EPA-600/7-76-006

# FEDERAL INTERAGENCY ENERGY/ENVIRONMENT RESEARCH AND DEVELOPMENT PROGRAM-STATUS REPORT II

JUNE 1976

PREPARED BY
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# PREFACE

An essential part of achieving national energy self-sufficiency is to minimize the environmental costs accompanying accelerated domestic energy resource development and use. This report summarizes a Federal environmental research and development (R&D) program directed at understanding and minimizing these environmental costs. This program is based on the recommendations of several Federal interagency studies of the nation's energy and environmental R&D needs.

The report examines the role of the Environmental Protection Agency's Office of Energy, Minerals, and Industry (OEMI), a newly-established operation within EPA's Office of Research and Development, which is responsible for coordinating the implementation of the Federal Interagency Energy/Environment R&D program. This report is organized into the following three chapters:

CHAPTER ONE: INTRODUCTION AND OVERVIEW. This chapter examines the philosophy underlying the Agency's increased emphasis on energy-related environmental research and development. It analyzes OEMI's role as coordinator for the Federal Interagency Energy/Environment R&D Program in the context of several factors: EPA's experience in R&D and in research on environmental control technology, health and ecological effects, and pollutant identification and monitoring required to achieve the Agency's statutory responsibilities; the need for continuity in, and coordination of, Federal Environment/Energy R&D; the objectivity and balance that EPA can provide to the Energy Research and Development Administration's mission of expanding domestic energy supplies; implications of the R&D Program for the national goal of rapidly expanding near-term use of abundant domestic coal while meeting clean air standards; and the necessity for anticipatory environmental R&D to be conducted along with development of energy technologies so that there are no unnecessary delays in the commercial application of new energy sources.

Chapter One also outlines the historical basis of OEMI's formation, reviewing the December 1973 report on The Nation's Energy Future, the two interagency task force reports to the Office of Management and Budget (Report of the Interagency Working Group on Health and Environmental Effects of Energy Use and Final Report of the Interagency Working Group on Environmental Control Technology for Energy Systems), and the Energy/Environment R&D budget requests and authorizations for FY 1975 and FY 1976.

This chapter discusses the Federal Interagency R&D Program which evolved from the interagency reports and which involves seventeen Federal departments and agencies, and the program's planning and implementation structure. Designed to achieve general R&D continuity and avoid needless duplication, the interagency effort is being planned and coordinated by EPA, which is legally responsible for the disbursement, monitoring, and control of the funding for several hundred research projects.

CHAPTER TWO: PROCESSES AND EFFECTS PROGRAM. This chapter describes the FY 1975 and FY 1976 plans for research into pollutant characterization, health effects, ecological effects, transport (pollutant dissemination), and integrated technology assessment. Tasks already underway, including the interagency

agreements which have been developed jointly by EPA and the participating agencies, are outlined in this chapter.

CHAPTER THREE: ENVIRONMENTAL CONTROL TECHNOLOGY PROGRAM. This chapter describes the FY 1975 and FY 1976 plans for R&D on environmental control techniques in four general subcategories: fuel extraction and beneficiation, fossil fuel combustion, synthetic fuels and advanced systems, and conservation. Projects underway, including interagency agreements, are discussed.

# CHAPTER 1

# INTRODUCTION TO THE INTERAGENCY PROGRAM

GOALS OF INTERAGENCY ENERGY/ENVIRONMENT PROGRAM

- PROTECTION OF HEALTH AND OF THE ENVIRONMENT DURING ACCELERATED DEVELOPMENT AND USE OF DOMESTIC ENERGY SUPPLIES
- PREVENTION OF ENERGY DEVELOPMENT DELAYS CAUSED BY INADEQUATE ENVIRONMENTAL INFORMATION
- DEVELOPMENT OF COST-EFFECTIVE POLLUTION CONTROL TECHNOLOGIES
- ASSURANCE OF ENVIRONMENTAL BENEFIT OF ENERGY CONSERVATION ACTIVITIES
- PURSUIT OF HEALTH, WELFARE, ECOLOGICAL, AND SOCIAL GOALS
- PROMOTION OF ENERGY-RELATED ENVIRONMENTAL INFORMATION TRANSFER
- ANTICIPATION OF IMPACTS FROM, AND PROVISION OF ENVIRONMENTAL CONTROLS FOR, FUTURE ENERGY TECHNOLOGIES

# CHAPTER 1

# INTRODUCTION TO THE INTERAGENCY PROGRAM

## PURPOSE

As the nation strives to reduce its energy dependence, increased consideration of energy-related environmental problems arising from domestic energy resource development is required. Accelerated efforts to expand existing energy supplies and develop new energy sources must be accompanied by accelerated efforts to anticipate, plan for, and control the more serious adverse health and ecological effects resulting from rapid energy development. On the Federal level, this need has been recognized by the expansion of research and development programs and capabilities which are located in a number of departments and agencies. Centralized coordination of these programs is provided via the Federal Interagency Energy/Environment Research and Development Program 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 heavily involved in those energy-related environmental research efforts, including the development of pollution control technology, necessary to help meet its statutory responsibilities. In particular, the Agency's work is well established in the areas of flue gas desulfurization technology, energy recovery from municipal waste, advanced automotive power systems (this program has subsequently been transferred to the Energy Research and Development Administration), fluidized bed combustion of coal and 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 Federal Interagency Environment/Energy R&D Program. OEMI's primary goal is the creation of a sound basis for the development of clean energy sources. This goal includes 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 new and existing energy, industry, and mineral extraction systems.

The Interagency Program recognizes that continuity is crucial in a successful R&D program. Often, the "surge effect" of accelerated R&D in response to a rapidly emerging problem can lead to a lack of continuity and, hence, to less useful results. The nature of energy/environment research requires well-established programs so that long-range effects and unexpected problems or developments can be assessed adequately. In addition, 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 also reflects the fact that a sound environmental R&D program must be conducted in tandem with the evolving energy development programs placed under the general direction 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. However, 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 mission, on the other hand, is environmental protection, and its objective in this area is to enable ERDA's efforts to progress as rapidly as possible while maintaining national environmental goals. Through this division of effort there develops a healthy, creative tension between the two agencies to ensure well-supported planning and strategy decisions.

Congress was cognizant of these two complementary roles when it enacted the Energy Reorganization Act of 1974, which established ERDA and called on the directors of EPA and ERDA to formulate interagency agreements to promote cooperative Federal Energy/Environment R&D efforts. The diversity provided by Congress' direction should help to ensure balanced, objective, and carefully weighed judgments. Greater protection of the public interest resulting from such a balancing process should foster public trust and increase confidence in national energy and environmental policy decisions.

The philosophy behind OEMI's mission recognizes that timing is critical in the overall relationship between energy and environmental R&D. In general, efforts to expand use of domestic supplies will focus on the nation's two primary fuel resources--coal and nuclear energy. Through the 1970's and early 1980's, however, only coal use can be increased to an appreciable extent. This will occur chiefly through direct

combustion in power plant and industrial boilers, but only if technologies to control emissions of sulfur oxides and other pollutants are successful and are applied. Thus, Environment/Energy R&D on near-term coal use will center 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 to minimize the adverse environmental effects of direct coal combustion, 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), 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 key aspect of the OEMI program is anticipatory R&D. Many of the new energy technologies being investigated by ERDA 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.

For these reasons, the mid-term and long-term emphasis of the Environment/Energy 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 effects of an energy technology system is required before the system is implemented. While maintaining at an adequate level research necessary to support EPA's regulatory role (scrubbers, for example), the program will emphasize the prevention of environmentally adverse effects of new energy sources through greater understanding of general environmental processes. This work is beginning. It will expand in the future 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 DEVELOPMENT AND HISTORY

The Office of Energy, Minerals, and Industry has developed a five-year planning and implementation program based upon the goals stated in the presidentially-mandated report on The Nation's Energy Future (The Ray Report) and upon two interagency task force reports commissioned by the Office of Management and Budget to recommend how Federal R&D funds in the areas of 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 (and often

referred to as The Ray Report), was completed in December 1973. Drawing upon the efforts of 36 Federal departments and agencies as well as the private sector, it recommended a five-year, $10 billion energy research and development program to achieve national energy self-sufficiency by developing five resource areas: energy conservation, oil and gas, coal, nuclear, and advanced energy systems. 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 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 reduced the appropriation to $100 million. The interagency portion of the program is about $32 million. Part of the reduction is associated with direct appropriation to ERDA of $6 million of their "pass-through" allocation. Another part is associated with the full funding, in FY 1975, by EPA of two large flue gas desulfurizaton demonstrations.

## INTERAGENCY TASK FORCE REPORTS

Following 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 key 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.

HEALTH AND ENVIRONMENTAL EFFECTS OF ENERGY USE. This working 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 destintion (fate) in man and the environment. In addition, the group covered any physical and chemical transformation 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 was directed towards 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:
  (1) environmental research,
  (2) social and welfare effects,
  (3) total environmental impact,
  (4) cost/risk/benefit, and
  (5) implementation alternatives.

To help simplify planning, the two closely related interagency category areas of ecological effects and transport processes have been combined into a single broad program. For an explanation of how these functional areas fit into the overall planning structure, see the OEMI program description on pages 1-13 and 1-14 and in Chapter 2. The FY 1976 health and environmental effects program, totalling $41-million, follows essentially the same distribution pattern as the $53-million FY 1975 program.

