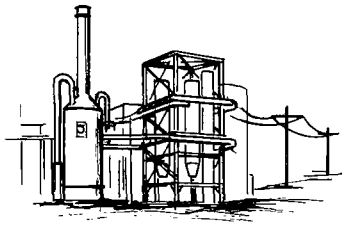
- Identification & measurement of hazardous discharges
- Waste treatment/disposal
- Resource recovery (char)



LOW-BTU GASIFICATION

- High temperature gas clean up
- Identification & measurement of hazardous discharges
- Waste treatment/disposal
- Resource recovery (char)

UTILIZATION



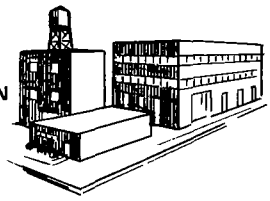
POWER PLANT
FLUIDIZED BED COMBUSTION
FLUE GAS CLEANING

- Sludge disposal or use
- Advanced processes (regenerable systems)
- Fly ash disposal
- Health and ecological effects of acid aerosols & fine particulates
- Measurement & monitoring of sulfates
- Control of fine particulates and hazardous materials
- Atmospheric chemistry & transport (acid sulphate aerosol formation)

PIPELINE

POWER PLANT

END USE



- Identify environmental effects of industrial energy conservation processes

Interagency Communication

To identify new priority research needs and provide a major forum for information exchange, OEMI has established "sector groups" for broad program areas. Led by a member of OEMI's technical staff, each group is comprised of EPA's research personnel, other EPA officials, and representatives of other agencies involved in related research areas.

The groups meet periodically to ensure that the research needs in each problem area are adequately covered. To date, sector groups have been established for three major categories—electric utilities, advanced fossil fuels, and Western energy resource development.

At the sector group meetings, participants present information on topical areas from their own unique perspectives. Sector group discussions highlight areas of major concern, explore solutions to current and potential problems, and identify gaps in ongoing research, potential areas of unnecessary duplication, and emerging areas of R&D opportunity. Information exchanged during these meetings is documented and is used in both the fine tuning of ongoing research and the conceptualization and planning of new R&D efforts.

Clearly, it is too early to assess the success of the planning structure. It was applied initially to the $134-million FY 1975 Interagency Program, the $100-million FY 1976 program and the $96-million FY 1977 program. Such a structure alone, of course, cannot achieve the coordination necessary for effective implementation of the R&D program. The structure may expedite a successful program, but continuing cooperation and communication between the participating agencies and their laboratories is required to ensure its success.

Program Summary

By using the same program planning process in FY 1975 and succeeding fiscal years, review is simplified, and possible deficiencies in the program are more easily identified and resolved.

To date, OEMI has approved more than 300 accomplishment plans using the fundamental planning concepts discussed earlier in this report. To summarize, OEMI is:

- Working toward the major national goal of expanded use of domestic energy resources at minimal dollar, social, and environmental costs.
- Adhering to the policy recommendations of the two Interagency Task Force reports on the Federal Interagency Energy/Environment R&D Program.
- Testing and refining the planning structure to assure that it meets the objectives of continuity, simplicity, logic, and effectiveness.
- Using a five-step implementation process designed to facilitate communication and coordination.
- Emphasizing that energy/environment R&D required to enable use of domestic coal as quickly and as cleanly as possible.
- Implementing a processes and effects program which also aims at facilitating the use of coal as well as at energy conservation.

Processes and Effects Program

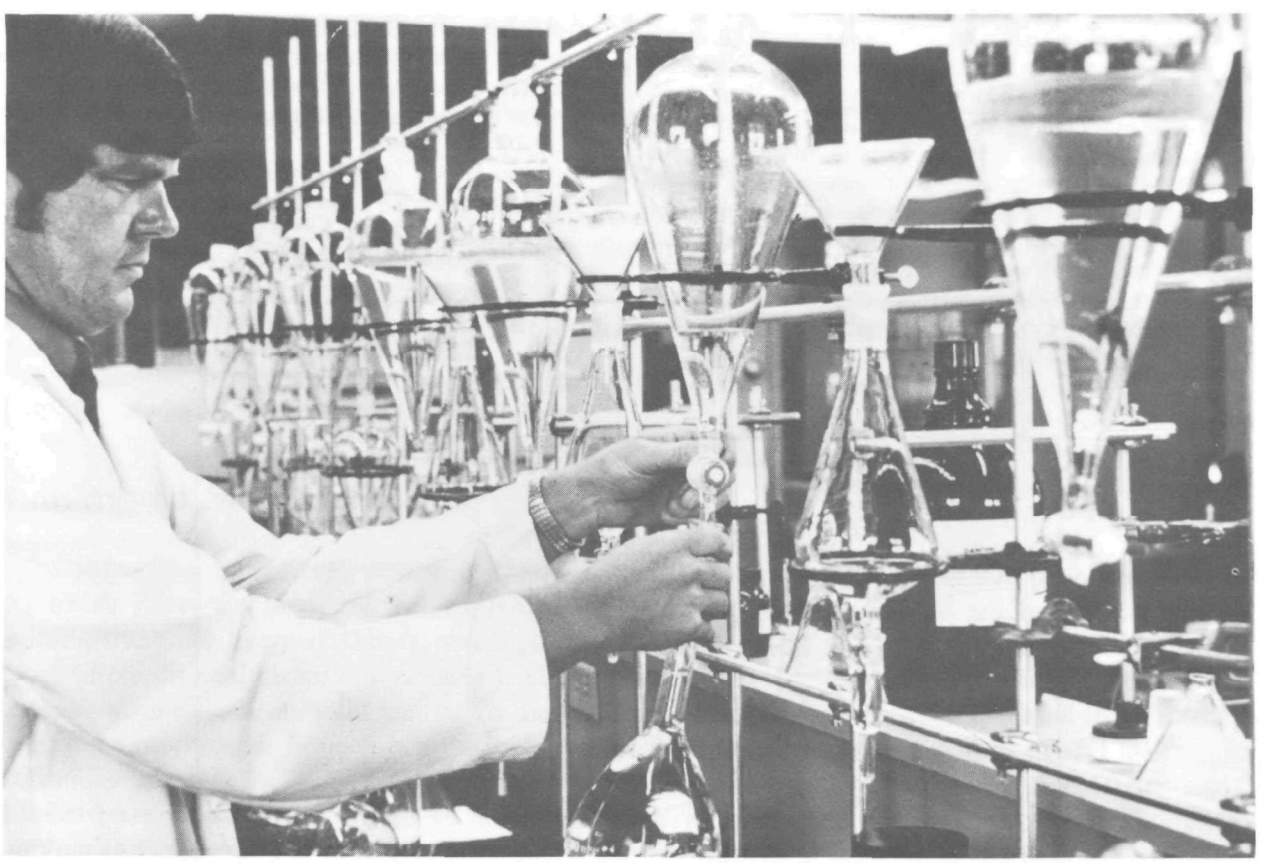
The processes and effects program within the Federal Interagency Energy/Environment Research and Development Program is designed to identify the mechanisms of movement within the environment and the effects on human, animal, and plant populations which are associated with energy related activities. The goal of the program is to compile and evaluate information to support decisions relative to the protection of natural biota, human health, welfare, and social goals.

The Office of Energy, Minerals, and Industry has established a comprehensive processes and effects research program. The FY 1976 research program is funded by a $40.3 million budget (excluding monies for program management) which represents more than 40 percent of the Interagency Energy/Environment Program. For a breakdown of the funding distribution, the program is divided into the functional areas of health effects (32.1 percent), ecological effects (28.2 percent), characterization, measurement, and monitoring (20.3 percent), environmental transport processes (11.8 percent), and integrated assessment (7.6 percent). Figure 5 shows the distribution of the actual 1975 and 1976 budgets and the planned 1977 budget. Approximately 45 percent of the processes and effects research activity occurs within EPA laboratories and facilities. Most of the research projects relate to the development of domestic coal resources. The research program assesses the environmental effects of each stage of an energy source's fuel cycle (extraction; processing; transportation and conversion; and utilization).

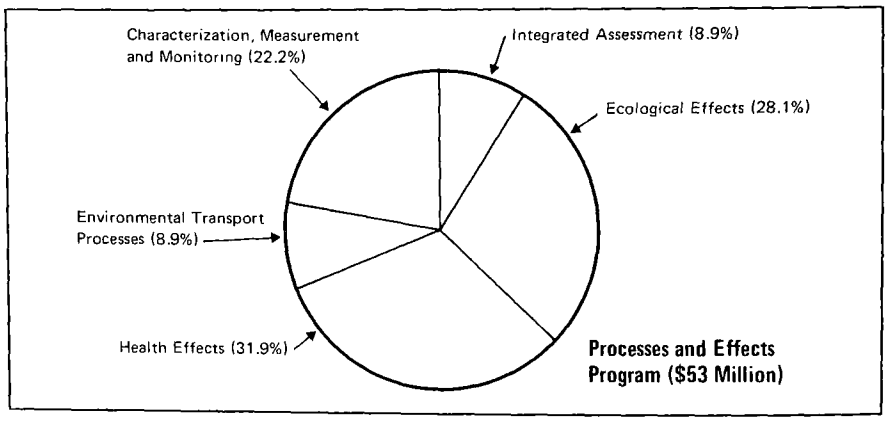
The criteria for determining research priorities were the:

- Potential magnitude and importance of human health and environmental effects;
- Nature and potential significance of the developing technology;
- Expected rate of development of the technology.

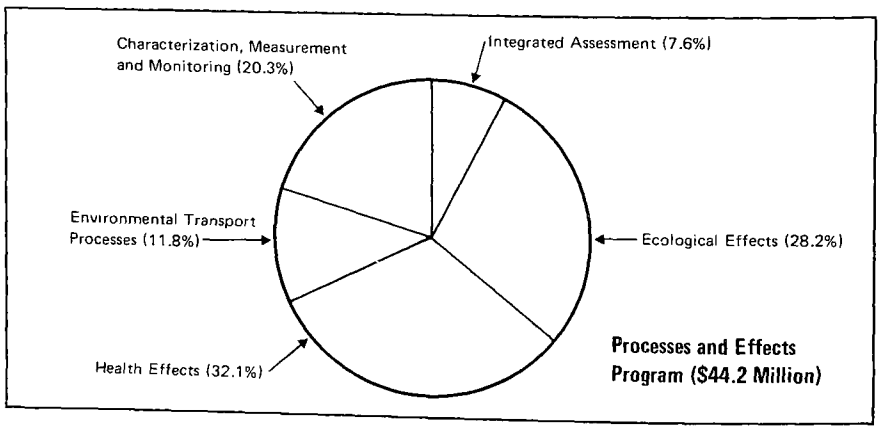
The salient aspects of the processes and effects program are described in the following sections.



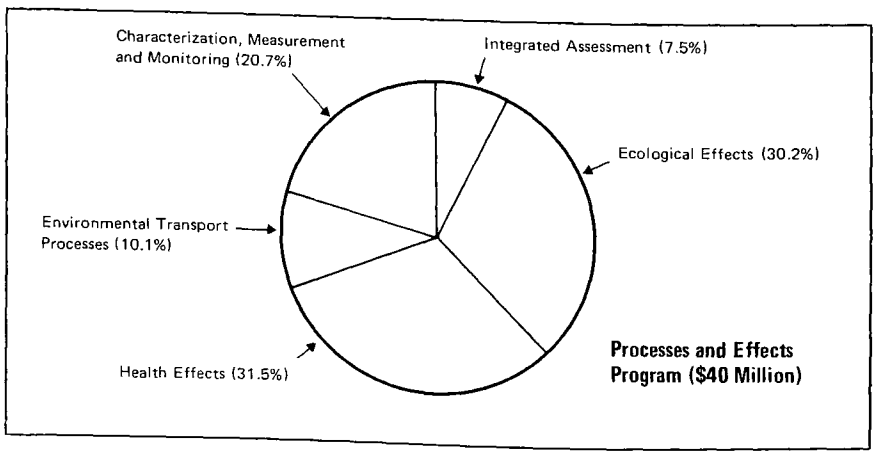
Process and Effects Funding by Interagency Category



FY 1975 FUNDING



FY 1976 FUNDING



FY 1977 FUNDING

Characterization, Measurement, Monitoring

One essential activity in the processes and effects program is the detection and measurement of pollutants. Included in this activity is quality assurance to ensure accumulation of valid information to provide a basis for energy/environment decision-making. The objectives of this research area are to accelerate the development of new and improved sampling and analysis methods for energy-related pollutants and to identify, measure, and monitor energy-related materials hazardous to the environment and to humans.

Industrial processes and energy development technologies often involve the discharge of liquid, gaseous, particulate, and solid wastes which are released to the air, land, and water. An understanding of the magnitude and diversity of pollutants emanating from sites of energy development requires an integrated, multi-media, and multi-disciplinary monitoring approach. An important example of such an integrative approach is the multi-year air, land, and water quality monitoring to establish baseline data in Western regions to support EPA standards. EPA, in coordination with other Federal agencies has established monitoring/programs within the Four Corners area of New Mexico, the Northern Great Plains, and oil shale areas in Colorado, Wyoming, and Utah.

Remote monitoring projects are designed to prove the effectiveness of high altitude remote sensing and photographic techniques for monitoring energy-related activities and impacts. Information related to land-use surface disruption, surface water, vegetation, and visibility is obtained for areas undergoing coal mining and oil shale development.

Groundwater monitoring projects determine the presence and extent of groundwater contamination as a result of coal strip-mining and oil shale extraction and processing. Emphasis is on the accumulation of geochemical and physical data to identify factors which contribute to contamination, and to demonstrate the effectiveness of groundwater monitoring.

The monitoring of solid wastes involves the analysis of fly ash, sludge, and slag materials from energy-related activities such as oil and oil shale processing, coal mining and conversion. Toxic trace compounds such as phenols, cyanides, nitrates and phosphates are characterized, and monitoring procedures and instruments are tested.

The characterization, measurement, and monitoring program comprises 8.2 percent of the total funding for the Interagency Energy/Environment R & D Program for FY 1976 and 20.3 percent for the Processes and Effects research program. Approximately 38 percent of the research within this area occurs within EPA laboratories. The rest is planned and coordinated by EPA as part of the Interagency Program, but is carried out by the Energy Research and Development Administration (ERDA), National Oceanic and Atmospheric Administration (NOAA), National Institute for Occupational Safety and Health (NIOSH), National Aeronautics and Space Administration (NASA), U.S. Geological Survey (USGS), and the National Bureau of Standards (NBS).

Most of the research activities within this program relate to coal technology. Secondary emphasis is on the development of oil and gas and oil shale resources. Several studies relate to nuclear, geothermal, and fuel conservation technologies. Almost all studies relate to either the acquisition of raw fuel materials or to the actual release of energy from fuels for use as power. The characterization, measurement, and monitoring projects can be better described in more detail in terms of four principal subcategories: multi-media, air, water, and quality assurance.

Multi-media Monitoring

The extraction, processing, conversion, and use of fuels to produce energy also produces pollutants which affect air, land and water quality. While in some cases pollutants are limited to a single medium, there are many situations where pollution is multi-media and must be viewed in that light. For example, in coal cleaning processes toxic substances may be blown into the air, discharged to water, or accumulated as solid waste. To understand the full environmental impact, all three media need to be monitored. Projects within this area involve identification, measurement and longterm continuous sensing for background parameters for energy related pollutants. This category also includes research studies designed to accelerate the development of new or improved methods of sampling and analysis. The following are representative examples of projects in this area.

Validate EPA's standards by establishing baseline air quality data in the Western region encompassing the coal mining and power plant regions of the Northern Great Plains, Black Mesa and Four Corners, Oil shale regions of Colorado, Wyoming and Utah, uranium mines in western states and geothermal energy regions including the Imperial Valley of California. The study will focus on reactive hydrocarbons, SO_x, NO_x, other toxic substances, and visibility.

Develop mechanisms for coordination of water monitoring activities associated with energy technologies. Coordination on an annual basis will be made for the water monitoring activities of EPA and other Federal Agencies.

Study requirements for groundwater monitoring for oil shale and coal strip mining for at least two water basins in the western United States. This study will provide information for the implementation of valid groundwater monitoring at future sites of energy development.

For coal-fired power plants, oil shale extraction and waste disposition, establish baselines for land use. The work includes studies on the usefulness of photographic and overhead remote sensing monitoring techniques performed in cooperation with NASA.

Develop techniques to monitor nuclear pollutants. Plutonium monitoring is stressed. In addition, assays will be made on other radionuclides such as uranium, thorium, and americium.

Identify low-level trace contaminants from energy technologies in solid waste and effluent water. Stress is placed upon hydrocarbons, carcinogenic organics and toxic inorganic elements and compounds. A primary goal is the monitoring of pathways of entry into drinking water.

A five year energy-impacted land use baseline will be established in eight energy regions in the Western United States which the EPA considers to be of high potential as pollution sources. The effort includes aircraft monitoring with techniques such as infrared photography and multi- spectral scanning. Data will be collected for a variety of energy sources such as strip and oil shale mining and power plant sites. (NASA)

Establish and appraise surface-water monitoring systems in coal mining regions of southeastern Ohio, southeastern Illinois, and Tennessee. (USGS)

Improve analytical procedures to isolate and identify certain power-industry-generated water pollutants. Reports have been prepared on arsenic and asbestos, and will address cadmium and zinc. (TVA)

Apply similar techniques to coal impacted regions of Arizona, Washington, and Alaska. (USGS)

Study air quality in the Western United States via meteorological analyses. Ambient air monitoring is included. This study will aid in characterizing the pollutants which are carried by various wind patterns. (NOAA)

Light detection and ranging (LIDAR) measurement techniques to trace and analyze power plant pollutants will be improved. This includes work on an FM/CW dopplar LIDAR sensor to quantify studies on atmospheric pollutant transformation processes. (NOAA)

Develop techniques to measure concentrations of oil spills and to forecast ultimate spill trajectories. The studies will include work on effects of water current (three dimensional), direct wind drag, wave transport, sea-air pollutant transfer and horizontal diffusion. (NOAA)

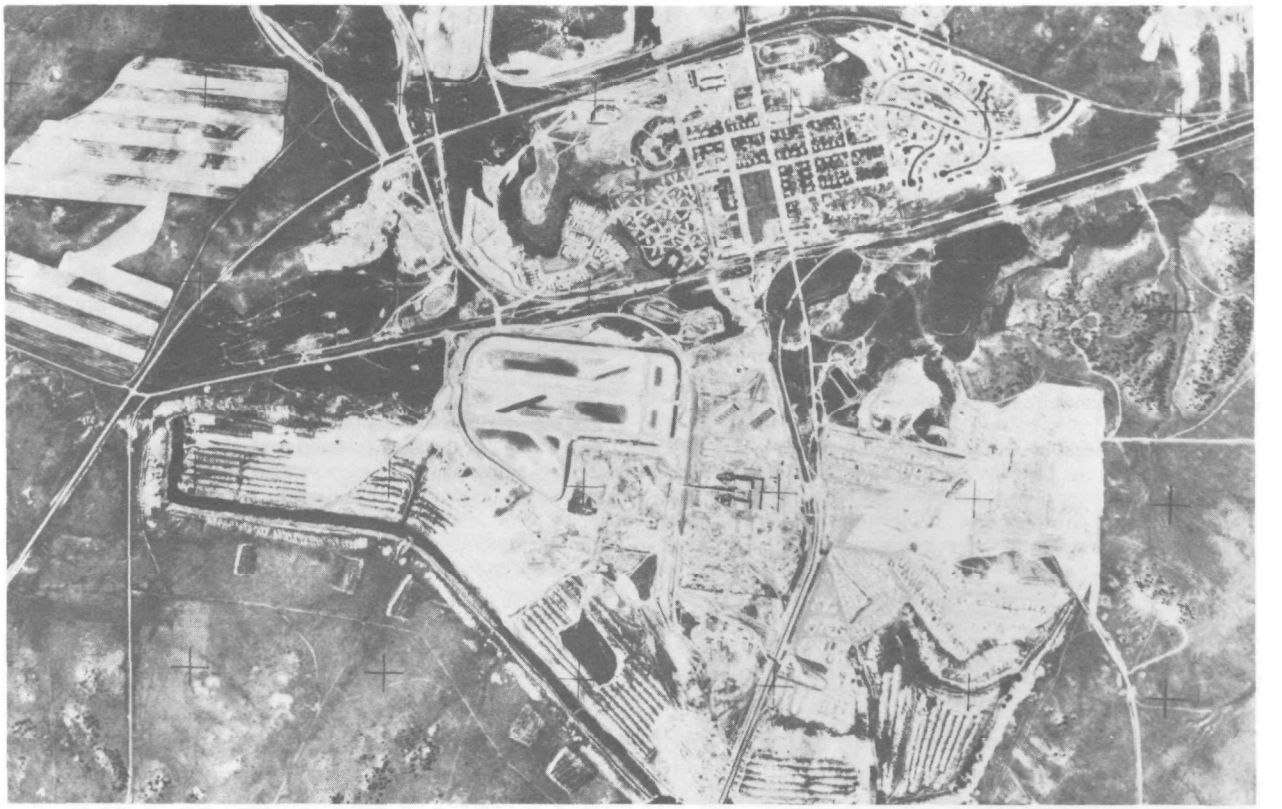
Develop SEASCAN to be used underway as an interactive measurement system, and a towed surface sampler for hydrocarbons. The project will follow accepted techniques for instrumentation development. One goal is an evaluation of the system for use with trace metals. (NOAA)

Implement baseline surface water monitoring networks in energy impacted areas of Colorado, Utah, Montana, Wyoming and North Dakota. Energy technoligies covered include coal, oil shale, uranium, oil, gas, and the general power development. Emphasis is on basins and waters downstream from energy sites. This project is complementary to the EPA projects in Western U.S. (USGS)

In conjunction with the above effort, other western regions will be studied in an effort to establish a groundwater quality baseline in severely energy-impacted aquifers. The work will include such activities as geochemical investigations of principal shallow aquifers and physical measurements for changes in the groundwater from oil shale extraction, and the correlation of various geological and hydrological parameters to various coal exploitation technologies. (USGS)

Air Instrumentation

While many activities associated with energy development and use result in multi-media pollutants which must be studied as such, there are also certain medium-specific problems. In the air medium, for example, coal combustion results in emission of SO_x, NO_x and fine particulates into the atmosphere. To be thoroughly understood and controlled, these pollutants must first be measured. Air instrumentation activities provide for the development of instruments for the sampling, measurement, and monitoring of air pollutants related to energy development. These include on-site continuous monitoring devices as well as portable samplers such as personal dosimeters for use in measuring health effects in humans.