ENVIRONMENTAL CONTROL TECHNOLOGY FOR ENERGY SYSTEMS. The interagency task force report on Federal R&D Programs for environmental control technology concentrated on the overall Federal effort in pollution control technology for energy systems, recommending 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 concentrated on the following nine programs, most of which relate to domestic coal and nuclear energy use.

- Energy resource extraction - The report examined 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 - The study examined processes for chemical and physical cleaning of coal to remove ash and sulfur prior to direct combustion.

- Flue Gas Cleaning - The report dealt at length with this area, since the major near-term priority item for the national Energy/Environment R&D Program is to complete demonstration of current generation flue gas desulfurization (FGD) systems and to advance the state of the art of regenerable (producing a useful byproduct) FGD systems. In addition to its emphasis on sulfur removal from flue gas, the report 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 Fuels - The report found that coal gasification and liquefaction technologies appear to be promising, but emphasize that little is now known about emissions and residuals released to the environment from the conversion process. The report concluded that appropriate control technology will have to be developed before commercial-scale operations can begin.

- Nuclear Fuel Cycle - The study determined that work is needed on nuclear waste control. It 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 - The report discussed disposal of waste heat from electric power plants, concluding that 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 - The report called for assessment of potential environmental effects of 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 coal use. Looking further into the future, it stressed that high priority should also be assigned to R&D on ways of using more coal such as physical/chemical cleaning and fluidized bed combustion. Because of the likelihood that successful commercial development of synthetic fuels would guarantee the utility of virtually all domestic coal, the report urged that early attention also 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.

Supporting the goal of minimizing the environmental costs of increased reliance on domestic fuels, priority has been given to environmental control technology R&D in the areas of coal extraction and beneficiation, fossil fuel combustion, synthetic fuels, and advanced systems and conservation. Well over 60 percent of all energy/environment control technology program funds are allocated for coal-related R&D in these four program areas.

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, they have also been adopted for portions of internal communications by several agencies, including EPA and ERDA. Details of EPA's program, including accomplishments planned for FY 1976 and beyond, both within the EPA and in other Federal agencies receiving OEMI pass-through funds, are contained in Chapter 3.

## INTERAGENCY PROGRAM PLANNING STRUCTURE

The Ray Report and the two interagency task force reports form the basis of the program undertaken by EPA's Office of Energy, Minerals, and Industry (OEMI). To implement the report's recommendations, OEMI has established a straightforward but comprehensive plan to ensure that the entire range of Federal Energy/Environment R&D is woven together into a manageable framework.

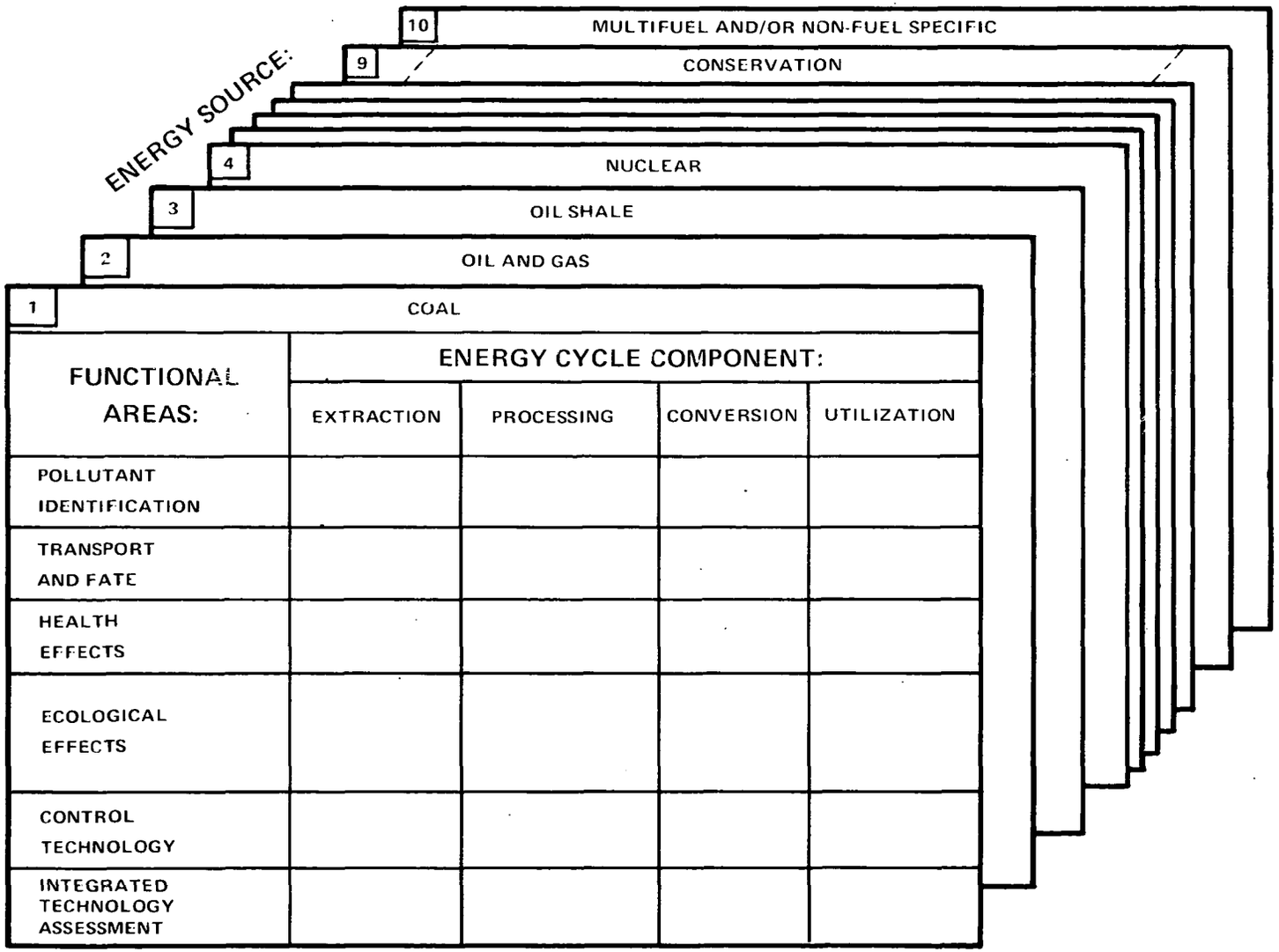
A multidimensional matrix is being employed to classify program content and resources. This format, depicted in Figure 1, provides both a means for classifying ongoing activities and a practical structure for program planning. The structure allows easy identification of the various elements of the program and is being used by OEMI, the EPA laboratories involved, and the other participating Federal agencies as the basis for the formal planning mechanism for energy-related environmental R&D projects supported by the Interagency Program.

An example of how this planning process works is shown in Figure 2. This figure illustrates typical environmental research areas for each stage of the fuel cycle for coal. It can be seen that 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 on the overlay. To illustrate, the ecological problems created by the surface mining of western coal require research into the revegetation of arid lands. Underground coal mining requires research into acid mine drainage. Coal cleaning, gasification, and liquefaction processes require research into waste disposal and treatment. Flue gas desulfurization systems require research into sludge stabilization and disposal and into advanced desulfurization technologies. Each of these environmental problems typifies areas of discrete research needed for a particular component of the coal energy cycle.

On the other hand, another benefit of specialized research is that many of the functional research areas permit information transfer among all fuel cycle components. For example, pollutant characterization studies are basic to the development of control technology for almost every component of the coal cycle.

To further illustrate the flexibility of this planning structure, Figure 3 shows how one major area of concern--western energy resource

FIGURE 1




INTERAGENCY PROGRAM PLANNING STRUCTURE

# TYPICAL ENVIRONMENTAL RESEARCH AREAS

- IDENTIFICATION & TREATMENT OF HAZARDOUS POLLUTANTS
- HEALTH EFFECTS OF HAZARDOUS POLLUTANTS
- WASTE DISPOSAL AND RECLAMATION
- RESOURCE RECOVERY

- 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

- ACID MINE DRAINAGE
- COAL MINING WASTE TREATMENT/DISPOSAL

- ATMOSPHERIC CHEMISTRY & TRANSPORT (ACID SULPHATE AEROSOL FORMATION)