Measurement and monitoring techniques are being developed for pollutant assay, stationary source emissions and ambient air. Studies will concentrate on particulate sulfate, size fractionated particulate matter, organic particulates, high molecular weight organics, sulfate, nitrate, carbonaceous aerosols, and sulfuric and hydrochloric acids. Compact portable air samplers are being developed. This project will provide tools which can be used in the detection and characterization of unexpected pollutant air masses brought about by unforeseen meteorological effects.

Develop airborne Raman LIDAR and other remote sensing laser techniques for the monitoring of fine particulates, SO_x and NO_x, particularly as these pollutants affect vegetation.

Develop instruments for the characterization, measurement, and monitoring of hazardous pollutants associated with the occupational environment of various energy technologies. The work includes development of a portable microwave spectrometer for trace metal analysis, personal gas and vapor monitors, personal samplers for cold environments, and a fibrous aerosol monitor. This project will provide equipment required for health effects studies relevant to industrial hygiene. (NIOSH)

Improve infrared and infrared laser instrumentation techniques for usage in remote sensing of energy related pollutants. The work will include both development and testing. (NASA)

Develop economical instruments for qualitative and quantitative studies of energy related air pollutants with particular regard to atmospheric aerosols. The work will include infrared studies of sulfuric acid and ammonium sulfate, sulfate and sulfur trioxide determinations, and completion of ammonia trap developments. (ERDA)

Develop instruments for use in the health effects program with particular emphasis on energy related aerosols. Measurement will be made of differences in fine particulates from sources of eastern and western coal and of organic carcinogens and trace metals. (ERDA)

Develop standard reference materials (SRM) for energy related air pollutants. Develop ambient air SRM's for such pollutants as SO_x, NO_x, and particulates. Workshops on SRM development will be conducted.

Characterize power plant pollutants to determine physical and chemical properties expecially with regard to pollutant impact on various meteorological phenomena. This study includes the dispersion of air pollutants. (NOAA)

Develop and evaluate an integrated approach to optimization of radiological surveillance programs for nuclear power plants. Guidelines and protocols for radiation monitoring are being formulated.

Water Instrumentation

While water quality measurement for power plant and industrial discharges has been under development forty years, new energy technologies and processes have created the need for better methods of monitoring an increasing number of potential water pollutants. Coal conversion plants, for example, may discharge hazardous amounts of phenols, cyanides, and other toxic substances into waterways. These must be monitored accurately so that effective controls can be developed. These studies focus on organics, particularly carcinogens, in water.

Develop water pollutant sampling, measuring and monitoring methods and instruments for use in assessing the hazards of various energy technologies. Instrumentation for continuous monitoring of toxic elements, phenols, cyanides, nitrates, phosphates, and total organic carbon will be developed and tested.

Develop instrumentation and techniques for analyzing materials in aqueous effluents. Concentration techniques to increase minimum assay sensitivity of pollutants are being developed by use of chelation resins. Other systems under consideration include inductively coupled plasma, analytic systems, neutron activation techniques and isotope spark source mass spectrometry. These techniques will allow for the detection of pollutants before they reach hazardous levels. (ERDA)

Develop instrumentation for the characterization, measurement, and monitoring of water pollutants and sediments. Emphasis will be on coal, oil shale, and related petrochemicals. The work will include instruments for high volume analysis, development of flumes and weirs for measurement of sediment laden stream flows, and investigation of techniques for the detection of chronic toxicity levels of various compounds. (USGS)

Quality Assurance

The foundation for developing methods for multi-media, air, and water monitoring is an effective quality assurance program. The data that is collected on environmental pollutants must be valid and reliable or no amount of money spent on monitoring efforts will be effective. Recognizing the importance of generating quality data, the Interagency Program includes a separate subcategory of projects designed to guarantee quality assurance in all monitoring efforts. These research activities center on the development of standard reference materials to be used in the calibration of instruments and methods for measuring or monitoring pollutants. Included are studies to develop quality control procedures for the avoidance of contamination during sample collection, transportation, and analysis; inter-laboratory calibration; and training of technical personnel. The "quality" data from the application of these techniques can be utilized with confidence in the decision making process relating to the effects of energy development.

Assure quality control in the field monitoring analytical functions as part of activities in select western regions. These efforts will lead to standard techniques which yield comparable results with a high level of accuracy.

Monitor visible effects on vegetation of sulfur dioxide emissions from fossil fuel electric generating stations. This study includes low and high altitude color, infrared, and multi-spectral scanning. Areas will cover the Ohio River (Cincinnati, Ohio to Paducah, Kentucky), Tennessee, Kentucky, West Virginia, and Alabama. Vegetation will include soybeans and mixed southern pine-decidous hardwood timber stands. This project will complement other studies within the Interagency Program which relate to the effects of air emissions on terrestial vegetation. (TVA)

Standardize and calibrate techniques for marine monitoring. This work includes a dissolved oxygen laboratory standard and standards capable of transportation for interlaboratory calibration. (NOAA)

Study aquatic biota and develop standard reference materials (SRM). Work will concentrate on heavy metals, petroleum drilling and refining, and oil shale products. Workshops are conducted and SRM's are referenced and delivered. (NBS)

Develop an inter-laboratory quality assurance program for radiation monitoring laboratories. Interim and final radiological guidelines will be developed.

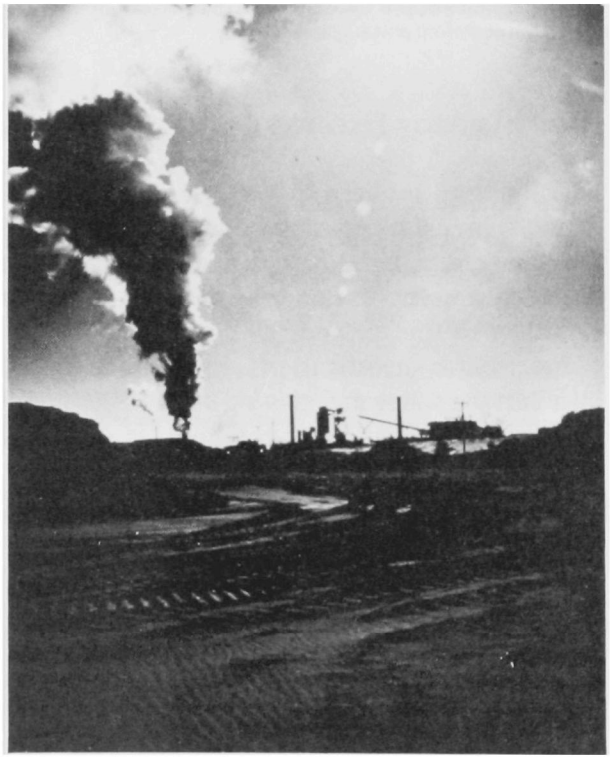
Develop standard reference materials (SRM) for radiological pollutants. These standards will include mixed gamma ray emitters, ^{210}Po, ^{238}Pu, ^{239}Pu and two heavy metal radio-nuclide standards. (NBS)

Environmental Transport Processes

This research area is closely integrated with the research areas of characterization, measurement, and monitoring, and ecological effects. Within the former research area, methods and tools are developed, tested, and applied to provide data useful in the understanding of transport and fate processes. Ecological effects studies relate to the effects of pollutants on natural organisms and their habitats. Environmental transport processes research addresses energy-related pollutants in terms of mechanisms of dispersion from sites of production, transformations which occur subsequent to release, and ultimate accumulation in man, domesticated and wild animals and plants, and in non-living material such as soil and sediments.

The environmental transport processes program receives 4.7 percent of the total funding for the Interagency Energy/Environment Program for FY 1976, and 11.8 percent of the funding for the Processes and effects research program. About 65 percent of the environmental transport processes research takes place within EPA laboratories. The research conducted outside of EPA, but coordinated by EPA as part of the Interagency Program, is carried out by the Energy, Research, and Development Administration (ERDA), the National Oceanic and Atmospheric Administration (NOAA), and the Tennessee Valley Authority (TVA).

Most of the transport processes projects relate to coal technology. Other studies consider the development of oil and gas, oil shale, or nuclear resources. Several projects relate to mechanisms of transport which are applicable to several fuel technologies. Environmental transport processes research requires the use of different physical, chemical, and biological disciplines in the study of atmospheric, terrestrial, freshwater, marine, and estuarine ecosystems. The objectives of research studies within each of these systems will be described separately and will include examples of projects underway in each area.



Atmospheric Processes

When pollutants are released to the atmosphere in energy development and use, they rarely follow straight or simple pathways in their dispersion and reaction with other elements. Before atmospheric pollutants reach the point where they are harmful to human health and the environment, they often undergo radical chemical transformations through association with other pollutants, catalysts, moisture, and sunlight. Understanding these processes is essential to the eventual control of air pollution. For atmospheric transport processes, major emphasis is on the understanding of: (1) the conversion of the oxides of sulfur and nitrogen to sulfate and nitrate compounds, (2) formation, composition, and transportation of photochemical oxidants, and (3) the mechanisms of visibility reduction, haze formation, and of the reflectivity balance of airborne aerosols produced by energy-related activities.

Develop techniques for predicting the chemical and physical processes involved in the generation, transformation, transport, and removal of sulfates, nitrates, photochemical oxidants and their precursors in plumes from coal and oil shale utilization in areas of both simple and complex terrain. Report on atmospheric effects including visibility reduction, haze, and radiation balance due to airborne aerosols generated by such activities. Determine the mass balance of pollutants contained within the air envelope encompassing energy-related sources, and develop predictive models describing atmospheric behavior of pollutants from emission to removal.

Evaluate and improve models for predicting radiological impact of gaseous releases from nuclear power plants (TVA).

Determine atmospheric transport and transformation of emissions from coal-fired power plants (TVA).

Determine the rates and mechanisms by which primary pollutants associated with coal, oil, and oil shale utilization are converted in the atmosphere to secondary pollutants such as sulfates and nitrates. Investigate the influence of light, temperature, water vapor concentration, ammonia concentration, catalytic elements, and aerosols on the atmospheric conversion process. Study mechanisms controlling aerosol functions and aerosol properties which influence visibility, radiation balance, weather and climate. Identify oxidation state and molecular composition of sulfur-containing compounds in the atmosphere.

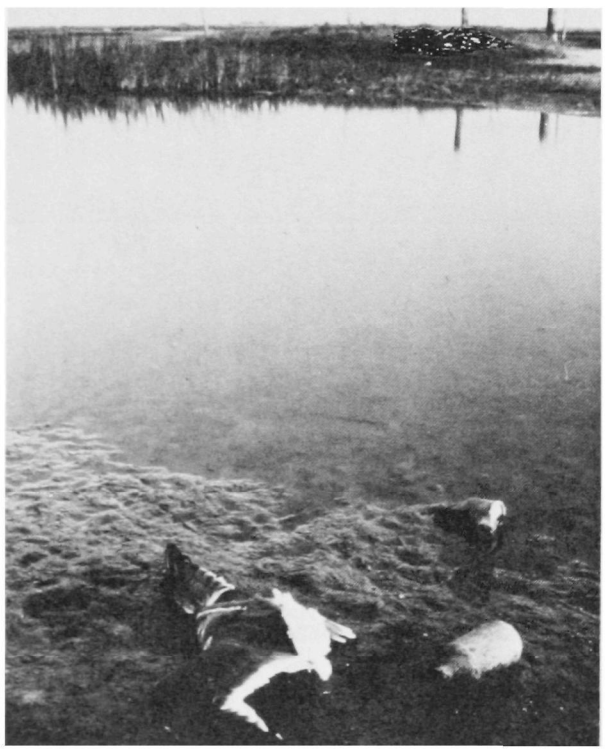
Evaluate weather modification effects of cooling towers (ERDA).

(These last three examples relate to specific facilities or technologies and are complementary to the more generally applicable research efforts by EPA.)

Freshwater Processes

Pollutants discharged into waterways may follow widely different pathways and be involved in many chemical transformations depending on density of discharge, chemistry of the receiving water, temperature, aquatic life, and other factors. Since the nature of the transformations determines the ultimate impact of the pollutants on health and ecosystems, it is important that these freshwater processes be understood.

Freshwater investigations characterize the pathways and fate of energy-related pollutants released into surface water and groundwater. These pollutants include organic compounds, metals, and other dissolved or suspended substances, as well as thermal discharges from coal and oil shale extraction, and coal gasification and liquefaction.



Determine, in fresh surface waters, the origin, load, transport pathways, transfer rates, and fates of organic and inorganic pollutants, particulates, and complex effluents resulting from coal and oil shale extraction and oil refining operations. The study will include analyses of leachates and runoff from surface-deposited wastes. This research will characterize in detail the nature of aqueous effluents, their pathways of movements, and their interaction with surface and subsurface bodies of water.

Characterize the groundwater ecosystems into which organic and inorganic pollutants will be discharged from coal and oil shale extraction and conversion sites. Identify the organic and inorganic pollutants being discharged and determine their physical, chemical and biological transport kinetics. Determine the influence of ground disturbance and the exposure of minerals on their susceptibility to transport through the soil and groundwater systems. This study complements the above research effort and expands the characterization of the movement and interaction of leachates within aquifers including the subsurface unsaturated zone of soil.

Determine transformation pathways, physical and chemical permutations, and the toxicity of crude oil to freshwater organisms in arctic lakes.

Determine, in Lake Michigan, the organic pollutant load and dynamics resulting from oil refinery wastes (ERDA).

Investigate formation rates of inorganics with acid formed from strip mines, the mechanisms by which these contaminants enter and are transported in waterways, and develop mathematical models to predict water quality in streams in acid mine areas (TVA).

Determine presence and abundance of arthropod pests and determine their quantitative and qualitative significance in selected coal strip-mine pools in Kentucky and Tennessee as related to ecological conditions and seasonal changes (TVA).

Determine mechanisms of transformation, degradation, and effect of crude oil in stream ecosystems. This study and the aforementioned study are major efforts to accumulate needed information concerning the effects of spilled oil and freshwater systems. Most similar studies have been oriented toward spills of crude oil within the marine environment.

Develop simulation models of thermal dispersion and fluid mechanics at critical locations in streams and reservoirs (TVA).

Marine and Estuarine Processes

Much of the new exploration to make the U.S. less dependent on foreign oil involves offshore development, and consideration for new power plants is increasingly given to coastal and offshore sites. Since our coastal areas contain highly productive wetlands and fish spawning grounds, the chemical processes of oil spills and heat and biocide discharges need to be thoroughly understood in order to protect these areas. The projects in this subcategory investigate the interactions of pollutants with the marine environment and biosystems so that effective controls can be developed.

Determine the dynamics of dispersion and dissipation in marine and estuarine waters and the long-term effects on marine and estuarine organisms of waste heat and biocides from coastal and offshore power plants. Develop ecosystem models of the fate and effects of thermal and biocide discharges ranging from simple planktonic assemblages to controlled field studies.

Extend a multi-layer, or two dimensional (horizontal) model of circulation to accept a heated discharge as a pollutant.

Determine persistence and dispersion of chlorine from onshore cooling discharges.

Determine organic pollutant load and dynamics resulting from refinery waste discharge into marine waters adjacent to Puerto Rico (ERDA).

Determine transport, transformations, fate, and effects of toxic metals and petroleum hydrocarbons on selected marine ecosystems. Determine ecological responses and recovery rates of a small coastal ecosystem subjected to intentional and controlled perturbations by petroleum-associated contaminants, and establish capability for routine analysis of petroleum hydrocarbons in the marine environment (NOAA). (These site specific studies should contribute details to the general understanding, obtained by previous studies, of the transport and fate of petroleum contaminants in the marine environment.)

(The above studies provide useful information concerning the movement and the ultimate fate of various pesticides such as bacteriocides, fungicides, and molluscacides used in the cooling water systems of power plants. Little is known regarding the long-term fate and effects of these substances within the marine environment.)

Terrestrial Processes

Not only air and water, but also the land itself varies in its ability to absorb pollution and in the transformations which the pollutants undergo once deposited on land. Different moisture, temperature, and soil characteristics will result in different chemical reactions and absorption rates. These factors are especially important in areas of extreme cold such as Alaska and in the arid western lands where accelerated coal and oil shale extraction is anticipated.

Terrestrial research projects involve the characterization of pollutants and their mechanisms of transport through various kinds of soils and subsurface formations. These studies include the identification and dispersion of materials in leachates from residuals such as slag, mine spoils, and sludges produced from energy operations.

Determine transport pathways, transfer rates and fate of pollutants and degradation products of crude oil in soil and in the active layer of permafrost terrain.

Evaluate oil spill persistence in tundra and its impact on the below-ground Arctic ecosystem (ERDA). This study extends work of a related EPA study of the subsurface tundra ecosystem.

Determine fate and effect of pollutants in terrestrial ecosystems in the Four Corners area and Mojave Desert. Coordinate this effort with ongoing EPA/Las Vegas and NOAA air pollutant measurement, plume, and transformation studies in the Four Corners area (ERDA).

Determine the transport and fate of fuel wastes through soil at solid waste disposal sites (ERDA).

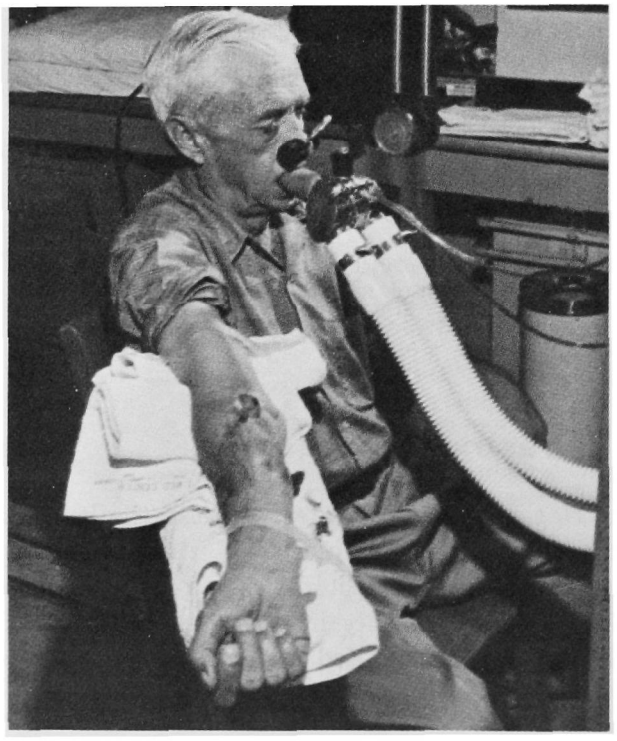
Health Effects

The health effects program seeks to determine the hazards to humans from pollutants released by various energy technologies. The program includes the development of bioassay and other techniques to measure hazards, and the application of these techniques to the characterization of hazards to human health. In relation to human health, the emphasis of the program is on the effects of agents which give rise to carcinogenesis, mutagenesis, teratogeny, toxicity, and disorders of the cardio-pulmonary system.

The funding for health effects interagency program is 12.9 percent of the total Interagency Energy/Environment Program for FY 1976 and is 32.1 percent of the total interagency funding for the Processes and Effects Research Program. Approximately 42 percent of the health effects research activity occurs within EPA laboratories. Health effects research within other agencies is coordinated by EPA and is carried out by the Energy, Research and Development Administration (ERDA), the National Institute of Environmental Health Sciences (NIEHS), and the National Institute for Occupational Safety and Health (NIOSH).

Most of the health effects research activities relate to coal technology. Several projects involve studies applicable to a variety of energy sources. A smaller amount of health effects research is associated with the oil shale, nuclear, and energy conservation technologies.

The health effects area is organized into five categories. These are identification of hazardous agents, dose and damage indicators, metabolism of hazardous agents, evaluation of hazards to humans, and damage, repair, and recovery processes. Examples of projects by EPA and other agencies are grouped below according to these categories.



Identification of Hazardous Agents

One of the first steps in documenting environmental health effects is to identify the specific pollutant agents responsible. While many of the agents are relatively well established from earlier research, many of the energy technologies under development are expected to involve the release of new hazardous materials which will require controls. Such materials may be carcinogens, mutagens, or teratogens, and their timely identification is essential to the future protection of human health.

The projects within this category relate to the identification of these pollutants and to the characterization of biological damage. Also within this category are projects related to the development of tests and procedures to identify hazardous agents.

Identify by means of cytological, biochemical and physiological indicators, the biological damage resulting from exposure to pollutants associated with energy development. These studies include the collection and characterization of refined particles and the establishment of a chemical repository for samples of emissions associated with various energy technologies. These studies are primarily directed toward coal technologies. With respect to oil and oil shale technologies, carcinogenesis assays will be developed for suspected pollutants.

Develop various procedures and tests to identify hazardous agents in coal and multi-fuel technologies. Mouse germ cells are used as an in vivo screen for gene mutations and to study chemical induction of chromosome aberrations. In addition, various other procedures, such as mouse-specific locus methods, are used to study the potential for mutation. Modern separation techniques are employed to fractionate coal conversion products for mutagenic studies. Modern tissue culture techniques (with cell line development when necessary) are in operation to study mutagenic and carcinogenic effects. (ERDA)

Evaluate various cytochemical and morphological identification procedures. Develop cytochemical markers and quantify by microfluorometry in order to examine cell transformation and carcinogenesis. In addition, a procedure utilizing sperm from mice will be developed to study mutagenicity, carcinogenicity and teratogeny. (ERDA)

Determine the teratogenic and genetic effects of pollutants emanating from energy related technologies. Studies are conducted to identify the factors that affect the transfer of metallic pollutants from fuels across the placenta and how these processes relate to teratogeny caused by such pollutants. In addition, Drosophilia (fruit fly) populations are used to study possible chromosome aberrations induced by electric fields. (ERDA)

Develop a pulmonary carcinogenesis test system to examine coal technology pollutants. (ERDA)

Determine, by various cytological studies, the direct effects of pollutants from multi-fuels. These studies relate to the effects of toxic agents on chromosomal structure and cell cycle kinetics as well as to the early detection of deleterious changes in pulmonary cytology. (ERDA)

Use mammalian tissue culture techniques to examine the affects of trace metals and hydrocarbons on teratogenesis, mutagenesis, and carcinogenesis. In addition, studies are carried out on co-carcinogenesis of hydrocarbons and hormones. Cell systems capable of measuring these parameters are being developed. (ERDA)

Develop bacteriophage systems to screen for carcinogenicity of polycyclic aromatic hydrocarbons, (ERDA)

Determine the effects on lung cells of exposure to flyash, chemical mutagens, and effluents. (ERDA)

Dose and Damage Indicators

Once hazardous pollutant agents have been identified, a next step in health effects research involves measurement and quantification of the dosage of the agent that actually damages health. Such information is clearly essential in setting standards which will be adequate to protect human health. Projects in this area involve exposure of known hazardous pollutants to chemical reactions in the laboratory and to live cells under controlled conditions.

These projects develop chemical or biological systems which can be used to quantify the degree of biological damage associated with exposure to known amounts of various hazardous materials. These studies also include research related to the combined action of different pollutants.

Examine the potential hazards of exposure to water contaminated with heavy metals and toxic organic compounds, particularly as applied to coal technology. Develop and apply in vitro neoplastic, mutagenic, cytogenetic, and translocation carcinogenesis bioassay systems. Study the effects of the contaminants on teratogeny and reproduction. Analyze the toxicological properties of methylbenzimidazole, dibenzofuran, methylbenzofuran, 1, 2, 4 trimethylbenzene, and thallium from various routes of exposure. In particular, these studies will provide further information on the chronic effects of these products of coal technologies.

Utilize mammalian cellular systems to quantify mutagenesis testing. (ERDA)

Develop methods for utilizing various systems as indicators for dosage effects. Teeth are studied as an indicator for tissue dosage of trace and heavy metals. In addition, fish model will be prepared to study carcinogenicity of coal conversion products. (ERDA)

Utilize various bioassay indicators to determine biological damage resulting from exposure to various pollutants. These studies include synergism which may exist between pulmonary carcinogens, airborne particles, and sulfuric acid mists. In addition, cytotoxicity is being evaluated for samples of ambient and source concentrations of sulfates. With regard to coal technologies, the effects of source materials on carcinogenesis are being studied. With respect to oil and oil shale, EPA will develop models of cellular systems to determine cytotoxicity from pollutants produced by the energy sources. EPA is also studying the influence of environmental materials which act as co-factors to stimulate carcinogenic activity.

Determine dose-effect relationship for mutagenic agents. Predictive toxicity utilizing organ test systems will be employed. (NIEHS)

Develop physiological indicators to estimate damage to humans arising from toxic agents in various energy technologies. Rigid quantitative analyses of various agents will be performed. (NIEHS)

Metabolism of Hazardous Agents

Hazardous pollutants, many of which result from energy development and use, initially cause metabolic responses in living things at exposures below that at which serious damage would occur. An understanding of these pre-clinical metabolic changes can aid in early diagnosis of exposure, and the way living hosts metabolize pollutants can suggest preventative measures and treatment.

Studies within this category characterize the metabolic changes that accompany exposure to hazardous agents. In addition, these projects include an assessment of the incorporation, degradation, and deposition of hazardous compounds by organisms.

Characterize the metabolic fate of air, water, and multi-route exposure to various pollutants associated with energy development, particularly Western coal development. This effort includes studies on extended inhalation of various pollutants and the biochemical changes that accompany such exposure.

Assess the mechanisms of incorporation, metabolism, deposition, and turnover of energy-related hazardous agents. Comparisons of species differences will be made. Studies involving organic compounds will be emphasized, (NIEHS)

Evaluation of Hazards to Humans

The preceding categories of health effects research follow a logical sequence of laboratory study of agents, damage levels and metabolism. The next step is to demonstrate conclusively that the laboratory results can be extrapolated to effects on humans. For example, if pollutants from coal conversion processes are carcinogenic to mice in laboratories, the probable danger to humans must be next shown.

These research activities are designed to quantify the extent of damages to human health which is associated with particular hazardous materials. The studies primarily relate to the observation of patients affected by pollutants or to the extrapolation of animal data to humans.

Evaluate the human hazards of air, water and multi-route exposure to pollutants associated with energy development, particularly in relation to coal technology. Studies characterize human exposure to pollutants in the ambient air as a result of coal conversion and utilization. These studies involve an investigation of a) hazards of human exposure to aerosol pollutants, b) the effects of the pollutants on asthmatics, c) levels of airborne trace substances in populations living near coal plants and the health of such populations, and d) the causes of morbidity and mortality in populations with long term exposure to coal combustion emissions. These projects include an evaluation of the influence of sulfuric acid mist on the cardio-pulmonary system, with particular emphasis on the effects of inhalation of acid aerosols, sulfuric acid, sulfur trioxide, nitric acid, and various particulates. General and chronic effects of respirable particles, gases, and mists are investigated with particular attention given to the in vitro carcinogenicity screening of air particles.

Determine the hazards of chronic, low level exposure to potential pollutants associated with nuclear energy production. In particular, investigations are carried out on the effects of krypton^{85} on skin carcinogenesis and on the induction of chronic and acute pathological manifestations of the lung. Behavioral and neurophysical effects of chronic lead and tritium exposure also are studied.

Evaluate the reaction products which result from the inhalation of particulates and sulfur dioxide. (ERDA)

Develop test models and concepts for the extrapolation of animal data to humans for various energy technologies. In addition, these models will be applied to the identification of damage to cells and cellular components caused by pollutants associated with energy production. (NIEHS)

Damage, Repair, and Recovery Processes

The final category in health effects research deals with damage to humans from exposure to hazardous pollutants, and investigations into how the damage can be repaired and the body recover. Of special interest are brain damage and cancer from toxic trace metals from energy development and from combustion gases.

Identify the trace metal toxicities associated with various routes of exposure to pollutants from coal technologies. Possible brain damage from rats exposed to sulfur dioxide is evaluated by the use of electro-encephalography. These studies are designed to assess the potential for critical damage by coal pollutants.

Assess the effects on metabolism of inhaled trace metal emissions from combustion processes. (ERDA)

EPA is studying the damage to the respiratory tract which is attributable to pollutants associated with various energy technologies, with particular emphasis to products from coal gasification. Modern analytical and separation techniques are used to ascertain the agents which are potentially most dangerous.

Ecological Effects

Ecological effects research is based on, and complementary to, the results of research conducted in other areas of the Interagency Program. For example, various methods and instruments developed and refined within the characterization, measurement, and monitoring area, and the results of environmental transport processes studies are used to characterize the ecosystem effects associated with energy development. The various research efforts determine the effects of organic and inorganic pollutants, thermal discharges and complex effluents on water and land ecosystems.

The ecological effects program comprises 11.4 percent of the total funding for the Interagency Energy/Environment Program for FY 1976 and 28.2 percent of the processes and effects research program. Approximately 36 percent of the research related to ecological effects is coordinated by EPA as part of the Interagency Program but conducted outside of EPA. Such research is carried out by the Energy, Research, and Development Administration (ERDA), National Oceanic and Atmospheric Administration (NOAA), National Institute of Environmental Health Sciences (NIEHS), Tennessee Valley Authority (TVA), U.S. Department of Agriculture (USDA), and the U.S. Fish and Wildlife Service (F&WS).

Most of the ecological effects research activities relate to coal technology. Secondary emphasis is on the development of oil resources. Several studies relate to oil shale and nuclear energy development or to effects

which may be associated with a number of fuel technologies. Most research activities focus on the effects of the extraction of raw fuels or on the accumulation of baseline information useful in forecasting environmental impacts related to the processing, transportation, and conversion of fuels.

Ecological effects efforts are divided into three separate categories. These are terrestrial ecosystem effects, freshwater ecosystem effects, and marine/estuarine ecosystem effects. The project examples described below are grouped into these three categories.

Terrestrial Ecosystem Effects

Large scale energy development and use will obviously have major impacts on lands where surface mining is required and where large processing, conversion, and power plant complexes are constructed. Additionally, pollutants emitted to the air and discharged to the water from these activities will have effects on crops, grassland and forests.

A major objective of terrestrial research within the effects program is to measure and predict changes in grassland ecosystems as a function of air pollution associated with energy development, to determine the effects of metals and other pollutants on crops and forest ecosystems, and to develop an information retrieval system for data relevant to the reclamation of strip mines.

Determine the immediate and long-term ecosystem dose-response relationships for single pollutants such as the oxides of sulfur and nitrogen, particulate materials, and trace metals, and combinations of pollutants released by western coal and oil shale extraction, conversion and utilization. In addition, determine metabolic and biochemical mechanisms and lethal and chronic toxicity levels. Develop biological indices using microcosm, greenhouse, and field studies. Evaluate existing ecosystem models and identify requirements for further development. This project is complementary to studies relating to the characterization, monitoring, and transport and fate of pollutants associated with the extraction of coal and oil shale fuel resources. It will contribute to an understanding of the nature and extent of environmental impacts attributed to such pollutants.

Develop a comprehensive information profile for major aquatic environments which could be seriously affected by energy development through a number of resource-specific biological studies. Studies will improve predictive capabilities, identify current stress components, evaluate energy facility location alternatives, assess interrelationships between biological, chemical and physical components in aquatic environments, and identify programs to mitigate impacts on the biological resource.

Determine the effects of heat and vapor discharge from large scale cooling systems on local weather such as near-field fogging and icing. Determine long-term regional effects which might be associated with source intensification such as power parks. This project should provide meaningful information concerning the ecological effects related to concentrated development of energy generating facilities within a limited geographical area.

Assess effects of mining-related transportation systems on water, air, soil, plant, animal, and aesthetic resources. This project will provide useful information concerning the environmental impacts related to the distribution of raw fuel resources to facilities for processing, conversion, or utilization. (USDA)

Evaluate the effects of oil spills on tundra and thaw ponds. This project will provide meaningful information regarding the effects of the development of oil resources in the Arctic zone. This study will complement various research activities by EPA relevant to the determination of the transport pathways, transfer rates, and fate of pollutants and the products of their degradation which are associated with the development of crude oil resources on permafrost terrain. (ERDA)

Determine the effects of trace metal contaminants on crops and forest ecosystems in the southeastern U.S. (ERDA)

Evaluate existing data, baseline needs, and dose-response relationships of atmospheric pollutants (primarily SO_x and NO_x) emitted from coal-fired power plants on terrestrial ecosystems in the southeastern U.S. (TVA)

Determine effects of moisture, heat, and chemical releases from mechanical cooling towers on vegetation and soil. (TVA)

Develop laboratory procedures to characterize the chemical properties of mine spoil and overburden materials in the western U.S. (USDA)

Design, establish, operate and refine a data management system for interagency energy-related marine and meteorological programs. (NOAA)

Identify and demonstrate a rapid, cost-effective and reliable method of inventorying and characterizing wildlife habitats. Determine how and to what extent various coal-related activities will impact wildlife. (F&WS)

Develop mechanisms to identify, locate, and to monitor the activities of endangered species in regions under stress from energy development. The habitat requirements and mitigation alternatives for these species will be assessed. (F&WS)

Freshwater Ecosystem Effects

Many of the energy processing and conversion technologies require large amounts of freshwater. They also are potential dischargers of pollutants into freshwater systems. Additionally, production and transportation of petroleum and discharge of cooling water by power plants can also impact freshwater ecosystems. Since physical, chemical, and biological changes can effect fish, insects, aquatic plants and human water supply, these changes must be well understood so that their effects can be controlled. Projects in this subcategory concentrate on aquatic effects of energy development in the arid west, oil transportation in Alaska, and thermal discharges in the Great Lakes area.

Determine the acute and chronic toxicological effects of organic and inorganic pollutants and complex effluents from coal and oil shale processes on freshwater ecosystems. Identify data required to complete baseline information for evaluating ecological impacts. Evaluate existing ecosystem models.

Determine the immediate and long-term effects of total waste heat loading in surface waters of the Great Lakes Basin on aquatic species and community populations. Waste heat sources include power plants (fossil and nuclear), refineries, and any other technology releasing waste heat into the aquatic environment.

Assess the effects of construction and operation of the Alaska pipeline on aquatic habitats. (ERDA)

Determine long-term effects of hydrocarbons on selected ecosystems and associated organisms. (ERDA)

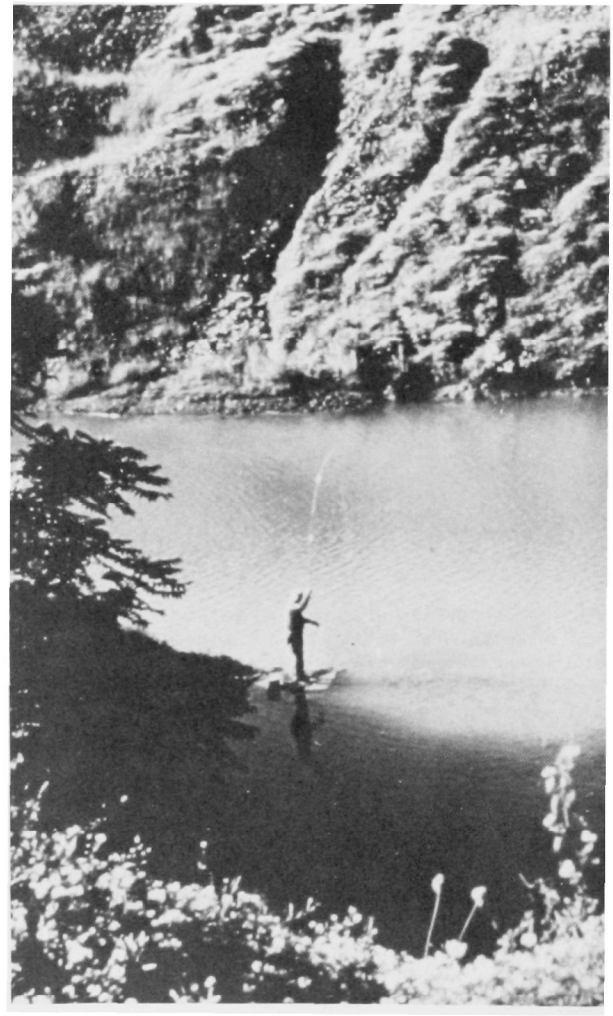
Determine methodology and investigate thermal impacts on freshwater shellfish, insects and other biota. (TVA)

Compare the pharmacokinetics and toxicity in mammals of metals consumed in diet through contaminated shellfish vs. drinking water. (NIEHS)

Assess technologies for redepositing and stabilizing mine spoils including technologies that will keep water quality within acceptable limits for aquatic organisms and associated wildlife species. (USDA)

Determine effect of strip mining and reclamation processes on the quality and quantity of water leaving the area. Develop predictive tools and management practices for restoring the hydrology of the mined areas. (USDA)

Determine water quantity needs of fish and wildlife in the Upper Colorado and Upper Missouri River Basins. Establish flow requirements necessary to maintain the fish and wildlife present. Develop in-stream flow methodologies to determine the maintenance flows required for biological/fisheries stability in other areas of the U.S. affected by increased energy development east and west. (F&WS)



Marine/Estuarine Ecosystem Effects

Coastal and offshore power plants and offshore oil production and transportation can have serious impacts on fragile but important marine and estuarine ecosystems. Power plant discharges and oil spills have the potential for severe disruption of wetlands, food chains, and fish and wildlife. Coastal wetlands are essential to the survival of most of our commercial fishing. If energy development and use is to proceed in coastal and offshore areas, it is essential that the full effects on marine and estuarine ecosystems are understood so that action can be taken to minimize adverse impacts.