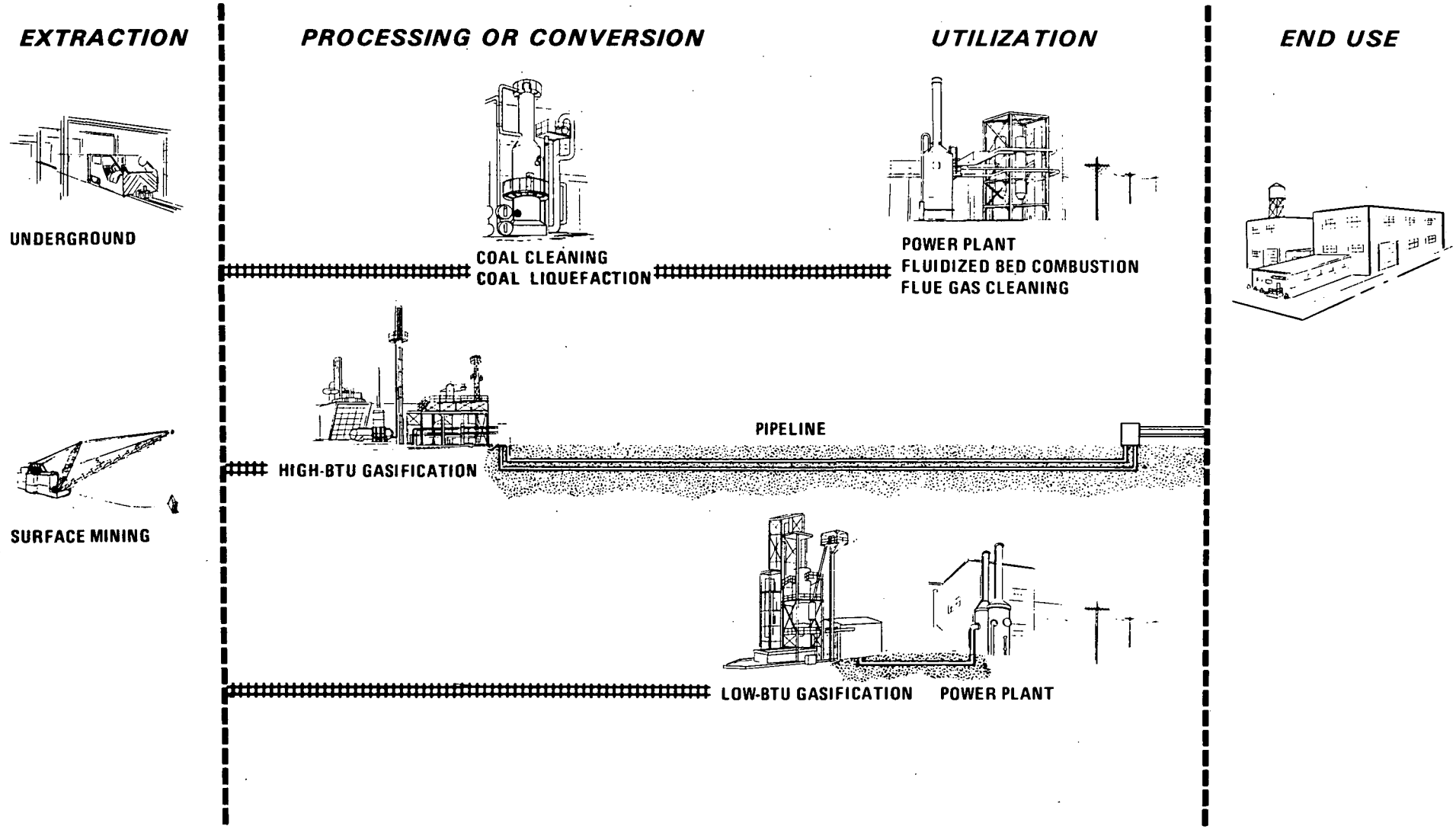
- IDENTIFY ENVIRONMENTAL EFFECTS OF INDUSTRIAL ENERGY CONSERVATION PROCESSES

- IDENTIFICATION & MEASUREMENT OF HAZARDOUS DISCHARGES
- WASTE TREATMENT/DISPOSAL
- RESOURCE RECOVERY (CHAR)

- REVEGETATION OF ARID LANDS
- DISRUPTION OF AQUIFERS AND NATURAL DRAINAGE CONTOURS
- POLLUTANT DISCHARGES AND EFFECTS
- SITE SELECTION
- SURFACE & GROUND WATER MONITORING

- HIGH TEMPERATURE GAS CLEAN UP
- IDENTIFICATION & MEASUREMENT OF HAZARDOUS DISCHARGES
- WASTE TREATMENT/DISPOSAL
- RESOURCE RECOVERY (CHAR)

# FIGURE 2
# COAL: TYPICAL FUEL CYCLE COMPONENTS



development--is both part of, and highlighted by, the Interagency Program category structure. This is a region-specific "cut" of the overall program. Other perspectives which could be easily chosen include fuel type (coal, oil, etc.), energy cycle (extraction, processing, etc.), technology (fluidized bed combustion, sulfur oxides control, etc.), and/or environmental concern (health effects, pollutant characterization, etc.). The information gained from the various research projects can thus be easily transferred among functional areas, cycle components, and energy sources, when appropriate, based on the relationships shown in the planning structure matrix (Figure 1).

OEMI's ROLE. This planning approach is being used by OEMI in its role as coordinator of the Federal 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 in terms of the interagency report recommendations. This process requires extensive consultation with field laboratories, Federal and private research organizations, and other EPA offices.

Step 2: After OEMI has identified a task, a short (two to four paragraphs) description (an Energy Objective Statement) is transmitted to the appropriate EPA laboratory or other agency for staff review in terms of current programs, experience, and potential for contribution.

Step 3: The participating laboratory responds with a concise description (Energy/Environment 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 in periodic interagency program reviews.

At OEMI headquarters, the Energy Coordination Staff implements the Energy R&D Program both within and outside of EPA. Its specific responsibilities include administration of the Interagency R&D Program as well as review and communication within the Office of Research & Development of technical reports resulting from these research efforts.

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

## SECTOR GROUPS COMMUNICATE

To identify new priority research needs and provide a major forum for information exchange, OEMI has established

"sector groups" for broad energy-related 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 group meets 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, and is now being applied to the $100 million FY 1976 program and the planning phases of the FY 1977 program. Alterations are being made as experience is gained. 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 STATUS

Since FY 1975, OEMI has planned, coordinated, and implemented the Federal Interagency Energy/Environment R&D Program, guided by the Ray and interagency task force reports mentioned earlier. By using the same program planning process for succeeding fiscal years, review to minimize duplication and needless overlap is facilitated, and possible deficiencies in the program are identified so that planning can close major gaps.

To date, OEMI has approved more than 140 accomplishment plans for the FY 1975 program, has issued approximately 80 objective statements for the FY 1976 program, and has approved 35 FY 1976 accomplishment plans using the fundamental planning concepts discussed earlier in this report. To summarize, OEMI is:

- Working toward the major national goal of reducing energy dependence through expanded and new use of domestic fuel 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 in terms of current efforts and future requirements

- Testing and refining the planning structure to assure that it meets the objectives of continuity, simplicity, logic, and effectiveness of implementation

- Using a five-step implementation process designed to facilitate program-oriented interjurisdictional communication and coordination

- Recognizing the critical timing of energy/environment R&D required to enable production and use of abundant domestic coal as

## FIGURE 3. WESTERN ENERGY RESOURCE DEVELOPMENT EFFORTS WITHIN INTERAGENCY PROGRAM R&D CATEGORIES

| Interagency Program Categories | Performing Agency: ENVIRONMENTAL PROTECTION AGENCY | ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION | U.S. DEPARTMENT OF AGRICULTURE |
|---|---|---|---|
| ENVIRONMENTAL CONTROL TECHNOLOGY: | RESOURCE EXTRACTION<br>• *Coal mining water quality*<br>• *Oil shale mining water quality* | RESOURCE EXTRACTION | RESOURCE EXTRACTION<br>• *Plant materials studies*<br>• *Control technology coal/ oil shale spoils effects*<br>• *Stabilization methods oil shale lands*<br>• *Revegetation technology* |
| | COAL CLEANING<br>• *Coal cleaning process development* | COAL CLEANING | |
| | FLUE GAS CLEANING<br>• *Low sulfur western coal in small boilers*<br>• *Electro static precipitator control of particulates* | FLUE GAS CLEANING | |
| | DIRECT COMBUSTION | DIRECT COMBUSTION | |
| | SYNTHETIC FUELS | SYNTHETIC FUELS | |
| | NUCLEAR<br>• *Uranium mill wastes studies - western*<br>• *Ground transport of buried wastes* | NUCLEAR<br>• *Uranium mill waste control* | |
| | THERMAL<br>• *Water conservation alternative - four corners sources*<br>• *Wet/dry cooling towers evaluation - western* | | |
| | ENERGY CONSERVATION | ENERGY CONSERVATION | |
| | ADVANCED SYSTEMS<br>• *Geothermal assessment & control technique* | | |
| HEALTH & ENVIRONMENTAL EFFECTS: | ECOLOGICAL TRANSPORT & FATE<br>• *Coal, oil shale effects, groundwater*<br>• *Transport & fate - fresh surface water* | ECOLOGICAL TRANSPORT & FATE<br>• *Trace pollution, coal combustion & processing* | |
| | ECOLOGICAL EFFECTS<br>• *Terrestrial/freshwater - colstrip*<br>• *Aerosol loading - Colstrip/ Four Corners* | ECOLOGICAL EFFECTS<br>• *Surface mine land reclamation* | ECOLOGICAL EFFECTS<br>• *Effects on biota - Montana, Wyoming* |
| | CHARACTERIZATION, MEASUREMENT & MONITORING<br>• *Air, water, groundwater monitoring*<br>• *Air, water monitoring* | CHARACTERIZATION, MEASUREMENT & MONITORING<br>• *Aerosols & particulate instrumentation - western coal* | |
| | HEALTH EFFECTS<br>• *Metabolic fate, toxicity - western fly ash* | HEALTH EFFECTS<br>• *Damage, repair, recovery coal, oil shale*<br>• *Kinetics & hazards, coal & oil shale*<br>• *Health effects - toxic agents* | |
| | INTEGRATED ASSESSMENT<br>• *Western resource/electric utility integrated assessment* | INTEGRATED ASSESSMENT<br>• *Cost-benefit methodology - western power* | INTEGRATED ASSESSMENT<br>• *Western coal/oil shale* |