Marine research will focus on a coastal area of eastern United States where power plants, deep-water ports, and oil rigs may be erected. This effort will develop baseline data, including background data on marine biota and their habitats, for the purpose of determining the effects on marine organisms of pollutants from energy development activities.

Conduct surveys to augment existing data on the Santa Barbara oil lease area relative to oil extraction and transport and related effects on coastal ecosystems. (ERDA)

Determine the various mechanisms by which cells of marine organisms take up metals from the environment. (NIEHS)

Determine the relationship between toxic fractions of crude oil and petroleum products and tumor formation in commercial vertebrate and invertebrate marine species susceptible to carcinoma. (NIEHS)

Conduct environmental assessment and develop predictive capability for impacts of petroleum-related activities on Northern Puget Sound and Strait of Juan de Fuca. Puget Sound is relatively unpolluted. However, tanker transport and refining activity is expected to increase rapidly within the next decade. The information collected will be useful in decisions regarding the development of petroleum facilities and in the regulation of tanker traffic within the region. (NOAA)

Perform a comparison of an existing marine ecosystem under stress of an active oil field with a similar ecosystem in an undisturbed area. Identify and document the extent of biological, physical, and chemical alterations in a marine ecosystem associated with development of an oil field and develop capability to predict the impact of oil field exploration and development on specific marine ecosystems. (NOAA)

Determine acute and chronic toxicological effects of organic, inorganic, and other pollutants, including metals, on marine and estuarine ecosystems. The sources include petroleum extraction, coastal oil refineries, and fossil-fueled power plants.

Determine thermal effects on marine organisms of energy utilization in synergy with metals.

Determine the nature, loading, distribution, and long-term effects of crude oil in the Gulf of Alaska marine and estuarine ecosystems.

Determine toxicity to marine organisms of petrochemicals and energy-related organic solvents derived from offshore activities and ocean dumping.

Prepare reports on three selected coastal regions subject to energy development. Emphasis is on the value of resources, especially fish and wildlife, and ecological processes subject to impact resulting from human-induced environmental alterations. (F&WS)

Determine the nature, loading, distribution and effects of hydrocarbons, organic and inorganic pollutants, and metals in marine and estuarine ecosystems. Develop ecosystem models of pollutant discharges to marine and estuarine waters on scales ranging from simple planktonic assemblages to control field systems. Determine correlations among the results of laboratory bioassays of system components and field studies of bio-accumulation, system dynamics and routes to humans of pollutants released from off-shore drilling, refinery processing, and oil/water separator effluents entering marine and estuarine waters.

Summarize results of laboratory experiments and field observations to evaluate the physiological, toxicological, and ecological effects of oil primarily on ducks. Develop a chemical methodology for analyzing duck tissues for oil, assess the kinetics of oil in duck tissues, and assess the ecological occurrence and effects of oil in wild ducks. (F&WS)

Integrated Assessment

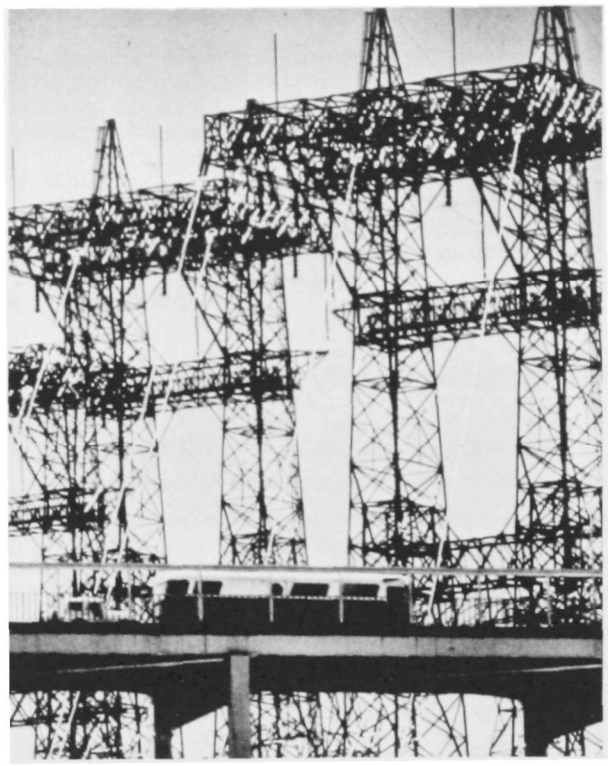
The objective of the integrated assessment program is to incorporate the results of the other research areas into a comprehensive whole. In addition, projects may include research data resulting from social, economic, cultural, and environmental analyses in identifying acceptable alternatives in the development of energy technologies.

This approach seeks to ensure that resultant stresses accompanying The adoption of particular energy technologies be analyzed fully, and mitigating measures be planned and implemented. The parameters of such analyses include population, migration, natural resource utilization, and pollution control as well as the cost/risks/benefits of developments with respect to controls. These assessments include studies from technological, regional and economic sector perspectives.

Integrated technology assessments will provide an information base for broad policy decisions which must be addressed on an interagency basis. A tool that will be used in integrated assessment is the technology assessment, which is defined as the systematic study of indirect or unintentional impacts on society which might result from a technology implementation. Other types of programs include supplementary studies to support on-going technology assessments and the development of new assessment methodologies.

The integrated assessment program comprises 3.1 percent of the total funding for the Interagency Energy/Environment Program for FY 1976 and 7.6 percent of the processes and effects research program. About 66 percent of the integrated assessment research occurs within EPA facilities. The research is coordinated by EPA but conducted by other agencies is carried out by the Energy Research and Development Administration (ERDA), U. S. Department of Agriculture (USDA), Tennessee Valley Authority (TVA), and the Department of Housing and Urban Development (HUD).

Most of the activities within this program relate to the development of coal resources. Many studies related to this fuel have been completed or are in progress. Several research projects relate to oil shale and energy conservation technologies. More studies are expected to be included within the integrated assessment area in the next few years as research projects in other categories are completed.



The integrated assessment research is separated into three categories: methodology development, integrated analysis, and supportive research. The project examples are organized by these three catetories.

Methodology Development

These efforts develop the tools with which to analyze the implications of various energy-related technology developments. These tools include the building of models, updating existing computer models, and the generating of data bases for future use. The data used in these models includes socio-economics, migration, residual wastes, etc. Output presentation via computer graphics is being tested by TVA.

Develop economic projection modeling capability necessary to drive modular energy and environmental system planning models at a multi-county (economic area) level. This project involves the expansion of existing regional economic simulation model for use in assessing an area's sensitivity to various national parameters, evaluating the impacts on population, labor force, employment, etc. of an incremental expansion to the energy generating system and, providing the macroeconomic data base at a multi-county level that is necessary for vigorous site specific analyses. (TVA)

Develop a model that can be used in conjunction with the TVA's Power System Integrated Planning Model to predict the residual output of a power system on a plant-by-plant basis. The model will provide inputs for detailed dispersion models for evaluating expansion policies of a power system. (TVA)

Develop and demonstrate applications of computer graphics to site-specific and regional integrated environment assessment of mixed-nuclear, coal-based and hydroelectric energy systems. (TVA)

Support selected large-scale modeling efforts by updating data files and revising and updating system components to increase energy assessment capabilities.

Develop a methodology for cost/risk/benefit analysis of nuclear, oil, oil shale, geothermal, and coal use for power production in the Western states. The objective is to develop and test a first generation method for balancing benefits to the Western states and to the Nation with the estimated costs of fuel throughout the energy cycle. The method will provide for inputs of primary, secondary, and derivative impacts as well as flexibility of inputing social perceptions and value scales for weighing these impacts. (ERDA)

Develop methods for integrating the results of environmental and energy research with relevant socio-economic factors for the purpose of formulating environmental policies. Adopt the results of research, including cost/risk/benefit analysis, being conducted by ERDA, other Federal agencies, and the private sector into a framework which is suitable for agency decision making processes.

Integrative Analysis

This category relates to the utilization of the data collected under methodology development. The analyses integrate social, economic and environmental information into the decision-making processes. In the process, an evaluation is made of cost/risk/benefit trade-offs of energy production in comparison with pollution control alternatives. This would enhance the implementation of new energy development technologies with minimum environmental damage and maximum related benefits.

Conduct Integrated Technology Assessments (ITA's) which deal with emerging technologies, economic sectors and/or geographic regions. The objective of the regional ITA's is to evaluate all environmental, social, and economic costs and benefits that result from various levels of development, and associated environmental controls, on one regional energy resource base. This assessment is conducted in the context of the totality of effects which are to be anticipated from alternative energy development scenarios. The objective of the technology-related ITA's is to evaluate the environmental and socio-economic consequences of developing selected emerging energy technologies, and to determine optimum environmental control levels, as well as means for implementing those levels. The economic sector ITA's address the entire constellation of social, economic and environmental pressures which have, and will continue to, shape the continued development of a major sector of our economy. To date, four major and many other lesser ITA's have been launched. The four major ITA's address western energy resource development, the electric utilities sector, energy development in the Ohio River basin, and in the Appalachian region. First-year reports are available on the first two assessments.

Provide an assessment of existing Federal coal leases and Preference Right Lease Applications in terms of the potential and relative effects of their development on the total environment. Analysis criteria and assessment of alternatives will be in terms of geologic, topologic, topographic, chemical, cultural, biological, climatologic, and socio-economic factors.

Supportive Research

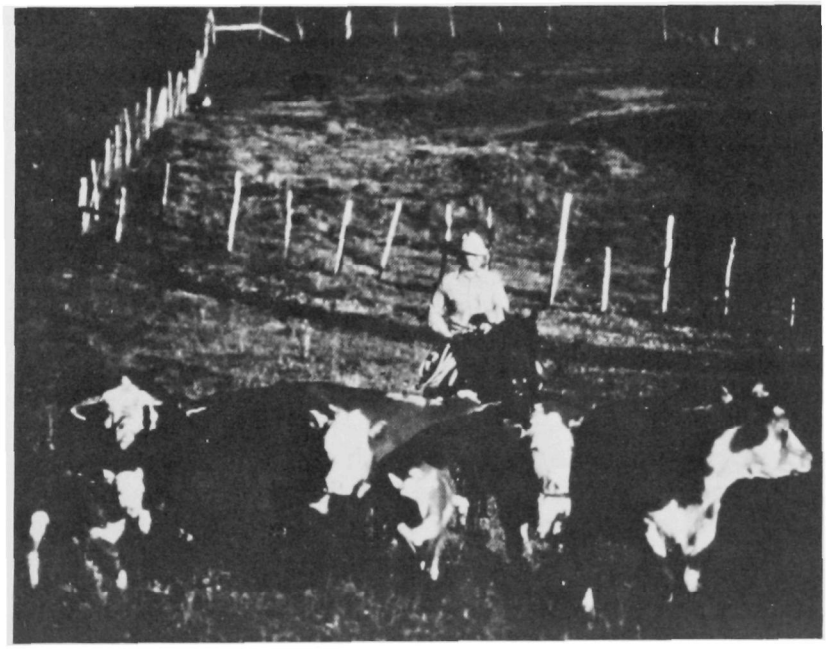
Supportive research tasks provide supplementary inputs for methodology development and integrative analysis. As such, their output may appear to be of a fragmentary nature until placed into the context of the overall assessment for which they are intended. The following projects are representative of the supportive research being carried out.

Provide selective augmentation to the Western energy resource development ITA. The complex nature of this technology assessment requires selected supplemental studies to feed into the central core ITA. These studies are programmed to enhance the value of the ITA for policy analysis and decision-making purposes.

Provide selective augmentation to the electric utility sector ITA now underway. Such augmentation may take the form of limited data gathering regarding certain benchmark inputs to the ITA.

Estimate economic, social, and cultural consequences of coal and oil shale developments to support integrated assessment studies. Among the objectives will be to develop regional reports on land and water use and projections on future resources uses and the resultant environmental impacts of alternative levels of coal and oil shale developments. (USDA)

Determine the economic and social impacts of energy conservation for the residential sector using buildings in 10 geographical areas. Efforts will be made to quantify the energy consumption, savings, investments and operational costs associated with a number of energy conserving modifications to residences in the selected areas. (HUD)



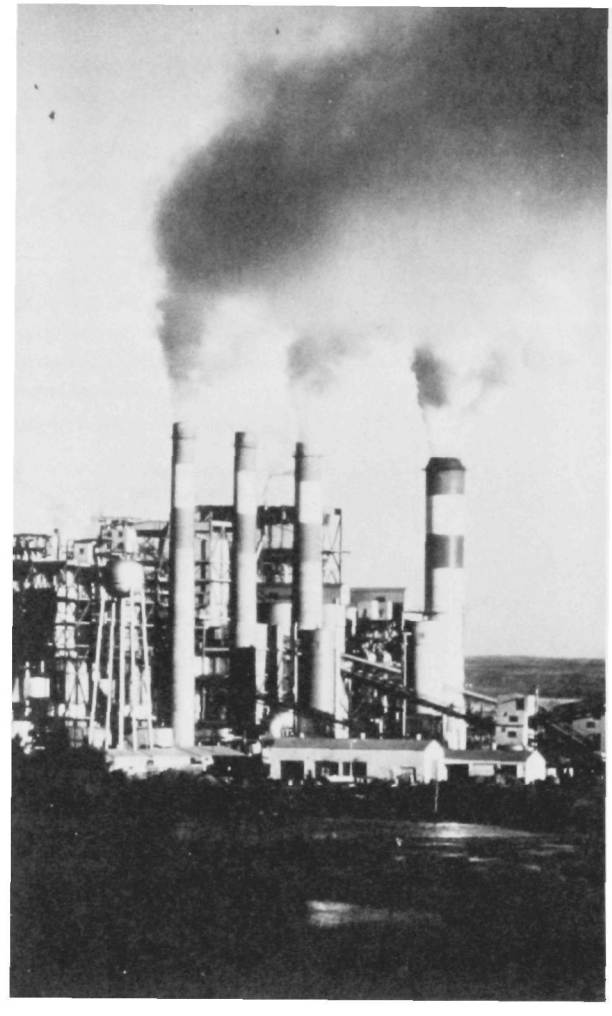
Environmental Control Technology Program

The Interagency Program included $81-million FY 1975 and $56-million in FY 1976 for the assessment and development of control technologies for Energy Systems. OEMI is now completing the implementation of the $56-million FY 1977 budget. As described in Chapter 1, the original interagency task force identified nine program categories in the control technology area. Figure 6 shows proportional distribution of FY 1975 funding allocations for these nine categories, the distribution of the $56 million FY 76 budget, and planned FY 77 budget.

The $56 million FY 1976 control technology program reflects a considerable shift of emphasis within major program areas relative to FY 1975. The major shift is within the fossil fuel combustion area, where resources are shifted away from flue gas desulfurization (FGD). This is because the FY 1975 funds fully funded two major FGD demonstration projects which will, it is expected, adequately demonstrate proven FGD technology. These demonstrations are of both the regenerable processes (in which process materials are recovered and reused) and the non-regenerable processes, (in which waste products or "sludge" are discarded.) Emphasis in FY 1976 shifted toward technology to control nitrogen oxides (NO_x) produced by combustion processes, and to address the special control problems encountered in these processes that produce both the oxides of nitrogen (NO_x) and of sulfur (SO_x). Emphasis on NO_x control for stationary sources is increasing in order to adjust for the possible relaxation of the NO_x automotive standards.

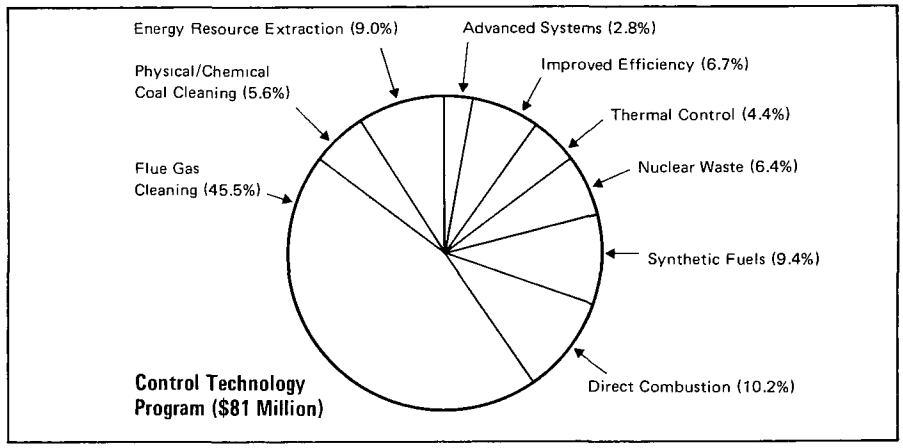
Another area of increased emphasis in the 1976 program is the control of environmental pollutants from the production of synthetic fuels from coal. Investigations have accelerated into promising advanced combustion processes such as fluidized bed combustion, in which a layer of pulverized coal or petroleum residue (or other fossil fuel such as coal or lignite) is formed while suspended in a "bed" of compressed air introduced beneath the fuel. Both fluidized bed combustion and synthetic fuels environmental research and development are being increased because of the likelihood that these technologies will see widespread use in the U.S. in the coming decades.

In line with the overall Federal objective of greatly expanding the environmentally acceptable use of the nation's coal resources, the largest amount of the FY 76 control technology program is, again, targeted for coal-related R&D. Nearly 64 percent of the budget is involved with coal related research. The remaining 36 percent is divided among waste-as-fuel, conservation, nuclear, multi-fuel, oil shale, geothermal, and solar R&D.

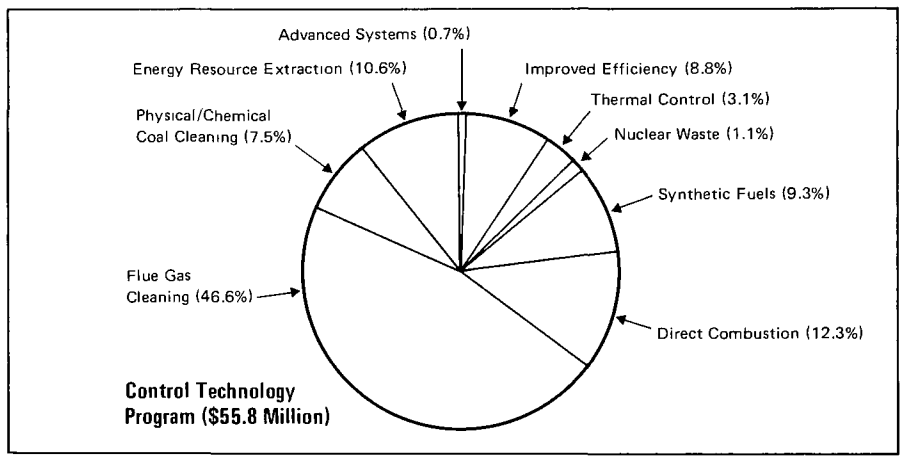


Details of the Interagency Program including major accomplishments for FY 1976 and beyond, both within the EPA and in other Federal agencies receiving Interagency funds, are presented in the following sections for each major program category.

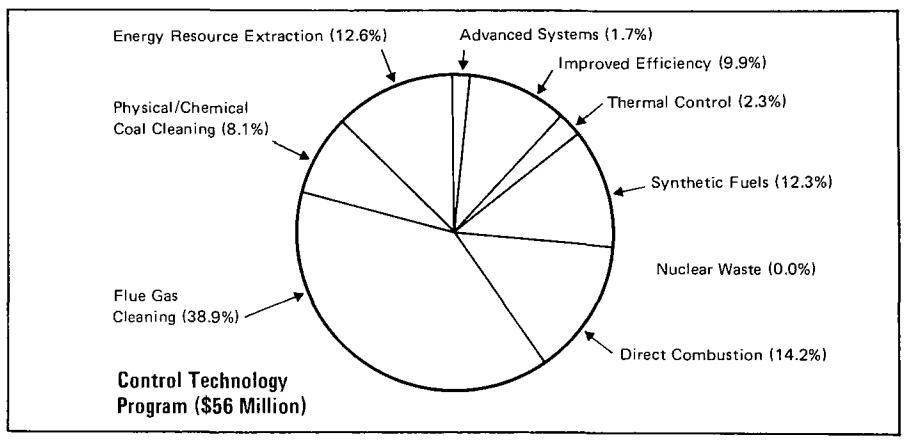
Control Technology Funding by Interagency Category



FY 1975 FUNDING



FY 1976 FUNDING



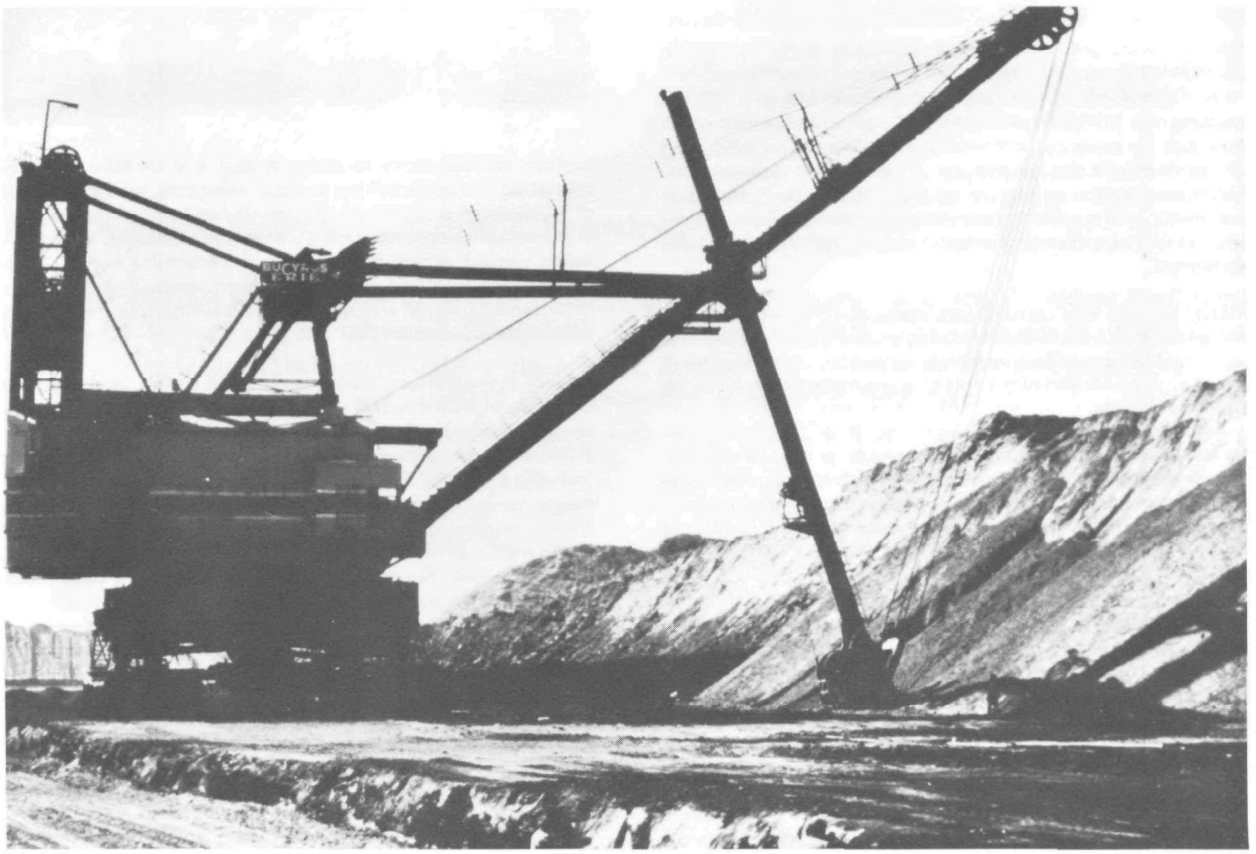
FY 1977 FUNDING

Energy Resource Extraction

If the nation is going to expand its use of domestic energy resources, it will first have to extract those resources. Digging and/or drilling for energy sources has, in the past, created massive environmental devastation. For example, in the Appalachian region more than 10,000 miles of streams have been rendered incapable of supporting life because of acid drainage from abandoned (mostly coal) mines. Already the nation has strip mined an area nearly equal to the state of Connecticut.

But all this is past. In the future energy supplies will be extracted from even more inhospitable zones where the environmental impacts can be far more pervasive. The semi-arid and arid areas of the west, where most of our low-sulfur coal and readily available oil shale are located, will be difficult if not impossible to restore after they are mined. The permanently frozen Alaskan oil fields and storm-tossed Atlantic outer continental shelf areas will provide significant oil and natural gas supplies. But here, again, controlling environmental impacts will be a serious challenge.

The Interagency Program's energy resource extraction efforts addresses these and other pressing environmental issues. The program is divided into two major components: solid fuel extraction, and oil and gas production. The funding for this program represents 6.8 percent of the total Interagency/Environment Program budget for FY 1976. The energy resource extraction program accounts for 11.7 percent of the total FY 1976 Interagency budget for control technology development. Projects corresponding to 71 percent of the FY 1976 budget for the resource extraction program will be undertaken within the EPA. Activities accounting for the remaining 29 percent will be performed by the USDA and ERDA.



Solid fuel Extraction

Projects in solid fuel extraction assess potential environmental problems and develop control methods for underground and surface coal mining and oil shale and uranium extraction. Specific projects, examples of which are shown below, deal with environmental assessments in mining areas, demonstration of environmentally sound mining techniques, and development of ground stabilization and vegetation methods for both eastern and semi-arid western mining environments.

Assess, develop, and demonstrate new surface mining technology for the Eastern U.S. The major output of this effort is a manual of practice on methods for beneficiation and reduction of environmental damage from active and abandoned surface mines in the eastern part of the country. This manual will be available shortly.

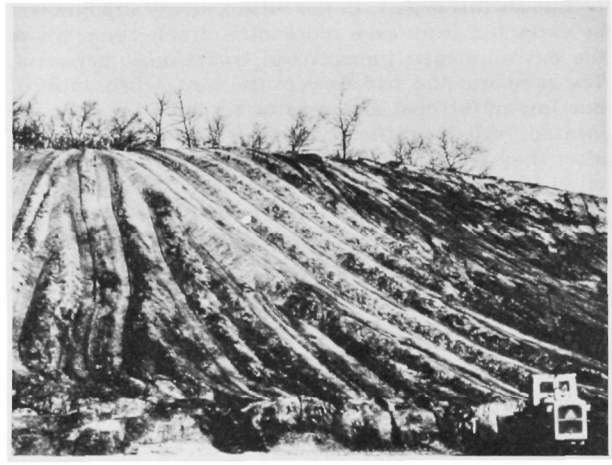
Assess, develop, and demonstrate methods for preventing pollution from active and abandoned Western coal mines, both surface and underground. The assessment phase includes the development of multi-media environmental baseline data on pollutants from mine spoils, evaluating impact of coal mining on Indian lands and the Northern Great Plains, and assessment of the environmental effectiveness of hydraulic mining. The demonstration phase includes active mine reclamation through use of surface manipulation of moisture concentration. An end result of the assessment of overall pollution will be a manual of practice on methods to abate and prevent such pollution.

Assess, develop and demonstrate methods to prevent pollution from oil shale and tar sands extraction. In coordination with other Federal, state, and local agencies and industry, EPA is assessing the pollution potential and cost effectiveness of oil shale and tar sands extraction and waste disposal methods, and will demonstrate the reclamation of spent shale disposal sites. Preliminary reports on specific oil shale development sites, data availability, and monitoring techniques are now available. A final product will be a manual of practice on pollution prevention and abatement.

Assess, develop and demonstrate methods to control environmental damage from uranium mining and milling. Assessment is being made of available control technology for active and abandoned mining sites and of the cost effectiveness of extraction and disposal methods.

Assess, develop, and demonstrate methods to control environmental damages from transportation of solids fuels. The complete assessment of the problem includes storage, handling, and transport methods. The primary product will be a manual of practice comparing and evaluating the available control techniques.

Prepare handbooks for revegetating Western coal and oil shale mines. Using existing data coupled with significant additional research, technical handbooks are being prepared for revegetating Western coal and oil shale mines for arid and semi-arid areas through irrigation practices. Included are recommendations on plant species, methods of planting, soil amendments, seed sources, and seed bed preparation. (USDA)



Surface manipulations to enhance coal and oil shale mine revegetation. In support of the two above projects, the Department of Agriculture is evaluating the use of non-mine waste material (e.g., sewage sludge, wood chips, straw, solid wastes, food processing wastes) as soil amendments in reclaiming mines. Additionally, the scientific criteria and recommended guidelines for determining quality and quantity of growth-supporting media will be developed. (USDA)

Reduce adverse effects from uranium mill wastes. Appraisals are being made of 17 inactive uranium ore milling sites in five Western states. Engineering studies and cost estimates for long term stabilization of radioactive wastes are being developed. The work includes a limited R&D effort into ways of minimizing radon escape to the environment, data for evaluation of site cleanup criteria, and guidance for stabilization. The project will provide a sound basis for remedial action to minimize public exposure and, where possible, restore the land for unrestricted future use. (ERDA)

Prepare handbook on Eastern surface Coal mining vegetative methods and materials. Based mainly upon existing data and requiring a minimum of new research, handbooks are being prepared for revegetating Eastern surface coal mines and waste piles. These handbooks will be used by mine operators, regulatory agencies, and planning and impact analysis agencies. (USDA)

Oil and Gas Production

The other major category under energy resource extraction consists of projects related to the production of oil and natural gas. Since most new domestic production is expected to occur offshore and in the Alaskan area, there is a very large potential for environmental damage from spills and other disruptions. For example, most of our commercial ocean fishing depends upon shoreline wetlands as fish spawning grounds. Such wetlands are exceedingly vulnerable to long-term disruption from even small-scale offshore oil spills and discharges. The R&D effort in this area consequently focuses on developing methods to minimize environmental risk and to protect and restore ecosystems should spills occur.

Demonstrate oil spill control and cleanup capability. The project involves use of a spills test tank for development and demonstration of control equipment and techniques. Specific areas of effort include effective sorbent systems, booms and skimmers for inland spills, ocean spill control equipment for offshore platforms and deepwater port facilities, proper disposal of spill-generated debris and sorbents, and chemical and biological spill control agents. The end products of the project will be manuals of practice for evaluating spill control methods and for assessing the extent of contamination and effectiveness of control measures.

Assess, develop, and demonstrate techniques for the protection and restoration of shorelines. Areas to be included are ocean coastal, estuarine, inland river and lake, and cold climate (primarily Alaska) waterfront areas. The principal end products will be manuals of practice for the protection and restoration of each type of shoreline.

Assess, develop, and demonstrate control technology for all aspects of installation and operation of offshore platforms, product transportation systems, and shore termination facilities. The main results will be a manual of practice for platform operations, environmental protection guidelines for siting onshore pipelines and supporting facilities, and a report on the best available technology for environmental control at offshore oil and gas production facilities.

Additionally, there are four other projects planned for implementation in the post-1976 period. These are evaluation of the 1973 Spill Prevention Regulations, development of treatment methods for bilge and ballast water at shore reception facilities including existing ports and planned deepwater ports, development of onshore secondary and tertiary recovery procedures, and development of spill control methods and equipment for the onshore storage and transportation of LNG and LPG.

Physical/Chemical Coal Cleaning

There are four points in the process of extracting energy from coal at which the major pollutants (especially sulfur) can be removed. These are: extraction (dig only low-sulfur coals), preparation (clean the coal or transform it into a clean fuel), combustion (especially in a pollutant-removing fluidized bed) and/or flue gas cleaning (electrostatic precipitators and "scrubbers"). Of all these methods, physical and chemical coal cleaning may well hold the most unrealized short- and mid-term promise.

The primary objective of the physical and chemical coal cleaning research, development, and demonstration program is to develop commercially available processes to remove the ash, the inorganic sulfur, and as much of the organic sulfur as possible from coal, thus making an increased quantity of coal acceptable for use in areas where air quality regulations allow the combustion of medium (one or two percent) sulfur coals. A corollary objective is to ensure that acceptable control or disposal methods are available for handling the pollutants and waste products from such processes, or that these waste products can be beneficially used in an acceptable manner. The latter objective will provide guidance to the regulatory offices for setting air emission and water effluent standards and disposal guidelines.

The budget allocation for the physical/chemical coal cleaning program represents 4.3 percent of the total FY 1976 budget for the Interagency Energy/Environment Program. About 7.4 percent of the control technology development budget for FY 1976 was allocated to the physical/chemical coal cleaning program. Projects accounting for 73 percent of the total FY 1976 budget are being undertaken within the EPA. Approximately 27 percent of the FY 1976 budget was transferred to ERDA and DOI under interagency agreements.

Coal cleaning efforts are divided into two topical areas: environmental assessment of coal cleaning processes, and technology development.

Environmental Assessment of Coal Cleaning

In conducting projects in this category, agencies collect information, conduct sampling, and analyze programs to provide the necessary data on coal transportation, storage, and physical/chemical coal cleaning technology. This provides multi-media data bases for identifying environmental problems, determining applicability and efficiency of existing control techniques, and developing the overall environmental assessment. Supporting tasks include contract efforts to aid technology transfer and provide quick and flexible technical and systems support to the program. The approach to obtaining the required environmental data is to conduct extensive sampling and analysis at two eastern coal cleaning plants, two midwestern plants, and two western plants, in that order.

Process and combustion studies of hydrothermally treated coals are underway. Caustic leaching of coals by the Battelle hydrothermal treatment process (BHP) is capable of removing up to 95 percent of the pyritic sulfur and 40 percent of the organic sulfur. The process is also capable of removing significant amounts of ash and other pollutant forming constituents from coal. A previous program evaluated the fuel combustion and emission characteristics of raw and BHP coals in small laboratory combustors. These studies are to be extended to evaluate combustion of raw and BHP coals in larger stoker-fired and multifuel furnaces and to evaluate and compare the combustion and emission characteristics of coals treated by other physical and chemical processes. Experimental work and engineering analyses are also being conducted to evaluate process improvements needed to lower the costs of caustic leaching.

Conduct a comprehensive assessment of environmental pollution which results from coal transportation, coal storage, coal cleaning and coal waste disposal. This assessment includes those pollutants which are currently regulated and all other pollutants, whether gaseous, liquid or solid, which pose potentially significant health and/or ecological hazards.

Analyze coal desulfurization by microwave energy. The objective of this program is to lead to a cost effective method for reducing sulfur oxide emissions (during coal combustion) to environmentally acceptable levels. The approach is based on the use of microwave energy which can be coupled preferentially into iron pyrites and leachates. Such an action will induce reactions which produce sulfur compounds which can either be separated easily from coal, or do not convert into sulfur oxides during combustion.

Technology Development

Within this category, agencies are investigating specific unit operations and processes for physical and chemical coal cleaning. Available and on-line pollution control for these processes are being evaluated, and on-site testing and evaluation of commercially used or developed control technology is continuing. Recommendations will be made on the development of new equipment or control technology needed for EPA/DOI/ERDA-funded demonstration projects. Specific control system and disposal technique evaluation and development is being undertaken on specific technologies which are shown to have the potential for improved control. The program supports development of new cleaning techniques. A coal-cleaning plant employing advanced processes is being evaluated: to identify new chemical approaches for removal of sulfur, nitrogen and other pollutants from coal, to evaluate existing concepts or technology, and to evaluate operation of benchscale testing programs at a versatile chemical cleaning technology facility. Supporting technical studies characterize coal residues, report on contaminants in coal, and provide the necessary program and technical support required.

Test and assess commercial equipment for removing pyritic sulfur from fine-size coal, evaluate new chemical processes for organic sulfur removal, and provide assistance and laboratory support for the EPA-Pennsylvania Electric-GPU physical coal cleaning demonstration. Also included are the following: develop the capability to predict washability as a function of equipment and cleaning circuit variables, develop technologies to eliminate the need for coal refuse black water ponds, and continue the design and construction of a coal washing test facility at Pittsburgh. (DOI)

Process different types of raw coal through a bench scale facility for chemical leaching of pyritic sulfur. The study will examine the raw coal samples for trace constituents, as well as gather the following data: sulfur removal by chemical leaching as a function of time, characterization of the products, and trace element distribution in the products.

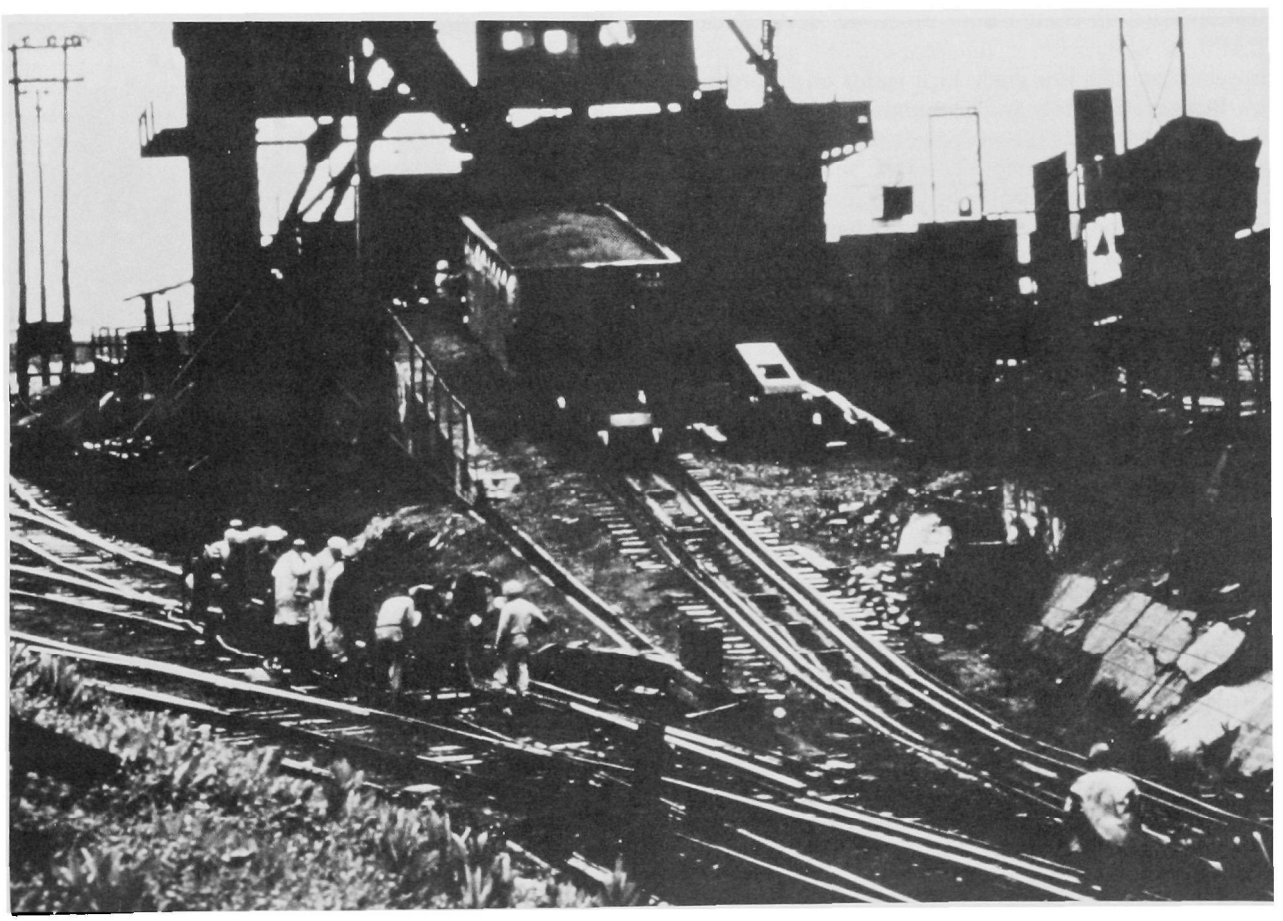
Continue efforts to characterize trace elements in coal cleaning wastes and evaluate elements which are potentially detrimental to the environment and/or have some economic value. (ERDA)

Analyze the cost-effectiveness of combined physical coal-cleaning and flue gas desulfurization (FGD), compared with FGD alone, for meeting established environmental standards with specific coals and specific power plant sites. The final report from this effort is now available and indicates that, in most cases, a combined coal-cleaning-FGD approach is significantly more cost-effective than FGD alone for meeting sulfur emissions standards. (DOI)

Evaluate physical and chemical processes which may be used to remove sulfur and other pollutants from coal. A combination of experimental and engineering analysis will evaluate the following: physical coal cleaning techniques for pyrite removal from fine coal, dewatering and handling techniques, coal preparation requirements for synthetic fuel processes, chemical coal cleaning processes, pollution control technology for coal preparation requirements for synthetic fuel processes, chemical coal cleaning processes, pollution control technology for coal preparation processes, the effects of cleaned coal on boiler and air pollution control device performance, and the costs and performance of competing equipment and processes.