Key

Interagency Program Categories - RESOURCE EXTRACTION

*Projects Related to Western Resource Development - Coal Mining Water Quality*

The Interagency Energy-Environmental Program provides a structure of R&D activities within which related research can be clearly identified from various perspectives. Such perspectives include fuel-orientation (coal, oil, etc.), fuel cycle (extraction, combustion, etc.), agency, environmental factors (health, ecological effects), technology (flue gas, desulfurization, etc.). *Highlighted on this chart is a region-oriented cut of the program as it addresses the crucial Western Energy* Resource Development issues. The tasks within the broad Interagency Categories indicated on this chart demonstrate the extent of this regionally oriented effort. These tasks are superimposed upon the overall planning structure (Interagency Categories) to provide an illustration of how the Interagency Program serves to coordinate research activities, across agencies and across program categories, to provide a comprehensive assessment of a particular problem area. All the Interagency Categories which are being addressed by the participating agencies as part of the Interagency Program are included. *Those which apply to Western Energy Resource Development are highlighted along with an indication of the type of work being performed. While this is only a partial listing of the entire Interagency Program, it does give a relatively complete overview of the western-related portion of the program.*

INTERAGENCY PROGRAM CATEGORIES NOT DIRECTLY APPLICABLE TO WESTERN RESOURCE DEVELOPMENT

ENVIRONMENTAL CONTROL TECHNOLOGY:

- FLUE GAS CLEANING (TVA, BOM)
- DIRECT COMBUSTION (TVA)
- THERMAL (TVA)

WESTERN SPECIFIC PROJECTS OF OTHER AGENCIES

HEALTH & ENVIRONMENTAL EFFECTS:

ECOLOGICAL TRANSPORT & FATE (NOAA)

ECOLOGICAL EFFECTS

- *Characterize aerosols colstrip* (NOAA)
- *Forum on fish & wildlife, Upper Colorado* (FWS)
- *Ecosystems research, Upper Missouri* (FWS)
- *Water quality needs, Colorado, Missouri* (FWS)
- *Human population impacts, Southwest* (FWS)
- *Survey of unallocated water, Western* (FWS)

CHARACTERIZATION, MEASUREMENT & MONITORING

- *Aerosol correlation Denver, Four Corners* (NOAA)
- *Meteorological prediction of air quality* (NOAA)
- *Standard reference materials - oil shale, geothermal, uranium* (NBS)
- *Instrumentation development, water quality, deep aquifers* (USGS)
- *Groundwater & surface water monitor network* (USGS)
- *Remote sensing ASVT demonstration* (NASA)

HEALTH EFFECTS

- *Hazards to workers, oil shale - Rifle, Colorado* (NIOSH)

HEALTH & ENVIRONMENTAL EFFECTS:

TRANSPORT PROCESSES (TVA)

ECOLOGICAL EFFECTS (TVA)

CHARACTERIZATION, MEASUREMENT & MONITORING (TVA)

HEALTH (NIEHS)

INTEGRATED ASSESSMENT (TVA, HUD)

| | |
|---|---|
| BOM | - Bureau of Mines |
| FWS | - Fish and Wildlife Service |
| HUD | - Housing and Urban Development |
| NASA | - National Aeronautics and Space Administration |
| NBS | - National Bureau of Standards |
| NIOSH | - National Institute of Occupational Safety and Health |
| NOAA | - National Oceanographic and Atmospheric Administration |
| TVA | - Tennessee Valley Authority |
| USGS | - US Geological Survey |

quickly and as cleanly as possible. To this end, the bulk of the $234 million FY 1975 and FY 1976 Interagency Program resources are slated to support near- and mid-term environmentally compatable coal use.

- Implementing the Processes and Effects Program plans, which are also directed chiefly towards facilitating the use of coal as well as towards energy conservation. The tasks assigned under this program stress research on health effects of coal conversion, atmospheric chemistry, and pollutant transport related to direct coal combustion, and improved air monitoring and measurement for coal use. Figures 4 and 5 indicate funding for the processes and effects program as distributed over the major functional areas of concern. Priority in each area, again, is given to facilitating coal use while protecting environmental quality. The integrated technology assessment programs underway involve western energy resource development, the electrical utility sector, and advanced fossil fuels. Figure 5 also indicates the FY 1976 program funding shift in priorities which is described in the following chapter.

FIGURE 4

# FY 1975
# INTERAGENCY ENERGY/ENVIRONMENT FUNDING DISTRIBUTED BY PROGRAM

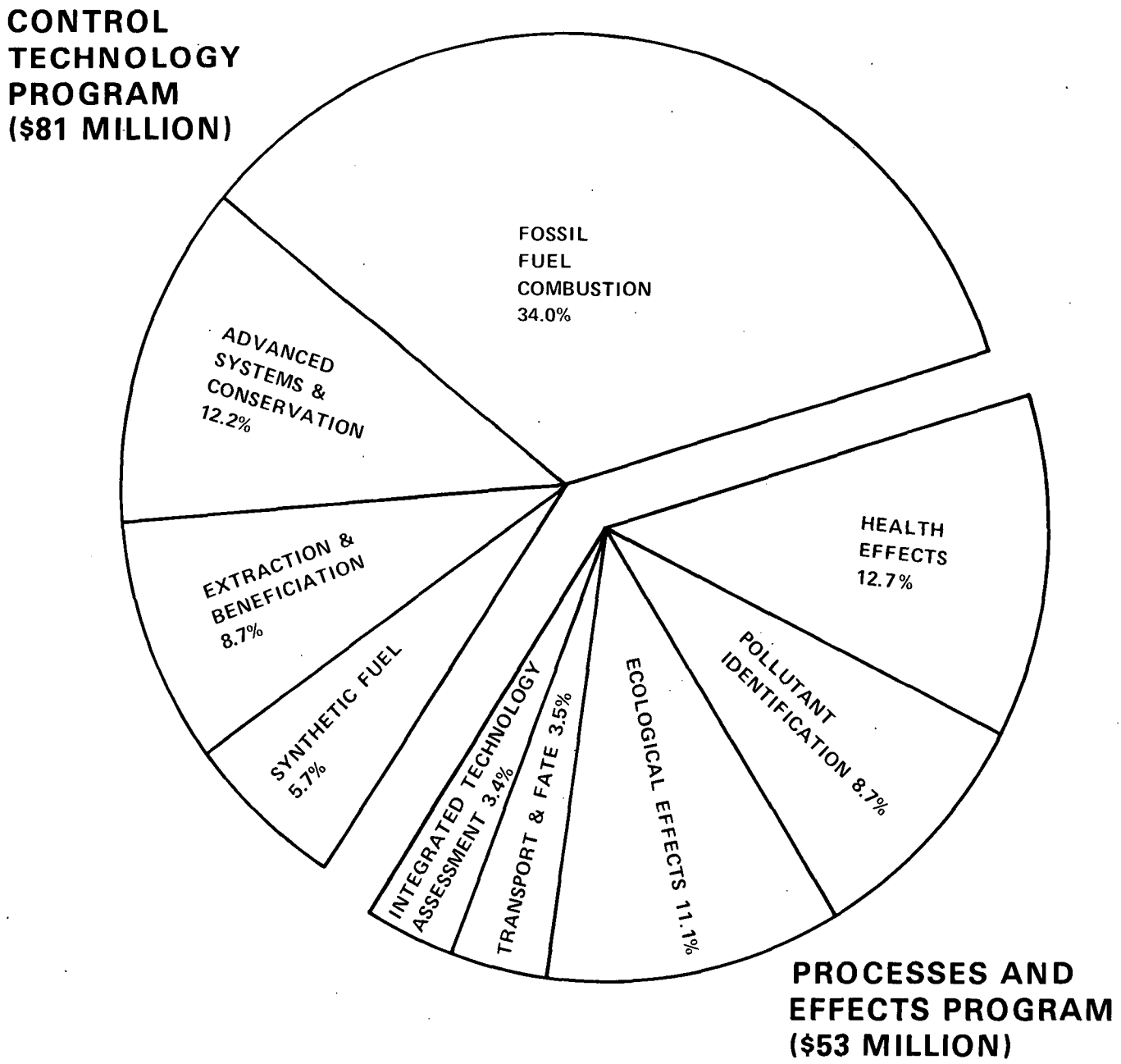
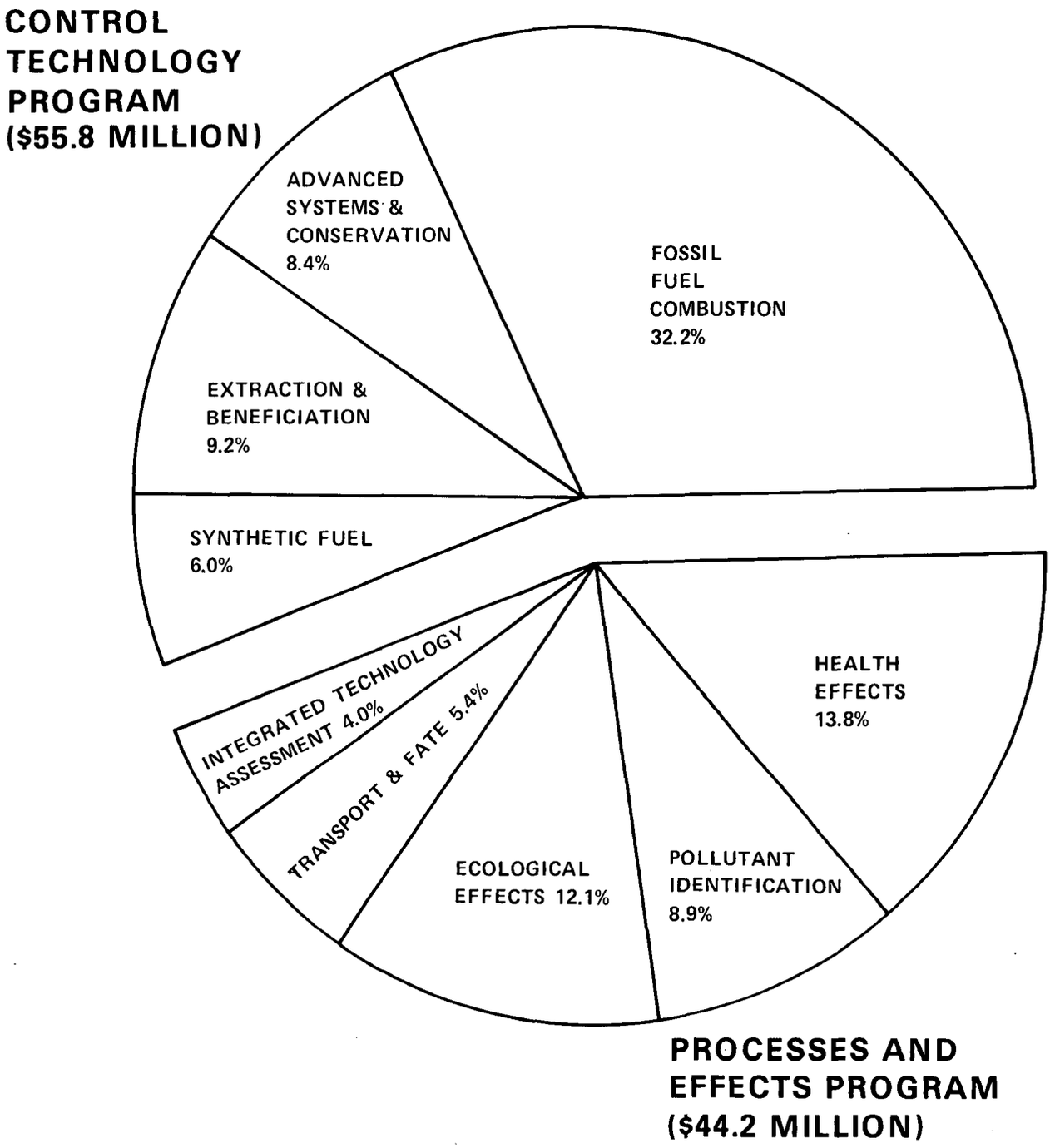