A development program for treatment of coal to produce low sulfur, solid fossil fuel is being conducted. This program will determine, on a bench- and pilot-unit scale, the operating parameters for the IGT Process to desulfurize coal by thermal and chemical means. Coal will be treated with a reducing atmosphere in the presence of a sulfur getter. Sulfur removal will be determined as a function of temperature, residence time, coal/getter ratio, coal composition, and particle size.

Construct a reactor test unit for evaluation of the pyrite leaching from fine coal, leach solution regeneration, and initial filtration operations of the Meyers Process for chemical coal desulfurization. The reactor test unit will operate at 250-270 pounds of coal per hour. The input material is properly sized coal, either cleaned or uncleaned. The output material is the reacted coal which has been filtered and washed on the filter.



Direct Combustion

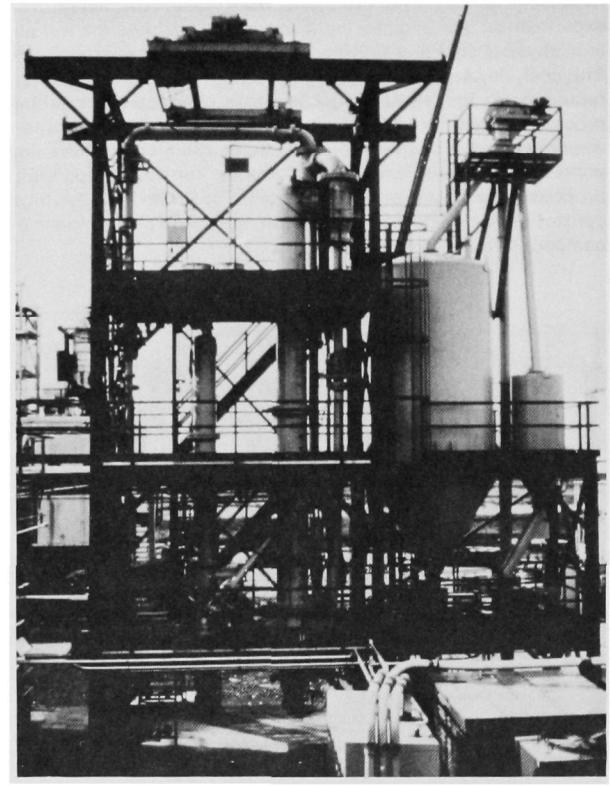
At present coal and residual oil provide most of the fuel used by utility and industrial boilers. It appears inevitable that direct use of coal in existing and new boilers will expand during the next decade. Fluidized bed combustors (FBC) are being developed by the Federal government and private industry to facilitate the environmentally acceptable use of coal, coal-derived products, and residual oil.

Large expenditures to improve existing coal-fired power plant technology would result in relatively little increase in efficiency. On the other hand, fluidized bed combustion has the potential for more efficient and reliable boilers with far less air pollution and solid waste for disposal. The Interagency Program for direct combustion involves: (1) environmental assessment of direct combustion technology, (2) development of environmental control technology for FBC, and (3) chemically active fluidized bed (CAFB) oil gasification/clean-up/combustion processes development. (CAFB is essentially a fluidized-bed oil gasification process that uses low grade high sulfur oil to produce low Btu gas effectively and economically.)

The objectives of the environmental assessment programs are to characterize air, water, solid waste, and other environmental problems associated with atmospheric and pressurized fluidized bed combustion processes, assess control technology in relation to environmental objectives, publish and update best available technology and best practicable technology manuals, and provide an overall environmental analysis.

A major objective of control technology development program is to support the National Fluidized Bed Combustion Program which has the goal of developing atmospheric and pressurized FBC technologies for commercialization. This support includes the development of laboratory and bench-scale add-on control technology and process modifications for control of SO_x, NO_x, total particulates, hydrocarbons, carbon monoxide, and hazardous and other pollutants from FBC, as well as treatment and final disposal techniques for spent sorbent and ash. The CAFB process for converting heavy high-sulfur, high-metals-content residual oils to clean high-temperature gaseous fuel will be demonstrated at small to moderate commercial scale.

Under the technology development effort, much of the laboratory and bench-scale work on conventional fluidized bed combustion is being conducted at EXXON's research laboratory in New Jersey and at ERDA's Argonne Laboratory. Most of the chemically active fluidized bed (CAFB) development has been performed by ESSO's United Kingdom Laboratories. Demonstration of the CAFB process in the U.S. is at the La Palma Station of Central Power and Light



(Texas) and is jointly funded by EPA and the utility company. Preliminary results to date indicate that these technologies not only remove a large portion of the sulfur from the fuels, but also a great deal of the heavy metals.

The FY 1976 budget allocation for the direct combustion program represents 6.9 percent of the total Interagency Energy/Environment program budget. The allocation for this program constitutes 11.9 percent of the funding for the control technology development activities in FY 1976. Projects representing 96 percent of the total funds for this program are being undertaken within EPA while ERDA is carrying out activities accounting for the remaining 4 percent of the FY 1976 budget. Like the coal cleaning program, the Fluidized bed combustion (FBC) program is divided into two parts: environmental assessment and technology development.

FBC - Environmental Assessment

Studies in this area provide for: (1) the characterization of air, water, solid waste, and other environmental problems associated with atmospheric and pressurized fluidized bed combustion processes, (2) development of environmental objectives, and assessment of control technology in relation to these objectives, and (3) publication of a best available technology manual including an overall preliminary environmental impact analysis. Comprehensive characterization studies are being done on all available atmospheric and pressurized systems. Supporting technical tasks will provide near-term preliminary environmental assessment information, identify the effects of scale on emissions from fluidized bed units, provide sampling and analytical manuals, consider the problem of special liquid and solid wastes, and evaluate the applicability and problems associated with industrial-scale fluidized boilers. During FY 1976, a preliminary environment assessment report on FBC, and a report on environmental problems identified through tests, comprehensive analysis and biological screening were issued. The following are examples of major environmental projects.

Provide a total picture of the fluidized bed combustion process, including the environmental consequences of fluidized bed combustion processes and the identification of important emissions to any medium and methods for their control, an assessment of the technical and economic feasibility of fluidized bed combustion process variations and any required emission control systems, and emission goals for the fluidized bed combustion process and desirable emission standards for the next 25-30 years.

Provide assessment of the CAFB process as a clean fuels producer for a wide range of fuels and uses.

Conduct a "devils advocate" preliminary environmental assessment of the CAFB process, determining which tests should be run on the unit, evaluate the test results, and prepare a final report with recommendations to EPA for follow up on project demonstration and environmental assessment.

Develop measurement techniques to generate engineering data for environmental assessment and control technology development projects evaluating high temperature, high pressure processes. The two processes of initial interest are high pressure fluidized bed combustion and coal gasification.

Assess the environmental impact of the disposal and/or utilization of residues from fluidized bed coal combustion and high-sulfur fuel oil gasification. The specific objectives are to: characterize the residues from these processes, identify the leachate quantities and constituents from land disposal of the residues, evaluate the potential environmental impact of disposing the residues into different environments, and investigate the commercial utilization of these residues.

Demonstrate, on a commercial scale (about 20 MW) the CAFB process, and perform environmental assessment of the process.

FBC - Control Technology Development

This category deals with the development of laboratory and bench-scale multimedia control technology for SO_x, NO_x, total particulates, hydrocarbons, carbon monoxide, and hazardous and other pollutants from fluidized bed combustion (FBC), as well as techniques for disposal of spent sorbent and ash. Available pilot facilities are being used for demonstration of these techniques. Bench and pilot scale fluidized bed studies are characterizing and developing existing and new control technology associated with FBC applications. Among the factors studied are: modification of design conditions, modifications of operating conditions, and add-on control devices for gaseous, liquid, and solid streams. Engineering and small scale experimental support focus on optimization of SO_x control using a calcium-based sorbent, alternate sorbents and means for SO_x control, NO_x formation and control, specific particulate control requirements, trace pollutants control, and means for disposal and utilization of ash and spent sorbent. During FY 1976, a report on the assessment of high temperature/pressure particulate control methods was issued, and recommendations are being developed for environmental test facility programs.

Develop environmental controls for fluidized bed combustion processes. The work includes utilizing calcium-based SO_2 control sorbents, utilizing alternative sorbents for SO_2 control, investigation of NO_x emissions, control of particulate emissions, control of trace element emissions, and disposition of ash and spent sorbent. The program extends previous work carried out by Westinghouse in the areas identified. It will develop design and operating data on a variety of fluidized bed combustion concepts, identify test programs and test alternative system components, provide technical support for existing and proposed plants, and provide evaluation of test data.

Tests are being done to evaluate three novel fine particulate control devices. A novel fine particulate control device for the purposes of this program is defined as an existing full-scale or pilot-scale device or system based on new collection principles or on radical redesign of conventional collectors. Control of fine particulates is emphasized.

Investigate the emissions from combustion of liquid and gaseous fuels in atmospheric and pressurized combustion. Comprehensive analyses for pollutants in addition to the criteria pollutants are being carried out over a range of operating conditions. Evaluate control technology on actual gas turbine and diesel engines. Water/fuel oil emulsions and catalytic exhaust devices are also being studied.

Conduct a theoretical and experimental investigation to determine the effectiveness of high temperature (1100°C) collection mechanisms, and to identify mechanisms that might be used to remove particles from high temperature and/or high pressure gas streams. Existing and proposed energy processes requiring high temperature and/or high pressure particulate cleanup are being studied to determine the important characteristics, cleanup requirements, and potential problems of each process.

Evaluate a novel concept for fine particle control in high temperature and pressure systems. The apparatus would collect fine particles by mechanisms such as diffusion, inertial impaction, interception and electrophoresis. Program includes theoretical calculations and testing followed by construction and testing of a model facility with at least a 500 SCFM capacity.

Conduct bench-scale experimental studies at elevated pressures.

Investigate control technology for the fluidized bed coal combustion and sorbent regeneration process over a wide range of variables at a scale equivalent to 0.63 MW.

Design, construct, and operate a small prototype unit (20 MW) at a utility boiler site. Supporting pilot and engineering projects are being conducted to provide needed background quick-response problem solving. This activity includes operation of batch and semi-continuous pilot systems, and engineering work in such areas as sulfur removal systems, stone disposal and market alternatives, advanced concepts such as pressurized CAFB, and other control technology evaluation and development.

In laboratory-scale studies, several approaches are being investigated to reduce the quantity of sulfated limestone discharged from the FBC system. Tests are continuing on regeneration methods other than reductive decomposition for converting sulfated limestone to lime for reuse in the combustion process. Also, scoping studies are being completed on selecting the best synthetic SO_2 sorbent and the methods of preparing it. A synthetic sorbent consisting of CaO impregnated on alumina is being exhaustively tested. Interactions of sorbent with coal ash, which reduces the reactivity of the sorbent, is being studied. In other laboratory studies, the mechanism of NO_x emission problem has been completed. The fates of trace elements introduced to the process in the coal and limestone will be determined for those elements that are biologically hazardous and those that are corrosive to metal equipment. Methods of minimizing the release of these elements are being explored. In bench-scale studies, better regenerative processes and equipment configurations developed in laboratory-scale studies are being tested. (ERDA)

Demonstrate the technical and economic viability of fabric filtration as a means of fine particle control at high temperatures (1500°F) and pressure (10 ATM).

Advanced oil processing-chemically active fluidized bed residual oil cleanup. Demonstrate, at small to moderate commercial scale, the chemically active fluidized bed (CAFB) process for converting heavy, high-sulfur, high metals content residual oil to clean, high-temperature gaseous fuel.

Determine the NO formation-destruction processes in continuously operated fluidized bed combustors. Batch-type kinetic studies are being carried out with an externally heated fluidized bed and a pressurized fluidized bed. The objectives of the study are to develop a mechanistic mathematical model for the prediction of NO emission, to generate information necessary for the development of new control technology of NO_x emissions, and to test the mathematical models over wide ranges of operating variables.

Flue Gas Cleaning

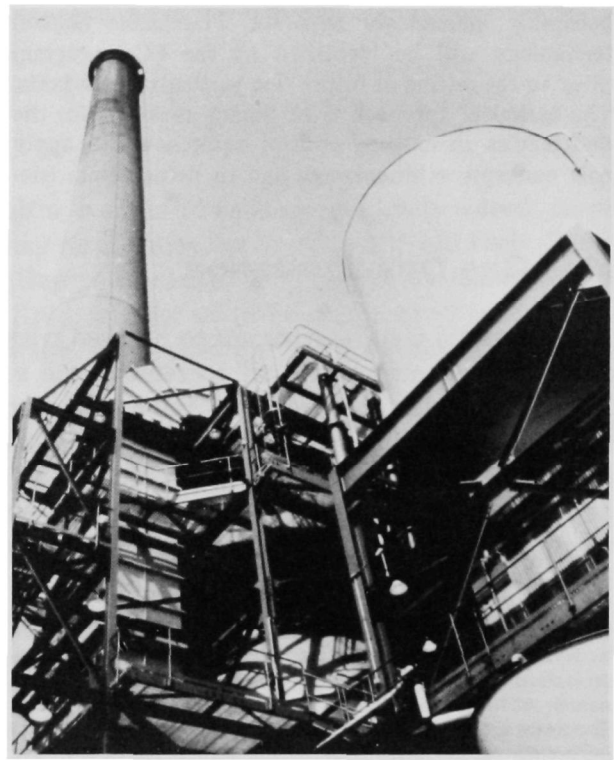
Cleaning of flue gases from coal-fired utility and industrial boilers has been assigned highest priority, in terms of FY 1975 and 1976 funding, within the EPA-coordinated Federal Interagency Energy/Environmental Control Technology R&D Program for several reasons. The primary reason is that flue gas cleaning (FGC) technology in general, and flue gas desulfurization (FGD) processes in particular, are important in terms of domestic energy development.

The only way to increase significantly near-term coal use without severe environmental disruption is to have air pollution control technology available to meet the Clean Air Act requirements. Coal conversion (gasification and liquefaction) processes offer promising alternatives to conventional fuels, but will not be ready for commercial application for a decade or more, and existing coal cleaning facilities cannot meet the full demand for low-sulfur fuel for a similar period. Successful flue gas desulfurization R&D will provide the most important coal combustion control technique available in the 1970's and 1980's.

Secondly, flue gas desulfurization systems, many of which are now in commercial operation or on order, are in the final stages of development. R&D efforts will be directed toward the remaining problems such as upgrading operation performance and reliability, minimizing costs, waste product disposal or treatment, and by-product recovery.

Another major, and growing, segment of the Interagency Program in flue gas cleaning addresses the control of nitrogen oxides (NO_x) emissions. The control of NO_x emissions is being approached from two directions. One involves preventing (or reducing) the formation of NO_x by modifications of combustion processes. The other involves post-combustion treatment of the flue gas to remove NO_x in a manner analogous to desulfurization. Analyses indicate that the combustion modification approach, if implemented by utilities and industry could achieve the required degree of control with less expense than by post-combustion treatment. However, combustion modification could not meet significantly more stringent standards than presently apply. Post-combustion treatment for NO_x control is being pursued by EPA in conjunction with investigators in Japan (where NO_x standards are more stringent) as a second approach in case combustion modification cannot meet changing requirements.

Funding for the Flue Gas Cleaning (FGC) program in FY 1975 provided capital for two advanced FGC demonstration plants. Funding levels in FY 1976 and subsequent years are decreasing since no further full-scale utility demonstrations are anticipated. Use of FY 1976 funds is producing major national benefits as these systems are improved sufficiently to enable large-scale commercial application.



The funds allocated to the flue gas cleaning program for FY 1976 represent 26.9 percent of the total allocation for the Interagency Energy/Environment Program. Approximately 46.3 percent of the FY 1976 funding for the control technology development program has been allocated to flue gas cleaning. Projects being undertaken within EPA account for 83 percent of the total, and TVA is undertaking projects for the remaining 17 percent of the funds.

Flue gas cleaning program plans include continued work on the two full-scale advanced system demonstration plants. One of these is an advanced non-regenerable system (sludge-producing), and the other will produce marketable elemental sulfur as a regenerable byproduct. As part of the Interagency Program, TVA is providing a commercial-scale facility to serve as host for a major demonstration.

In addition to R&D on advanced scrubber systems, waste disposal techniques, and NO_x control systems, the FGC Program includes the characterization of fine particulates and other hazardous pollutants such as trace materials from coal combustion and metallic acid sulfates. It also includes R&D on possible control techniques for these pollutants.

The role of fine particulates (that is, particles in the <5 micron range) as biologically active air pollutants is becoming increasingly apparent. Practicable control technology will be identified by the FGC program prior to the setting of future fine particulate standards. The technical approach is to pursue remedies for the deficiencies in existing control equipment, to apply new concepts as discovered, and to demonstrate successful advancement in fine particulates removal technology. High priority is being given to a comprehensive technology transfer program so that the expertise generated under the Interagency Program can be applied commercially.

To facilitate a fuller understanding of the extensive flue gas cleaning research and development effort (the largest single study area in the Interagency Program) the many individual projects have been grouped into four categories. These are: (1) flue gas desulfurization, (2) control of nitrogen oxides and other combustion pollutants, (3) treatment of control process wastes, and (4) technology transfer supporting research. The principal projects are described below according to these four categories.

Flue Gas Desulfurization

If domestic coal reserves are to be used without unacceptable damage to health and the environment, a way must be found to remove the sulfur from higher-sulfur coal before or during combustion or from flue gases after the coal is burned. For a number of years, EPA has led efforts to remove sulfur compounds from flue gases, and flue gas desulfurization is proving to be a major success of the Interagency Program. Current efforts are concentrating on improving cost efficiencies and developing and refining regenerable processes where the material which removes the sulfur can be repeatedly reused within the system. The major project areas of flue gas cleaning are described in more detail below.

Non-regenerable flue gas desulfurization. This program involves both in-house and extra-mural development/demonstration projects directed toward improving the performance and economics of lime and limestone flue gas desulfurization (FGD). The major emphasis is on the continuation of the advanced testing program at the Shawnee prototype facility (TVA). The TVA and venturi/spray scrubbers are being tested with the objectives of improving the reliability of system components such as mist eliminators, and minimizing sludge production through the maximization of alkali utilization. A computer program for performing economic trade-off analysis is being developed, and this program will be used for minimizing capital and operating costs.

Regenerable flue gas desulfurization. The objective here is the demonstration of FGD processes which regenerate the sorbent and produce marketable sulfur products. The initiation or continuation of prototype or full-scale demonstration projects involving Wellman-Lord/Allied, magnesium oxide, and citrate processes and the pilot-scale evaluation of the ammonia-ABS process occurred in FY 1976. Additionally, the final design of a selected advanced (second generation) regenerable process demonstration system was completed. The construction and demonstration of this system is in progress. In coordination with the NO_x flue gas treatment (FGT) program, evaluation of processes capable of removing *both* SO_x and NO_x is being conducted. Activities will be continued in support of expanding the applicability of magnesia scrubbing FGD and demonstrating the generation and use of reductant gases for production of elemental sulfur.

Energy conservation study of selected processes for removing SO_2 from power plant stack gases. This activity involves surveys of (1) published data on energy requirements for selected processes and (2) energy requirements for operating and planned demonstration, and commercial units. Summaries of current energy requirements based on the above surveys of desulfurization processes were prepared during FY 1976. This will be followed by the preparation of a feasibility study of process modifications for reducing energy requirements of selected processes. (TVA)

Advanced concepts SO_2 removal process improvements. This activity involves laboratory and bench-scale studies of absorption and regeneration in a potassium-based scrubbing system. Oxidation in solution, and slurry scrubbing systems for SO_2 removal are being studied at the laboratory and bench-scale levels. Laboratory studies of recovery of SO_2 as dilute sulfuric acid and utilization in fertilizer processes is also being conducted. (TVA)

Development of flue gas desulfurization technology-Shawnee lime/limestone scrubbing program. The Tennessee Valley Authority (TVA) has undertaken the development of non-renewable lime and limestone scrubbing processes for flue gas desulfurization. The Shawnee lime/limestone scrubbing program involves short-term and long-term testing of advanced concepts for improving the reliability and economics of these processes. The equipment and materials of construction are being evaluated. During FY 1976, the base portion of a lime/limestone process economic evaluation computer program was completed. Field testing of sludge disposal techniques has been undertaken.

An intensive test program at the full-scale lime scrubbing facility at Louisville Gas and Electric's (LG&E) Paddy's Run Station was initiated during FY 1976. Factors responsible for reliable and unsaturated operation of this scrubber are being identified. An evaluation of lime scrubbing (Bahco process) as a viable control technology for industrial coal-fired boilers is currently being performed at the Rickenbacker Air Force Base. Development/demonstration of double alkali FGD systems, as reliable second generation alternatives to lime/limestone scrubbing, will be continued. Pilot-scale test studies in support of EPA-sponsored test program at Gulf Power's 20 MW prototype D/A system has been completed in FY 1976. A full-scale demonstration of a competitively selected double alkali process on a coal-fired utility boiler will be initiated via an industry/EPA cost-shared contract. An independent third party will formulate and perform a comprehensive test program at this demonstration facility. The efficiency of using double alkali technology for SO_x control of industry boilers will be evaluated by completing tests now underway at a General Motors 32 MW facility. The scrubber evaluation phase of the LG&E test program has been completed and the results will soon be published. The pilot/prototype test program and the design of a full-scale double alkali installation has also been completed during FY 1976.

NO_x and Other Pollutants

As energy/environment problems involving the sulfur content of fuels are gradually solved, more emphasis is being given to other pollutants which may result from the burning of fossil fuels. Chief among these pollutants are oxides of nitrogen and fine particulates, including many trace metals. Environmental assessments are currently underway for a number of promising control techniques. In addition to flue gas cleaning, combustion modification processes are under development which manipulate fuel burning to produce less pollutants.

NO_x control environmental assessment/application testing. Determine the environmental emissions of NO_x and other combustion-related pollutants from stationary combustion sources and evaluate the environmental effectiveness and impact (as compared to the uncontrolled state) of combustion control modifications. Such modifications include alternative operating conditions, retrofit control, maximum stationary source technology (MSST) for existing units (extensive retrofit) and MSST for new units (optimized design or alternate processes). Analyses will assess the impact of the control technologies, as applied to various sources, on the environmental quality of various regions or areas, and will investigate various NO_x strategy options.

Combustion pollutant assessment and control technology for conventional combustion systems. An identity matrix across air, water, and solid waste pollutants summarizing current and planned work will be included in a preliminary environmental assessment document. This matrix will define the major data base by combustion system type. A total environmental assessment of conventional combustion systems will be conducted to quantify the potential air, water, and solid waste pollutants identified in the matrix. The environmental assessment will quantify all pollutants, rank pollutants according to environmental impacts, delineate the established or potential impact in the areas of air, water, and solid waste pollution, and define operating parameters deemed relevant to the composiiton and quantity of pollution emissions.

Develop and demonstrate practical technology for controlling NO_x and related combustion-generated pollutants. Due to the nature of the generation of nitrogen oxides, the emphasis is on the modification of the conditions under which fuel combustion takes place. The effective techniques for combustion modification can be optimized to reduce or eliminate emissions of other pollutants. This program emphasizes source-specific field application of control techniques to a variety of stationary sources, including utility, industrial, and commercial boilers, residential furnaces, industrial process furnaces, stationary engines, and advanced processes.

NO_x flue gas treatment assessment including an assessment of the extent to which FGT could be used in an optimized NO_x control strategy for stationary sources. Based on these assessments, the program provides for the development and demonstration of NO_x FGT technology, and will produce information concerning the economic, energy and environmental aspects of commercial application. The four major elements of this program are: (1) continuation of ongoing FGT bench and pilot scale efforts directed toward NO_x removal in the presence of low SO_x concentration (in coordination with regenerable FGD projects); (2) initiation of a project for development of processes which will remove both SO_x and NO_x; (3) evaluation of both the U.S. and the Japanese FGT technologies in order to identify the most promising processes for U.S. applications, with the objective reviewing and modifying the total NO_x FGT program where appropriate; and (4) based on the above efforts, undertake demonstration of larger scale prototypes.

Fine particulate control technologies capable of effectively removing large fractions of ~3 micron particles from waste gases. The technical approach is to identify capabilities of existing equipment (electrostatic precipitators, filters, scrubbers and proprietary devices), determine deficiencies in present design and operating procedures, and pursue remedies for the deficiencies through research and development. Results will be applicable to improvements in high temperature, high pressure particulate removal devices, including entrainment separator systems, utility boiler and municipal incinerator baghouses, mobile scrubber test units, foam scrubbing, fine particle charging, and charged droplet scrubbers.

Treatment of Control Process Wastes

Most of the flue gas cleaning schemes which remove sulfur and other pollutants from stacks result in accumulations of waste sludge. So that the solid waste problem does not become as much of an environmental burden as pollutants emitted from stacks, a substantial category of the flue gas cleaning program is devoted to finding means to recycle or dispose of the waste sludges from stack cleaning processes. Besides treatment methods for safe disposal and design of systems to reuse wastes, other projects seek to develop byproducts from the wastes that can be sold to offset the costs of controls.

Control of wastes and water pollution. Evaluate, develop, and demonstrate environmentally acceptable, cost-effective techniques for disposal and utilization of wastes from flue gas cleaning, with emphasis on FGD sludge. Demonstrate systems for maximizing power plant water reuse/recycle. This effort includes laboratory and pilot field studies of disposal techniques for untreated and chemically treated FGD sludges, including lined and unlined ponding and land-fill, coal mine disposal and ocean disposal. Additional efforts support bench- and pilot-scale testing of FGD sludge utilization schemes such as the use of FGD gypsum in Portland cement, sludge conversion to sulfur (with regeneration of limestone), and extraction of alumina from fly ash or clay (with conversion of FGD sludge to dicalcium silicate and sulfur).

Byproduct marketing. In this project, the potential for marketing of byproducts (S, H_2SO_4, $(NH4)_2SO_4$, $CaSO_4$) of SO_x abatement processes is subjected to a system analysis of these processes. The potential uses of abatement sulfur byproducts in the fertilizer industry are also being studied. A flue gas scrubbing strategy system will be developed for evaluating alternative strategies for optimum technology mix considering product markets (sulfur, sulfuric acid, ammonium sulfate, phosphate fertilizers, wallboard, etc), process cost differentials, and clean fuel alternatives. (TVA)

Processing lime/limestone sludges. Fertilizer production from lime/limestone scrubbing sludges is being studied, and scrubber operations are being correlated to sludge characteristics. Disposal methods for waste products from fluidized-bed combustion processes are also being determined. (TVA)

Fly ash characterization and disposal. The major tasks are: (1) summarization of data on coal and ash, emphasizing the quantity, physical characteristics and chemical properties; (2) characterization of physical properties and chemical constituents of coal, ash and ash effluent; (3) identification and summarization of promising methods of disposal and utilization of fly ash; (4) summarization of methods of treatment for making power plant water suitable for reuse; and (5) summarization of methods of dry and wet fly ash handling, and identification of major considerations in the design of dry and wet fly ash handling systems. (TVA)

Characterization of effluents from coal fired boilers. Characterization and assessment of coal pile drainage, assessment of pH adjustment on ash pond effluent, characterization of chlorinated water effluent, analysis of ways to reduce chlorinated effluent, and assessment of the influence of chemical constituents from the ash pond on ground water quality. (TVA)

Technology Transfer and Support

Within the flue gas cleaning program, there is a need for integrative studies which tie together the component parts. A flue gas desulfurization system for a power plant is not the only environmental requirement. For example, the plant may also emit nitrogen oxides and fine particulates, and may produce accumulations of control process solid waste. Technology transfer supporting research looks at all aspects of flue gas problems to develop information on comparative cost and efficiencies of various control technologies and combinations of technologies.

FGD technology transfer and supporting studies. This program deals with effective dissemination and application of the findings of EPA, utility, and industrial FGC development/demonstration efforts. Major activities include surveys of control technology application status, the development of a model for site-specific FGC option determination, the evaluation of relative impacts on ambient air quality of emissions from various combustion sources, and the study/development of new innovative sludge disposal techniques.

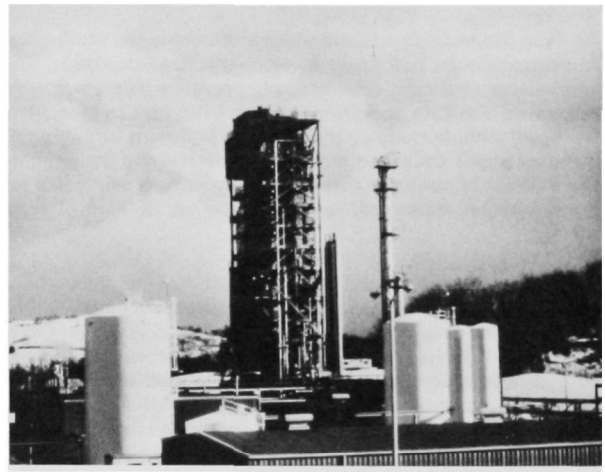
Develop comparative economics of control processes. The study includes economic analysis of one citrate, one sulfur-producing (regenerable), and one double alkali process, including: base-case capital investment and operating costs of selected processes, and capital investments and operating costs of alternative methods of sludge disposal. (TVA)

Synthetic Fuels

The Interagency Program for synthetic fuels seeks to assure that large-scale commercial application of synthetic fuel production and utilization can be achieved within tolerable environmental limits. The program's approach involves three principal efforts: assessing environmental effects of synthetic fuels technology, establishing control objectives through standards-of-practice manuals and support of standard-setting, and developing control technology as necessary.

The synthetic fuels program itself is mainly concerned with the conversion of coal to clean liquid and gaseous fuels, the processing of oil shale, and the recovery and utilization of byproducts. Optimally, this program would require sequential R&D following the logical progression from one functional area to the next (i.e., from pollutant identification, to transport processes, to health and ecological effects, to control technology RD&D, to integrated technology assessment). However, environmental control technology R&D will have to be conducted concurrently with environmental assessment R&D because some synthetic fuel processes using currently available technology (such as Lurgi) may be employed in first generation commercial plants in the near future. Development and/or assessment of appropriate control technology is accelerated to permit early commercialization and to minimize the diseconomies associated with retrofitting of pollution controls.

Under EPA's strategy, first-generation synthetic fuel processes (such as the Lurgi, Koppers-Totzek, Winkler processes which are currently in commercial use in foreign countries) will be rapidly assessed from the available data. Standards of practice manuals will be issued in the near future to guide pollution control technology for these first-generation processes. For second-generation processes (e.g., HYGAS, Synthane, CO_2 Acceptor, SRC, etc.) more time will be available for obtaining more complete assessment data and for performing additional R&D as required to develop optimal control processes. These assessments will be completed and control technology requirements defined well in advance of commercialization of the second-generation processes.



The FY 1976 budget allocation for the synthetic fuels program amounts to 5.4 percent of the FY 1976 funding for the Interagency Energy/Environment Program, and 9.4 percent of the budget for control technology development. The projects being undertaken within EPA represent 80 percent of the total budget for the synthetic fuels program. ERDA is undertaking projects accounting for the remaining 20 percent of the budget.

Environmental Assessment of Synthetic Fuel Processes

This category involves characterization of fossil fuels to determine potential pollutants that may be released as a result of their conversion to synthetic fuels. It also includes analysis and field environmental testing of specific conversion processes to determine pollutant releases. A portion of the characterization of coal conversion processes will be performed on specific ERDA-sponsored processes. Testing will also be done at foreign facilities representative of first generation plants. The overall effort will provide an evaluation of available control technology and manuals of pollution control practices on a schedule consistent with both EPA's standard-setting schedule and ERDA's anticipated commercial-scale installations. This activity will also provide directions, data, and

samples to the environmental effects programs. The following are some of the major projects currently underway.

Perform an assessment of coal conversion technologies which produce a low- and/or intermediate-Btu gas. The impacts of utilizing the product gas for fuel or chemical feedstock purposes will also be determined. The study will be based primarily on an engineering analysis of existing data to predict impacts, assess control technology capabilities, and identify additional data requirements.

Analyze the factors and conditions which cause the production of environmental pollutants in synthetic fuels processes. The approach is to design, fabricate, and operate a laboratory scale reactor to simulate conditions of synthetic fuel reactors. The work will include studying the effect on pollutant formation of different input coals and reactor parameters, and determining the kinetics of pollutant formation in order to provide data for environmental assessment and development of control technology.

Perform an environmental assessment of fuel gas generation/combined cycle power generation. This will be accomplished via paper studies which utilize the latest gasifier performance data and effluent discharges data. Air and oxygen blown gasifiers will be evaluated as well as fluidized bed and molted salt types. The program will provide a comparison of these gasifiers on both an environmental and economic basis when operating in an integrated coal gasification-advanced cycle power generating system.

Develop methods for chemical characterization of aqueous effluents from the retorting processes being used to develop oil shale in the Green River formation. (ERDA)

Perform a multimedia environmental assessment of the technologies for converting coal into high Btu products, including preliminary impact assessment, input material characterization, process engineering studies and control technology evaluations.

Provide a preliminary evaluation of biomass production and conversion technologies, and their associated environmental consequences. Five categories of biomass production are considered in detail: agricultural and forestry wastes, aquaculture (aquatic plant species which may be cultivated for energy production), silviculture (intense cultivation of tree species) energy crops (special crops adaptable to intense cultivation for the production of energy), and urban and industrial waste.

Evaluate the environmental impact and effect on industrial processes when a low or intermediate energy gas from coal is used as an on-site generated industrial fuel.

Assess the environmental impact of oil shale development. The project includes acquisition of the necessary background data on the principal industrial shale recovery processes and U.S. shale resources, a comparative assessment of their environmental acceptability and an evaluation of technologies available for the control of air, water, and solid waste emissions. Preliminary reports on these projects are currently available.

Assess the environmental impact of wastewater contaminants originating from the production of synthetic fuels from coal, and to evaluate alternative waste water treatment technologies for the control of these contaminants.

A compilation of available techniques for treating and controlling emissions from the various processes and operations will be developed. From these efforts, a comprehensive test program for ERDA coal conversion facilities will be developed and conducted. The test program will be based on specific processes being supported by ERDA and identified by mutual agreement between EPA and ERDA. This test program will identify processes and effluent streams to be monitored, types of analytical methods to be used, and operating data to be collected. (ERDA)

Control Technology - Synthetic Fuels

The major effort in control technology development has been evaluating the need for new technology for the major process streams in first and second generation processes. Ongoing efforts concentrate on controlling pollution from secondary streams (i.e., waste or byproduct streams). Technology for high-temperature high-pressure desulfurization and particulate removal from gas streams, and transfer of control technology from metallurgical and petroleum processing to synthetic fuels processing, will be investigated. The following are some of the major projects underway.

Characterize coal, its products, byproducts, and wastes with regard to their pollutants and possible mechanisms for control in synthetic fuel processes. Develop reliable methods for identifying the location, circumstances, and form in which organically-combined potential pollutants in coal are bound and released.

Evaluate emission performance of alternate fuels and advanced concept control techniques. The study uses a 300,000 Btu/hr versatile experimental furnace for comparison of alternate fuel performance. The basic furnace allows for burner design changes as well as staged combustion and flue gas recirculation.

Estimate effectiveness of alternative control technologies for synthetic fuels systems. Capital and operating costs will be determined. A description of each control technology including its costs, effectiveness, limitations, advantages and disadvantages will be produced. Most of the coal processes under consideration will produce byproduct streams which may or may not be fuels. In addition, the control system will itself generate effluents. These primary and secondary materials will be identified and the quantities estimated. Methods of disposal (by sale, conversion to useful materials, or discharge) will be identified to permit operation in an environmentally acceptable manner. Effluents not only from the process and control systems, but from ancillary units such as hydrogen and oxygen production, water treatment, and other unit processes will be considered. (ERDA)

Analyze use of low Btu gas (LBG) with careful attention to overall system design. Special emphasis is on use of high temperature, Nitrogen compound containing LBG without production of high levels of NO_x and other pollutants.

Conduct additional experiments to produce optimum low-emissions burner design criteria for the major burner classes. Establish the relative controls available through the various burner designs and classical modification techniques as well as establish what operation parameters will be changed. Results will provide a basis for low-pollution design criteria with other fossil fuel systems including low-Btu gases at ambient and elevated delivery temperatures.

Obtain data on an existing coal gasification complex and to analyze its significance to the environment. Gather existing data, much of it unpublished, on the quantities and compositions of effluent streams. The information will be multimedia and will include descriptions of the process, flow diagrams, heat balances, and material balances on important constituents.

Nuclear Waste Control

The objective of the Interagency Program for nuclear technology is to minimize the environmental impacts of the processing of nuclear fuels and the disposal of nuclear wastes at various stages in the nuclear fuel cycle. Under the Interagency Program, ERDA has the lead role in organizing systematic efforts to develop methodologies for assessing the environmental impact of high level and low level radioactive wastes, and to develop techniques for the disposal of these wastes.

The FY 1976 budget allocation for the nuclear waste control program represents approximately 0.5 percent of the total Interagency Energy/Environment Program budget and 1 percent of the funds for control technology development. The following projects are currently underway.

Evaluation of problems and limitations of the ocean as a radioactive waste management alternative. The target for this project is to complete the container evaluation studies and the physical, chemical, biological and radiological measurements at both the East and West Coast sites for dumping radioactive wastes.

Improving model for simulating groundwater transport of radioactive pollutants from buried low-level radioactive wastes.