FIGURE 5

# FY 1976
# INTERAGENCY ENERGY/ENVIRONMENT FUNDING DISTRIBUTED BY PROGRAM



# CHAPTER 2

# PROCESSES AND EFFECTS PROGRAM

## CHAPTER 2

## PROCESSES AND EFFECTS PROGRAM

The energy-related interagency environmental processes and effects program is designed to determine the environmental effects of each stage of each energy source's fuel cycle (extraction, processing, conversion, utilization and multicomponent). The goal of the program is to compile and assess fundamental data so that, as energy production increases, measures can be taken early enough to protect both the ecosystem and human health, welfare, and social goals.

The Office of Energy, Minerals, and Industry has carried out the detailed planning and initiated the implementation of a $53 million FY 1975 processes and effects program and is now completing the detailed planning of the $44 million FY 1976 program. As recommended by the interagency task force, the criteria for determining research priorities were:

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

The program is divided into four functional areas: (1) Pollutant Identification: Characterization, Measurement and Monitoring; (2) Ecological Effects and Transport Processes; (3) Health Effects; and (4) Integrated Technology Assessment. Salient aspects of the processes and effects program are described in the following pages. EPA's part in the interagency program is presented first, followed by the projects supported by interagency program funds and implemented by other agencies.

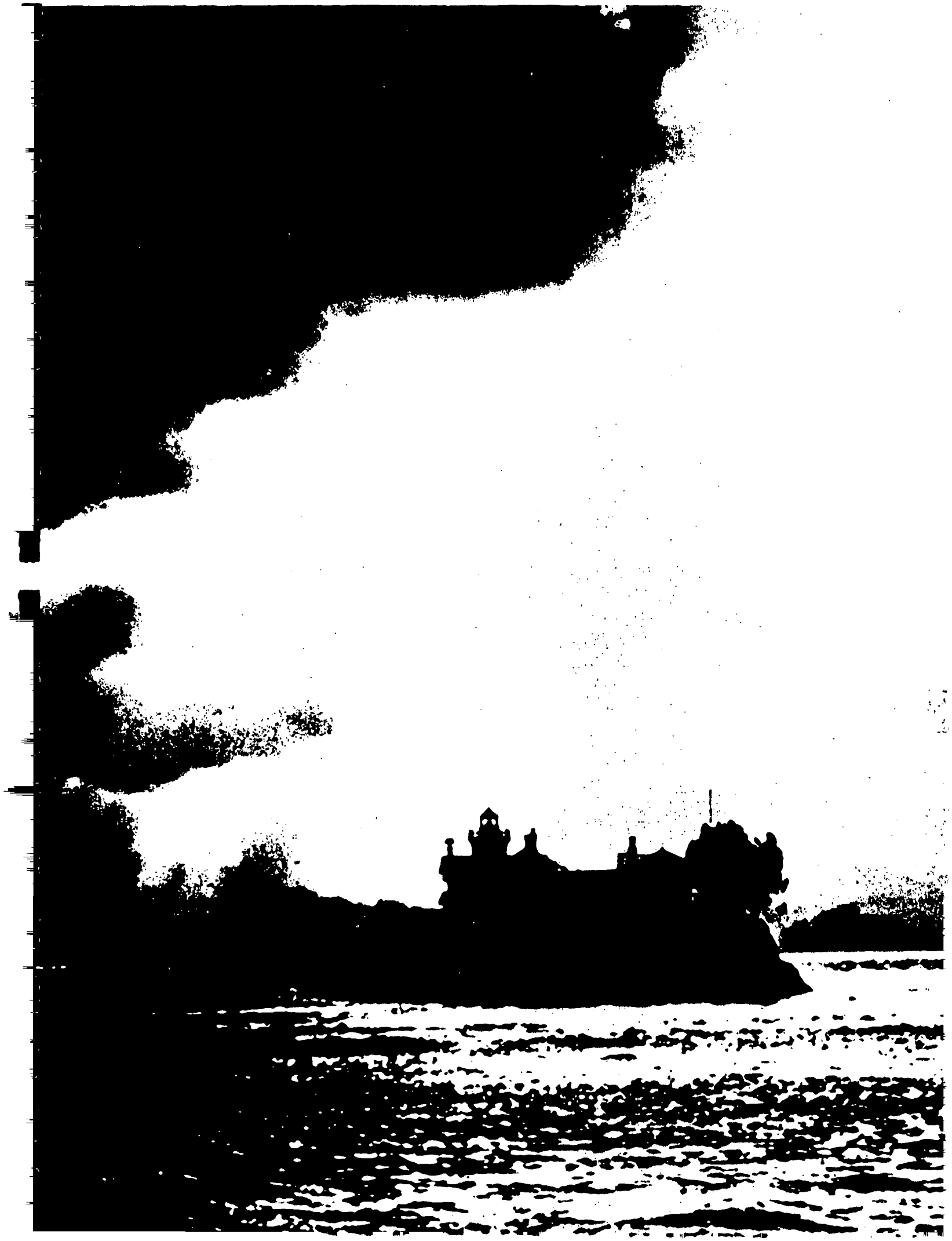
Figure 6 illustrates FY 1975 funding distribution of the $53 million budget among the aforementioned five functional areas in the processes and effects program. To help simplify planning, the two closely related areas of transport processes and ecological effects have been combined into a single broad program. Figure 7 shows the equivalent distribution for the FY 1976 $41.3 million budget.

### POLLUTANT IDENTIFICATION: CHARACTERIZATION, MEASUREMENT AND MONITORING

This research area involves identifying and quantifying pollutants related to energy production or use, as well as improving pollution measurement capabilities. In this area, the program has two objectives: to accelerate development of new and improved sampling and analysis methods for energy-related pollutants and to identify, measure and monitor pollutants associated with rapid implementation of national energy goals, particularly those related to coal conversion processes. In pursuit of these objectives, research tasks on pollutant identification have been initiated by EPA laboratories and by other Federal agencies via the Interagency Program.

#### POLLUTANT IDENTIFICATION PROJECTS WITHIN EPA

- Develop methods and instruments to measure energy-related pollutants, including characterization of pollutants introduced by new energy technologies at specific



western energy resource sites. Special attention is given to pollutants from coal gasification and liquefaction plants, coal mining operations, oil shale processing and geothermal energy projects. The research products will be used to develop and assess treatment processes, identify toxic wastes, establish monitoring programs and develop identification and measurement techniques.

- Demonstrate the effectiveness of overhead remote sensing and photographic techniques to monitor environmental aspects of energy related activities. Emphasis is on coal mining, oil and gas extraction and oil shale extraction. Results will include data on impacts of mining and oil and gas extraction on land use, surface disruption, surface water, vegetation and visibility. Geographical emphasis is on the western U.S. with the objective of establishing a baseline for key parameters in this region, especially, Four Corners area, oil shale region (Colorado, Utah, Wyoming and Northern Great Plains).

- Provide direct technical assistance, application of R&D, development of methods and quality assurance for major process measurements in areas of the OEMI program where highly specialized expertise or proprietary devices are needed. Specific outputs include: technical manuals for sampling and analysis of reduced inorganic species and organic substances, measurement systems for high temperature, high pressure sampling, and a technical manual for fugitive emissions sampling.

- Analyze ash, sludge, slag and effluent water from energy related activities for toxic substances including trace elements. Identify specific chemical form of toxic substances, particularly hydrocarbon compounds, carcinogenic organics, inorganic compounds and toxic elements, as well as their compounds. Emphasis is on low level concentration of toxic substances and their paths into the environment.

- Develop compact, portable air samplers as personal dosimeters for use in measuring health effects in humans. Include in this development the necessary laboratory instruments for analysis of pollutants collected in the samplers. Pollutants of interest include: size fractionated particles, $SO_2$, trace metals and particulate sulfur.

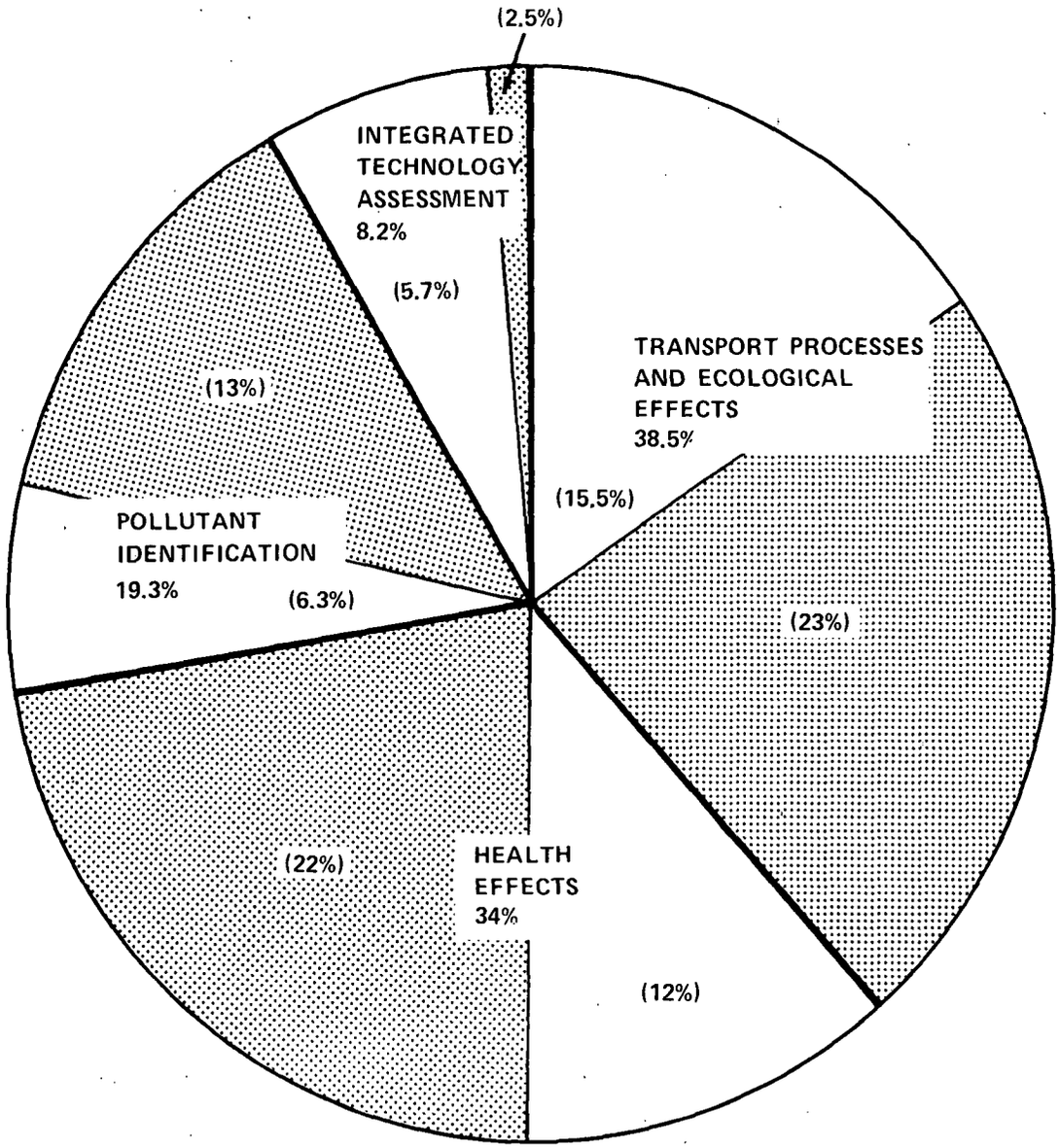
- Provide technical measurement support for the Energy Research and Development Administration (ERDA) to assess the impact of environmental radioactive contamination from inactive uranium mill tailings sites at Lakeview, Oregon, Salt Lake City, Utah, and Shiprock, New Mexico.

- Conduct research on the development of techniques to monitor the output of nuclear power facilities. This research will be carried out in the vicinity of newly operating nuclear plants with the objective of developing techniques applicable to new reactors including breeder reactors. Emphasis is on plutonium monitoring techniques.

POLLUTANT IDENTIFICATION PROJECTS IN OTHER AGENCIES. Interagency agreements formulated between EPA's OEMI and other Federal agencies in the pollutant identification area include the following projects:

FIGURE 6

# FY 1975
# HEALTH AND ENVIRONMENTAL EFFECTS OF ENERGY USE



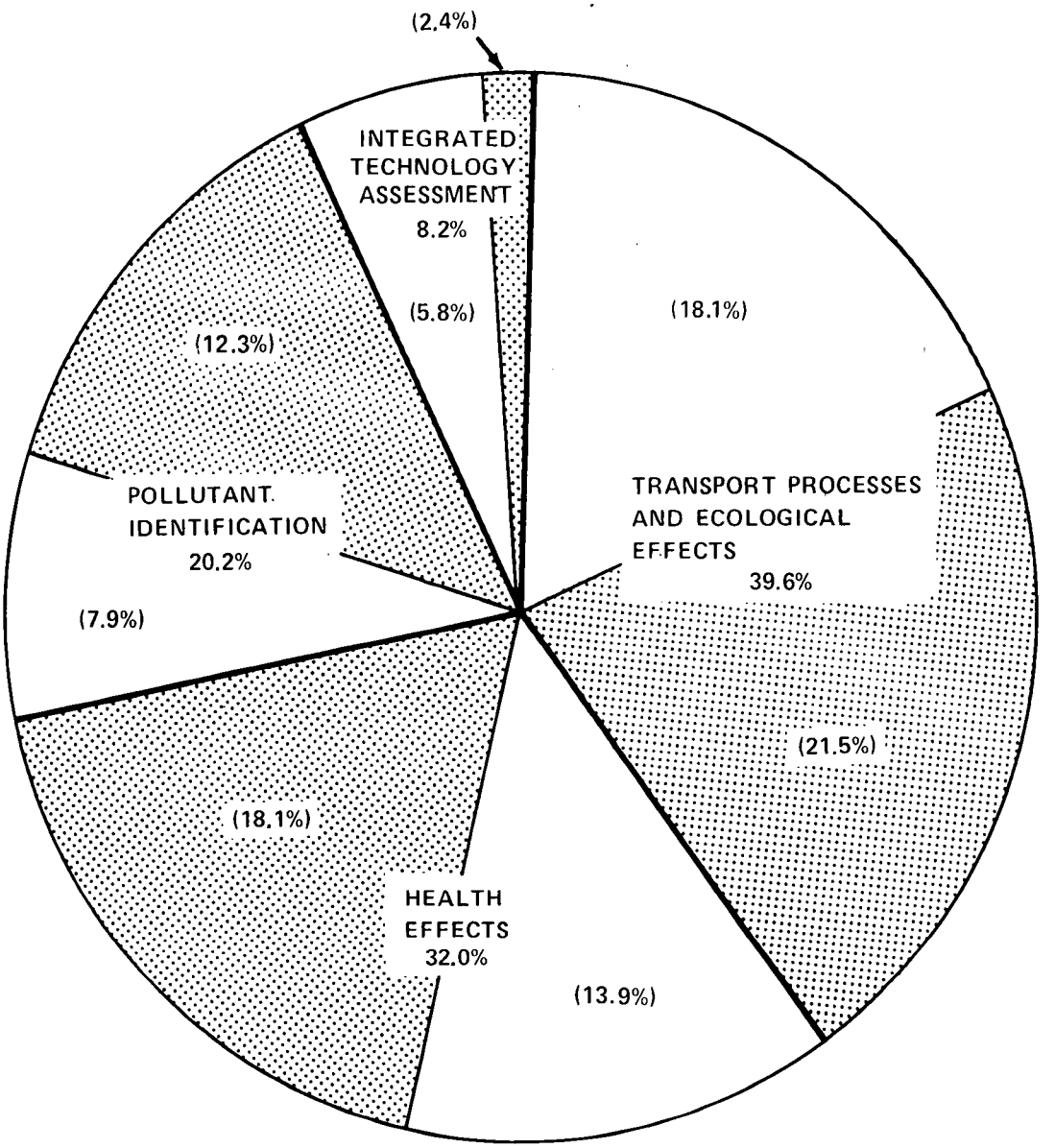

INTERAGENCY R&D PROGRAM ($53 MILLION)

EPA

INTERAGENCY

FIGURE 7

# FY 1976
# HEALTH AND ENVIRONMENTAL EFFECTS OF ENERGY USE




INTERAGENCY
R&D PROGRAM ($41.3 MILLION)*
* DOES NOT INCLUDE $2.9 MILLION IN PROGRAM MANAGEMENT FUNDS.