Definition of the radon-222 source term from uranium mill wastes. This project involves summarizing the interrelations among radium content, moisture and radon exhalations from fill tailings piles in a variety of climatological settings typical of the pertinent areas of the U.S.

Management and engineering study for commercial low-level burial sites. A bibliography is being developed of pertinent completed studies on on-going work in the area of low-level radioactive burial sites.

Thermal Control

Power plants discharge large amounts of heat into cooling water (ranging from 48 percent of the total heat input for fossil fuel fired plants to 60 percent for power plants using nuclear fuels). The construction of new coal fired and nuclear electric power plants to either meet new demand or replace outdated equipment is expected to magnify the problem of waste heat in plant siting. Under the Federal Water Pollution Control Act of 1972, EPA is required to regulate thermal effluents.

The FY 1976 budget allocation for the thermal control program represents 1.8 percent of the total Interagency Energy/Environment Program budget and 3.1 percent of the control technology development allocation. About 76 percent of the funding for this program is associated with projects being performed within EPA.

The major objectives of the thermal control program are: (1) provide design and performance data for improved cooling devices to be used in conjunction with nuclear and modern fossil fueled power plants; (2) reduce the dependence upon rivers and lakes as heat sinks for power plants (and minimize the environmental impact of heat discharged when it is impossible to avoid using natural water bodies as heat sinks); and (3) explore the use of waste heat for agricultural, cyclic storage, and other purposes. Projects in the Interagency Program for thermal control divide into two major areas: cooling technology; and waste heat and water use.

Cooling Technology

Emphasis is on the development of attractive second generation cooling technologies applicable to a variety of power generation systems. This effort involves TVA support in evaluating the performance of advance cooling towers (dry and wet/dry cooling towers) and rotary spray coolers, and in studying means of diverting fish from cooling water intake structures. Where necessary, control technology development for secondary environmental impacts associated with these innovative techniques will be undertaken. A program for developing control technology for ice fog generated by boilers and cooling ponds is also underway. The effectiveness of these techniques will be demonstrated.

Advanced cooling technology performance and economics. Studies deal with optimization techniques for dry heat exchangers, the application of wet/dry cooling technology to power plants for water conservation and fog control, and the development and demonstration of controls for secondary waste streams from cooling systems. The application of vertical tube evaporators in blowdown control commenced in FY 1976, as did a one-year evaluation of alternatives to chlorine for the control of algae and fungi in condenser cooling systems, and the demonstration of a vapor compression brine cycle concentrator for blowdown treatment. Reports on these activities are, or will soon be, available.

Develop ice control fog technology for stationary sources (University of Alaska). Initially, ice fog from heat and power plants and H_2O scrubbers for coal fired plants are being evaluated. Evaporation prevention on closed cycle cooling is viewed as a technique for controlling ice fog.

Test and evaluate advanced waste heat control technologies. Studies include the application of membrane technology to power plant waste waters, the evaluation of fish pumps and other techniques for directing fish away from intake channels at power plants, and the assessment of rotor spray cooling devices. In addition, the performance, economics and water quality of wet and dry cooling towers are being compared. (TVA)

Waste Heat and Water Use

The program for waste heat and water use addresses the identification and demonstration of multiple cascading uses of energy at ever-decreasing temperature levels. Efforts seek to determine the feasibility of using the energy content of residual heat streams—air and water—from non-power energy intensive industries and emerging energy conversion technologies. This portion of the Interagency Program has EPA cooperating with the Departments of Interior and Agriculture.

Advanced waste heat and water utilization. This activity involves identification and demonstration of integrated use facilities, utilization of residual heat, and assessment of associated environmental benefits and penalties. Cascading energy use application, and the feasibility and economics of utilizing power plant heat for agricultural purposes is under study.

Determine the feasibility of high density recovery production of catfish using waste heat discharges from steam electric power plants. (TVA)

Identify the technology needed for recovering heat energy from power plant condenser discharge waters for use in food and fiber production. Tasks include the heating of soil to extend crop growing season, optimizing the biological cycling of nutrients in livestock waste, and environmental controls for confined livestock operations. (TVA)

Improved Efficiency

For the foreseeable future, one of the most important sources of an added increment of energy availability will be the combined efforts to both conserve energy and to use it more efficiently. At first glance, it would appear as though the conservation of energy were, by definition, of benefit to the environment. For instance, if the energy is not consumed, then all of the pollution and environmental disruption associated with its extraction, conversion, processing and use is avoided.

On closer scrutiny, however, it becomes apparent that some energy-conserving processes are more environmentally beneficial than others, and that a few energy conservation activities could cause severe environmental disruption or threaten human health.

EPA's projects aimed toward reducing adverse environmental effects from energy conserving industrial processes are grouped into two main components: industrial conservation and wastes as fuel. The FY 1976 budget allocation for the improved efficiency program amounts to 5.1 percent of the total outlay of the Interagency Energy/Environment Program. The improved efficiency program accounts for 8.8 percent of the funds allocated to the control technology development activities in FY 1976. All the "improved efficiency" projects with FY 1976 funding are performed by EPA. About 29 percent of the FY 1976 funds are allocated to the industrial conservation program and the remaining 71 percent will be expended on "wastes as fuel" projects. The waste-as-fuel program is being emphasized because of its potential in helping to solve two problems at once. First, combustion or conversion of wastes may add significantly to our energy supply. Second, processing wastes for fuels significantly reduces both the volume and environmental impact of our solid waste disposal burden. These projects are described below.

Industrial Conservation

Energy-saving industrial process changes due to increased energy costs and governmental regulations or incentives may cause unanticipated pollutant emissions. It is essential that projects in the Interagency R&D Program address the potential adverse environmental impacts of any of these process changes which are designed primarily to conserve energy use. The projects in this subcategory range from literature surveys to on-site environmental assessments of specific industries.

In addition to evaluating the environmental impact of new and adapted energy conserving processes, research is underway to develop systems which will not increase pollution burdens. The objective of the control technology category is the development of energy-conserving processes which also result in less pollution or which are amenable to pollution control systems.

Identify expected process and practice changes for major energy consuming industries, characterize the total environment impact, determine adequacy of available control technology and identify situations where policy decisions are needed to assure maximum energy savings with minimal environmental insult.

Research is currently underway to assess the potential environmental impact of advanced fuel cycles such as high temperature, open and closed cycle gas turbines, potassium topping cycles, thermionics, thermogalvanics, magnetohydrodynamics (MHD), and Feher cycle. Systems being developed will be compared for environmental effects, energy savings, efficiency, economics and reliability.

Develop, demonstrate and evaluate various industrial process and pollution control technologies which are environmentally beneficial. Presently planned are assessments of hyperfiltration in the textile industry and off-gas heat recovery in non-ferrous smelters and a glass agglomerate/preheat system.

Review available information on indoor air quality measurements and the effects of energy conservation efforts on indoor air quality. Monitor and model indoor air quality as a function of energy conservation measures.

Examine and develop systems which simultaneously conserve energy and reduce pollutants. Test these systems for overall efficiency and pollutant emissions and determine their economic feasibility.

Waste-as-fuel Assessment

The principal objective of this research category is to assure the Nation's ability to tap an as-yet essentially unused energy resource—solid waste—to help meet the energy needs in an environmentally acceptable manner. Major waste-as-fuel technologies and methods will be explored to determine their environmental impact. These include the use of waste as fuel in large pulverized coal-fired boilers, other types of coal-fired burners, oil-fired boilers, industrial and smaller institutional boilers and waste pyrolytic (or other thermochemical) conversion to fuels and/or other materials. The program will produce the technological, economic, and environmental assessments of major waste-as-fuel processes under development.

Evaluate co-incineration of sewage sludge with waste to address the technical, economic, and environmental aspects of supplying the heat required to thermally degrade sewage sludge with refuse-derived fuel.

Report on air pollution control technology for existing processes involving particularly the cofiring of wastes with conventional fossil fuels and involving the thermochemical conversion of wastes to energy.

Develop environmental assessment criteria, sampling and analysis techniques, and the acquisition of pollutant emission data for new and existing processes for resource recovery and waste bioconversion processes.

Identify and characterize industrial and major non-industrial waste streams and project quantities, distributions, and compositions to 1990. Develop scenarios to account for the effects of increased conventional energy costs, regulatory actions, market forces, and institutional relationships.

Produce comparative technical and economic evaluations of major competing waste-as-fuel processes (supplementary fuel options vs. direct conversion to electricity vs. pyrolytic conversion vs. bioconversion, etc.). Research and development is being conducted on a large scale to develop and environmentally assess different waste-as-supplementary fuel options. Data is being gathered on the technical and economic feasibility of directly converting energy from municipal wastes to electricity in a gas turbine. Technical, economic and environmental assessments of the concept of co-firing refuse-derived-fuel with oil in large boilers is being performed.

Evaluate and assess existing equipment, techniques, and processes for preparing refuse-derived fuels and feedstocks for energy recovery. Develop and evaluate pre-processing equipment and systems for various energy recovery technologies.

Waste-as-fuel Development

Besides performing environmental impact assessment for the various waste-as-fuel schemes, the Interagency Program also has an active role in the development of the most promising waste-as-fuel technologies. Projects in this area include pre-combustion processing techniques for waste, several pyrolysis processes, co-firing waste with other fuels, and development of specific waste-as-fuel pollution control technology. A number of studies are being conducted in cooperation with cities and utility companies to demonstrate that waste-as-fuel is a viable energy alternative that can also be environmentally acceptable.

Provide third-party engineering evaluation of emerging waste-to-energy processes. The evaluation includes cost figures and potential technical problems for the most prominent of the current and developing processes.

Develop models relating fraction of fuel products (gas, liquid, solid) produced in pyrolysis of various types of solid wastes as function of pyrolyzed conditions. Investigate chemical conversions including steam gasification, partial oxidation, and catalytic effects of bed materials, and characterize pyrolysis products including char and oil.

Design, fabricate, and test a portable pyrolytic conversion system capable of converting bulky wet low energy agricultural wastes into a dense dry high energy fuel.

Evaluate the operational worth and environmental aspects of adding combustible solid matter to wastewater plant sludges and filter cakes to offset part or all of the fuels conventionally used in sludge incineration. Low-sulfur coal and combustible solid wastes are being utilized as admix materials in various test sequences. Wastes to be tried include shredded combustibles from refuse, in pelletized and loose form, wood chips, and industrial combustible wastes. A full-scale multiple hearth furnace in a modern wastewater treatment plant is being used. Applicability to other incinerators of the 200-plus total in United States' communities is being assessed. Assay of stack gases, after scrubbing, includes relevant chemical properties of public health significance. Scrubber drainage and ash are also assayed.

Assess the effects of using municipal solid waste (MSW) as a supplementary fuel at the Ames, Iowa plant. Since one of the Ames boilers is the same as that at St. Louis, studies permit confirmation and comparison of St. Louis test results.

Study technical and economic aspects of alternative preprocessing equipment and systems for converting municipal solid waste into a fuel or feedstock for fuel conversion systems. The study is intended to advance the state-of-the-art of waste-to-energy systems. Field tests of existing equipment and systems will be conducted to provide design and operational information.

Complete test and evaluation of the refuse preparation and firing processes used by the City of St. Louis in its municipal wastes-to-energy projects.

Analyze the technical and economic aspects of preparing and using densified forms of municipal solid waste as a supplementary fuel in industrial and institutional stoker coal fired boilers. Investigations are being conducted to establish methodology for preparing densified refuse derived fuel (d-RDF). Process and product characterizations are being developed to enable establishment of specifications for d-RDF.

Determine the feasibility, both technical and economic, of pyrolyzing the organic fraction of municipal solid waste to sufficient quantity of hydrocarbon gases (ethylene, ethan, etc.) to produce chemical intermediates. Phase I is directed towards the polymerization of hydrocarbon fraction to liquid fuel (polymer gasoline) suitable for internal combustion engine operation.

Advanced Energy Systems

Advanced energy systems are now under development and will gradually have an impact on our energy picture. In this area, the Interagency Program concentrates on anticipatory research and development for those energy systems which will be developed over the long term. Assessment studies will provide baseline information about the potential environmental impact of geothermal and solar energy systems. In the geothermal research program, the emphasis is on prediction and control of pollutant buildup in ground and surface waters. The solar energy systems research examines land use and siting difficulties associated with such systems and their resultant social, economic and institutional implications.

The funding allocation to the interagency program for advanced energy systems represents 0.25 percent of the total Interagency Energy/Environment Program budget for FY 1976, and 0.43 percent of the control technology development program. All the projects in this program are being undertaken within EPA. The following advanced energy research programs are underway.

Provide a preliminary environmental assessment of the potential uses of the geopressured geothermal waters of the Gulf Coast area of the United States. It will be accomplished by a literature survey and compilation of available data to characterize the resources, potential and projected uses, potential multimedia emissions and effects, waste control requirements and control technology.

Evaluate the effect of geothermal energy pollutants on the local species. Samples from plants and animals in the vicinity of geothermal development areas are being analyzed. Effect of geothermal pollutants will be noted and included as a part of the total monitoring strategy.

The environmental impacts of solar energy technology and systems will be identified and assessed (e.g., construction and emission including thermal). Based on NSF, NASA and ERDA projected experimental programs, the pollutant release potential to air, water, and land will be characterized and assessed. Eventually, a model will be used for assessing the hourly, daily, and seasonal average improvement in air quality as a function of the fraction of residential and commercial facilities using solar heating and cooling systems in medium to major urban areas.

A guideline document will be developed for the multimedia monitoring strategy around any geothermal resource development. A handbook of referenced geothermal sampling techniques and sample analyses is being developed.

Glossary

The following terms appear in the text and frequently are used to characterize various aspects of control technology or processes and effects associated with the development of energy technologies. These terms are defined and, where appropriate, are related to energy activities.

Aquifer—a subsurface geological formation containing water.

Some aquifers are situated near the land surface where their upper limit is defined as the water table. Deeper aquifers may be utilized as a source of potable water. Aquifers may become contaminated by pollutants associated with materials disposed on land and which migrate through porous soils, gravel, and fissures, cracks, and caverns in subsurface rock formations.

Aromatic compound—an organic compound possessing at least one unsaturated bond in a ring structure.

Many aromatic compounds vaporize easily. Most compounds identified as carcinogens are aromatic.

Bacteriophage—a virus that is a parasite of bacteria.

Bacteriophages are utilized in studies designed to determine the effects of pollutants on genetic mechanisms.

Benign tumor—a tumor that has no tendency to metastasize, form new foci of disease in a distant part, and is usually somewhat size restricted.

These tumors are of interest as some are precursors of malignancies.

Cancer—an abnormal, uncontrolled growth of cells or cellular tissue that, if untreated, is likely to cause death.

Cancerous growths usually are distinguished from other tumors by their ability to metastasize or to give off cells that spread to other parts of the body to form new tumors. Certain pollutants associated with various stages of energy production are suspected to be carcinogens.

Carcinogen—a substance which is responsible for the production of cancer (carcinogenesis).

EPA has a strong interest in the identification, isolation, and elimination of carcinogenic substances resulting from energy operations.

Co-carcinogenesis—a process in which a compound activates a potential carcinogen.

Many pollutants exist in mixtures of waste products. Co-carcinogenic effects are investigated as a potential cause of cancer in humans.

Cytotoxicity—the state of being poisonous to cells or cellular tissues.

Various types of cells are used to assess the degree to which various pollutants are deleterious to human health. Cytotoxicity usually is expressed as an estimation of the number of cells killed as a result of exposure to a particular concentration of a pollutant over a specified period of time.

Flume—an artificial trough carrying water or a natural narrow passageway for water, usually in a river.

The amount of water moving past a particular point is measured in a flume. These measurements are important in determining the total amount of a pollutant existent in a water body.

Free radical—a compound or element possessing one or more unpaired electrons.

Free radicals are extremely active and combine readily with certain substances. They are suspected to be involved in many processes harmful to human health, including carcinogenesis.

Furan compounds—derivatives of the ring compound, furan.

Furans are produced in coal technologies and are examined for their toxicological properties.

Infrared spectroscopy—a technique in which the measurement of the amount of absorption of infrared light is used to identify organic compounds.

This is a sophisticated technique which can be used to identify certain types of molecular groups and is useful in the identification and measurement of organic pollutants.

In vitro—a latin phrase used to indicate the existence of an artificial environment which is outside of a living organism, usually in a test tube.

In vitro tests are adaptable to replication, controlled experimentation, and unrestricted observation. These conditions are not easily obtainable in live animal testing.

In vivo—a latin phrase used to indicate a condition existent within a living organism.

In vivo studies are essential to ascertain how various pollutants affect the living organism as a whole.

Malignant tumor—a tumor that usually has the tendence to metastasize and, if untreated, often is fatal to the host organism.

This type of tumor is commonly referred to as a cancer.

Metastasis—the process whereby a malignant tumor releases cells which are carried within the blood or lymph system to other parts of the body where they implant and form new malignant tumors.

Microwave spectrography—a technique in which the measurement of the amount of absorption of microwave radiation is used to identify free radicals or metals which possess one or more unpaired electrons.

This is a new technique which has a high potential for use in the detection and measurement of low concentrations of potential pollutants.

Mutagenicity—the capability of a chemical or physical agent (mutagen) to induce mutations.

EPA has a strong interest in the identification, isolation, and elimination of mutagenic substances resulting from energy operations for the protection of human health.

Mutation—an inheritable change in the genetic code and thus the characteristics of an offspring as contrasted to the parent. This term may be applied to cells of a given type or to whole organisms.

Neoplasm—a new or abnormal growth.

This term is often, but mistakenly, restricted to malignant tumors. Neoplasms may originate from many causes. They may become cancerous as a result of stress from pollutants which stimulate neoplastic changes.

Neurophysiology—a science which relates to the functions, vital processes, and parts of the nervous system.

Many pollutants act in an insidious manner on the nervous system and their effects may not be observable until the damage is irreversible. A considerable effort is made to identify and control these pollutants.

NO_x—various oxides of nitrogen.

These compounds are released mostly as air emissions by various energy operations. Many are toxic and are a focus for research with regard to their environmental transport, fate, and effects, and to the technologies for their control.

Phenols—aromatic ring compounds which possess one or more hydroxyl radicals as the primary group.

Various energy technologies produce phenols as waste by-products, some of which are highly toxic.

Polycyclic aromatic compounds—aromatic compounds possessing many rings.

These compounds represent the largest and most potent class of carcinogens and represent a primary research effort in terms of pollution control.

Raman spectroscopy—the use of visible monochromatic light, usually laser light, to irradiate a sample for measurement of the quality of the scattered radiation.

This is a new technique which is advantageous with respect to infrared spectrography and other methods utilized for pollutant analysis in that it has a high sensitivity for the detection and measurement of inorganic materials dissolved in water.

SO_x—various oxides of sulfur.

These compounds are released mostly as air emissions by various energy operations. Many are corrosive and are harmful to human health when inhaled. The abatement of emissions of these substances is a main goal of the control technology research program.

Synergism—the simultaneous action of several compounds or agents so that their combined effect is greater than the sum of their individual effects.

Since specific pollutants generally are released in association with other pollutants, the effects of their combined action is a major area of research.

Teratogen—a substance capable of causing physical defects in the developing fetus (teratogeny or teratogenesis).

With an increasing number of women entering the work force, a problem of the incidence of birth defects caused by pollutants emanating from energy facilities is of major importance. Investigations are being conducted to characterize the nature and extent of the potential problem.

Toxicity—the state of being poisonous.

Many pollutants cause harmful effects which are observed within a short period of time. Others exhibit chronic toxicity wherein their effects are not readily observable. Toxicity usually is measured as the concentration of a pollutant required to produce a defined response within a specified period of time.

Tumor—a mass of tissue distinct from its surroundings and not found in the normal body. Tumors are generally classified as malignant or benign.

Tumorigenesis—the production of a benign or malignant tumor.

Weir—a low man-made impoundment usually constructed to divert water through an aperture designed to measure the rate of flow.