EPA

INTERAGENCY

- Provide surface and groundwater monitoring techniques on the effects of coal mining from actual and potential mining sites across the United States. Selected sites are in the vicinity of Black Mesa, Arizona, Centralia, Washington, Tennessee (strip mining), Southeastern Ohio, Southeastern Illinois, Indiana (strip mining), and Alaskan coal reserves. [Performing agency: Department of Interior (DOI), U.S. Geological Survey, Water Resources Division]

- Develop instrumentation for sampling, measuring and monitoring water pollutants and sediments related to energy development, with emphasis on petrochemicals and coal mining. (DOI, U.S. Geological Survey, Water Resources Division)

- Groundwater monitoring to develop geochemical, chemical and physical data regarding energy development in EPA's Region VIII, which includes the Northern Great Plains area. Selected sites for study are in the vicinity of Piceance Creek Basin, Colorado; Hayden and Craig, Colorado (shallow aquifer system); Tongue River, Decker, Montana; Fort Union Formation between the Yellowstone and Missouri Rivers in Montana; Gascayne Mine, Southwest North Dakota; the oil shale area of Utah; coal areas of Utah; and the Gillette, Wyoming coal basin. (DOI, U.S. Geological Survey, Water Resources Division)

- Surface water monitoring to develop data and a monitoring network for areas in EPA's Region VIII which are or will be subject to energy development. The planned surface water monitoring network will traverse the Hayden-Craig areas of Northwest Colorado; oil shale areas of Colorado; Yellowstone River Basin; Missouri River Basic, North Dakota; energy development areas in Utah, and the Southern and Western areas east of the Continental Divide. (DOI, U.S. Geological Survey, Water Resources Division)

- Develop advanced instrumentation and methods for the measurement and analysis of air pollutants resulting from energy developments, including atmospheric aerosols. Stress is on the development of reliable and economical field instrumentation which will be tested through associated field studies. [Energy Research and Development Administration (ERDA)]

- Develop instrumentation and methods for the measurement and analysis of energy-related effluents including organics in water, stressing carcinogens--and specific chemical analysis. (ERDA)

- Develop instrumentation and methods for analysis of pollutants in water effluents from energy-related sources. Emphasis is on potential carcinogens and multi-element analyses from oil shale, oil refining, and geothermal processes. (ERDA)

- Develop instrumentation needed for health effects research, with emphasis on energy-related aerosols and particulates as they directly affect health. The need is most pronounced for development of techniques to determine the difference between fine particulates from eastern and western coal, to accurately reproduce aerosols of a specific size, to determine the presence of

carcinogenic organics and trace metals in each particle size fraction, and for the precise identification of aerosols during test exposures. (ERDA)

- Develop instruments and techniques for measurement of environmental radiation created by emissions from facilities associated with any part of the nuclear fuel cycle. Emphasis will be on instrumentation systems capable of making quantitative distinctions between radioactive iodine released in gaseous emissions and in liquid effluents. (ERDA)

- Develop standard reference materials for energy-related air pollutants such as sulfur dioxide, fine particulates and nitrogen oxides to support the Interagency Program's energy-related air monitoring efforts. Simultaneously, work will proceed on development of air instrumentation for sulfur pollution. [National Bureau of Standards (NBS)]

- Develop standard reference materials for energy-related pollutants in estuarine and fresh water, with emphasis on heavy metals, petroleum drilling and refining, and oil shale products. This work supports the integrated efforts to identify and control environmental assaults stemming from western energy development. Work will also proceed on development of water pollutant instrumentation for pollutants such as hydrocarbons from power plants and effluents from oil shale and petroleum operations. (NBS)

- Develop standard reference materials for radiological pollutants associated with nuclear energy sources and production. (NBS)

- Develop instruments and methods to characterize, measure and monitor hazardous agents in the energy-related workplace. Emphasis is on personal direct reading monitors to take worker breathing zone samples and detect the presence of toxic chemical substances, portable microwave gas monitors sensitive enough to selectively detect several toxic or hazardous trace contaminants in the air, personal gas detection monitors for cold environments for use along the Trans-Alaskan Pipeline, and personal monitors to measure concentrations of fibrous aerosols, such as fibrous glass, which will be used more extensively due to energy conservation measures. [National Institute of Occupational Safety and Health (NIOSH)]

- Improve procedures to isolate and identify water-borne pollutants associated with steam-fired electric power generation. Emphasis will be on the study of acrolein, heavy metals such as lead and cadmium, comparison of digestion techniques for suspended and dissolved metals, arsenic, asbestos and sulfates. [Tennessee Valley Authority (TVA)]

- Develop an integrated approach for nuclear power plant radiological surveillance, including the development of uniform quality assurance procedures. (TVA)

- Develop remote sensing instruments to detect and monitor the visible effects of $SO_2$ emissions from coal-fired electric power plants on vegetation. Low and high altitude flight tests are being conducted from NASA-supplied aircraft to determine the best instruments for detecting $SO_2$ effects on Southern pine

and deciduous hardwoods and soybeans. (TVA, with NASA collaboration)

- Identify the best instruments and techniques for measurement and monitoring of pollutants in the ambient air from coal-fired electric power plants. Emphasis is on suspended particulates which are analyzed for concentration, size distribution and elemental and chemical composition, e.g., sulfates, nitrates, trace metals, etc. This work supports ongoing and planned studies on the health impacts of suspended particulates since recent research indicates that the elemental and chemical composition of fine particulates changes with particle size. (TVA)

- Develop water sampling system to measure and monitor currents, which might interfere with energy-related equipment, and hydrocarbons on the water surface. [Department of Commerce (DOC), National Oceanographic and Atmospheric Administration (NOAA), National Ocean Survey - Engineering Development Laboratory]

- Develop techniques to forecast concentrations and movement of ocean oil spills using wind, tides, waves, ocean floor topography, and currents as indicators. (DOC, NOAA, National Weather Service - Techniques Development Laboratory)

- Develop an automated instrument system for shipboard monitoring of atmospheric and surface oceanographic data. (DOC, NOAA, National Weather Service - Systems Development Office)

- Develop standardized and intercalibrated techniques for marine monitoring. (DOC, NOAA, National Oceanographic Instrumentation Center)

- Develop lidar techniques for measuring particulate pollutants from power plants and their atmospheric transport and dispersion. (DOC, NOAA)

- Provide meteorological assistance to the EPA in describing and predicting air quality in the western United States from existing or proposed energy resource activities. (DOC, NOAA)

- Provide technical support for overhead (aircraft and satellite) remote sensing monitoring to establish current (baseline) environmental quality of areas in the western United States expected to be impacted by energy development. [National Aeronautics and Space Administration (NASA)]

- Develop and evaluate instruments for remote and *in situ* sensing of power plant plumes. (NASA)

- Develop and operate a data management system for interagency energy-related marine and meteorological programs. (DOC, NOAA, Environmental Data Service)

## TRANSPORT PROCESSES AND ECOLOGICAL EFFECTS

This section includes what were considered in the interagency report as two separate functional areas--ecological effects, and transport and fate. Because transport is so closely related to ecosystem effects, combining them into one overall discussion is a logical extension of their functional role.

TRANSPORT PROCESSES. This area refers to the transmission by air, water and soil of pollutants and heat emitted from energy operations from their sources to their destination (fate) in man and the environment. Additionally, it covers any physical and chemical changes in the pollutants occurring during transport.

Technologies under study in the near-term are coal combustion, coal extraction, oil shale, and coal gasification and liquefaction. Emphasis in air transport research is on conversion of sulfur and nitrogen oxides--chiefly from coal burning power plants--to sulfates and nitrates. Transport of photochemical oxidants from various sources is also emphasized. The terrestrial aspects of this research focus on the ecological impact of oxidants and toxic metals from coal and oil-shale mining processes. Some major Interagency Program projects now underway in transport processes are listed below:

TRANSPORT PROCESSES PROJECTS WITHIN EPA

- Evaluate existing ground-water models needed to predict changes in water flow and quality caused by mining operations. In addition, establish background conditions prior to mining and assess the mineralogy of disturbed and undisturbed overburden from surface mining operations. The results of this research effort will be used by regulatory agencies and industry in attempting to develop western coal resources with minimum damage to the environment.

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

- Determine the transport and final destination (fate) in the ecosystem (both atmospheric and surface and ground-waters) of single pollutants and combinations of pollutants associated with energy development. Stress is placed on: transformation of $SO_2$ and $NO_x$ to sulfates and nitrates in plumes from coal-fired power plants, establishing a data base to construct an air quality simulation model for complex terrains, formation and composition of aerosols from energy technology--including the contribution of various energy sources to aerosol concentrations in the ambient air.

- Determine transformation products formed by the interaction of cooling tower plumes and stack gases and their transport and fate in the environment. Determine the effects of heat and vapor discharge from large scale cooling systems on local weather such as near field fogging and icing. Determine longer range regional effects which might be associated with source intensification such as power parks.

- Determine, in marine and estuarine waters, the origins, loads, transport pathways, transfer rates and fates of organic and inorganic pollutants. The focus is on metals resulting from oil and gas extraction at offshore wells, oil refinery waste discharges and effluents from coastal and offshore power plants.

- Determine the fate of pollutants released by pipeline spills in the arctic environment. Perform a problem assessment of the potential nature and extent of the impact on water quality and aquatic and terrestial biota from pipeline spills in the arctic environment. Considerations include transport pathways, transformations, rates and fate of pollutants, as well as heat transfers.

- Develop primary data regarding the transport and probable fate of energy-related pollutants in fresh surface water. Five specific pollutants are being studied in an attempt to develop estimates of their pathways and fate in aquatic systems.

TRANSPORT PROCESSES PROJECTS WITHIN OTHER AGENCIES. Interagency agreements formulated between OEMI and the participating agencies include the following projects in the area of transport processes:

- Characterize energy-related atmospheric particulates at Colstrip, Montana. (DOC, NOAA)

- Evaluate environmental impacts of fuel extraction and transport in arctic and subarctic regions, with special emphasis on oil spills, including persistence, rate of decomposition in arctic soil, and its effects on organisms dependent upon arctic ponds for survival. Another aspect of the Alaskan oil program is an evaluation of the impact of pipeline construction on aquatic habitats. (ERDA)

- Determine and assess transport processes and environmental effects of coal strip-mining activties in the Northern Great Plains, the Midwest, Appalachia, and the Southwest. Included is data accumulation and coordination, followup studies on previously reclaimed land, and research on revegetation, soil stabilization, and hydrology. Another task under this project is evaluation of the physical effects of mining operations, such as soil erosion, exposure of toxic substances and ground water disturbance. Other aspects of the project are land management and use, which includes information for modeling before and after mining, effects of mining and power plant complexes on potential land use and productivity, alternative of vegative cover, and evaluation of conventional land reclamation techniques. (ERDA)

- Determine the transport and effects of trace contaminants from coal combustion and processing in the environment. Stress is on information regarding the persistence of these contaminants in the terrestrial and fresh-water ecosystem, the rates at which trace elements are reintroduced to the geochemical pool, and the biological effects of their introduction into the biosphere. The project will include studies of soil absorption of pollutant gases, evaluation of fuel water disposal techniques, and development of biological indicators to predict ecological effects of energy-related pollutants. (ERDA)

- Determine the thermal transport and ecological effects of cooling systems. An important part of this project is an evaluation of the weather modification

effects of cooling towers for nuclear power plants. The remainder of the project assesses the ecological effects of pollutants from cooling water systems, including the effects on aquatic organisms and selected marine ecosystems of chlorine, ozone and temperature. (ERDA)

- Determine the transport and fate of pollutants from offshore power plants, concentrating on biocides and anticorrosion agents routinely used in cooling systems, and particulates--including sediments--dispersed during construction. The project is being conducted off the Atlantic Coast and the western coast of Puerto Rico. (ERDA)

- Develop procedures for predicting atmospheric physical and chemical transformation of emissions from coal-fired electric power plants and for predicting the atmospheric transport and dispersion of pollutants in various situations, such as complex terrain and coastal areas. Chemical composition and physical behavior of power plant plumes after wet stack gas scrubbing is being studied, with emphasis on rates of conversion of $SO_2$ to sulfuric acid and sulfate and on conversion of NO and $NO_2$ to nitrates. (TVA)

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

- Improve theoretical computer models of thermal effluent dispersion and fluid mechanics at critical locations in streams and reservoirs. (TVA)

- Develop baseline information for use in evaluating potential effects of coal-fired electric power plant emissions on terrestrial ecosystems. Emphasis is on sulfur oxides and nitrogen oxides emissions in terms of existing data, baseline needs, dose-response relationships, and transfer and fate. (TVA)

- Identify the fate and ecological effects of atmospheric emissions from cooling systems on terrestrial habitats. Emphasis is on emissions from mechanical and natural draft cooling towers and cooling lakes. (TVA)

- Determine the fate and environmental effects of toxic metals and petroleum hydrocarbons on marine ecosystems and organisms. (DOC, NOAA)

- Determine chemical and physical characteristics of airborne pollutants from power plants. Criteria will be developed to assess their effect on clouds, precipitation, weather modification and local radiation. (DOC, NOAA)

ECOLOGICAL EFFECTS OF ENERGY SYSTEMS. This area addresses the environmental aspects of watershed (freshwater), marine (ocean) and terrestrial ecosystems. Near-term watershed studies concentrate on coal development and extraction, oil shale, and coal gasification and liquefaction. Similarly, near-term marine research is to establish background contaminant levels in both ocean-dwelling organisms and their habitats. Research will focus on a study of one major eastern United States coastal area, where deepwater ports and oil rigs may be located, in order to develop baseline data for determining the effects on marine life of deepwater ports, petroleum

extraction and conversion operations, and electric power plants.

ECOLOGICAL EFFECTS PROJECTS WITHIN EPA

- Determine the acute and chronic toxicological effects on freshwater organisms and resultant ecosystem impacts of organic and inorganic pollutants and complex effluents released by coal and oil shale extraction and conversion process. Identify gaps in analytical techniques and data required to complete the necessary baseline information for evaluating the potential effects of coal and oil shale extraction on freshwater ecosystems. Evaluate existing ecosystem models for predicting the impact of energy extraction and conversion activities on freshwater ecosystems and identify requirements for further development.

- Determine the effects on marine ecosystems of wastes, heat and biocides from coastal and offshore power plants. Field investigations will be conducted in the Chesapeake Bay area in order to identify some of the major pollutants--particularly halogenated organic compounds--formed in saline power plant cooling waters. In addition, the effects of chemicals from power plant cooling water effluents on certain marine organisms --such as decapod crustaceans and mollusks--are to be studied.

- Determine the immediate and long-term effects of waste heat in surface waters of the Great Lakes Basin on aquatic species and community populations.

- Determine the effects of energy-related thermal pollution in combination with other pollutant stresses on freshwater, marine/estuarine and terrestrial organisms and ecosystems.

- For selected western arid and grassland species, determine the immediate and long-term dose-response relationships for single pollutants and combinations of pollutants released by western coal and oil shale extraction and conversion and coal utilization. Pollutants include $SO_x$, $NO_x$, particulates and trace metals. Determine metabolic and biochemical mechanisms and lethal and chronic toxicity levels. Develop biological indices using microcosm, greenhouse and field studies. Evaluate existing ecosystem models for predicting the impact of energy extraction, conversion and utilization activities on terrestrial ecosystems and identify requirements for further development.

- Develop models--for predictive purposes--to assess the impact of pollutants on natural fish population patterns.

- Establish a major facility to conduct large-scale simulation studies of various ecosystems in order to determine the impact of pollutants from petroleum extraction, refineries and fossil fuel use. An independent advisory panel of U.S. scientists will be consulted in planning the simulation facility, which is expected to provide immediately useful answers on the relationships between ecosystem response and heretofore traditional bioassays in order to support regulatory and planning activities.

- Determine the toxicity to near shore marine organisms of petrochemicals and energy-related

organic solvents from offshore energy activities and ocean dumping.

ECOLOGICAL EFFECTS PROJECTS WITHIN OTHER AGENCIES. In addition, the following interagency agreements have been formulated in the area of ecological effects of energy systems:

- Develop and implement a rapid, reliable and economic method of identifying and characterizing wildlife habitat in areas affected by coal development. Emphasis is on food, cover, breeding and other critical requirements for maintenance of wildlife species. [U.S. Fish and Wildlife Service (FWS) Office of Biological Services]

- Evaluate the physiological, toxicological and ecological effects of oil on birds, specifically ducks. The project is assessing the effects of oil on reproduction and survival. It is developing a chemical methodology for analyzing duck tissues for oil. Initial studies on sea birds are planned. (U.S. FWS)

- Develop methodology and characterize major coastal ecosystems, with emphasis on fish and wildlife affected by offshore oil and gas development. The project focus is on Southwest Louisiana, Puget Sound and the coast of Georgia. (U.S. FWS, Office of Biological Services)

- Conduct a forum to identify impacts on the quantity and quality of western waters and the specific fish and wildlife problems and research needs resulting from energy development in the Upper Colorado River Basin. (U.S. FWS, Office of Biological Services)

- Conduct conference on research needs regarding effects of energy development on water and associated ecosystems in the Upper River Basin. (U.S. FWS, Office of Biological Services)

- Determine water quantity needs of fish and wildlife in the Upper Colorado and Upper Missouri River Basins. The project is to establish in-stream flow requirements necessary to maintain the viability of all the fish and wildlife species present at specific locations. (U.S. FWS, Office of Biological Services)

- Determine baseline concentrations, transport and biological effects of organic and inorganic pollutants released in coastal waters as a result of offshore oil drilling and refinery operations. Specific studies are to be made on transport and dispersal of wastes from oil refineries in freshwater (Lake Michigan) and estuarine waters (Puerto Rico) and in sites along the Pacific coast (Santa Barbara and Puget Sound). (ERDA)

- Determine the effects on marine ecosystems of toxic agents associated with non-nuclear energy technologies. Particular emphasis is on transport, accumulation and excretion of heavy metals, hydrocarbons and pesticides on marine organisms and mammals inhabiting both cold and warm waters. In addition, analysis is being made of carcinogenic effects of petroleum hydrocarbons on marine and estuarine organisms. [National Institutes of Environmental Health Sciences (NIEHS)]

- Determine the effectiveness of land treatment programs in restoring the ecological balance

of a watershed disturbed by toxic spoils after coal strip mining. Evaluate the rate and degree of recovery of such a system following intensive remedial land treatment. (TVA)

- Develop baseline information on thermal impacts on freshwater shellfish, insects, and other biota in order to assess environmental stress. Recommend intake designs for condenser cooling water systems of steam electric power plants which would most effectively prevent entrainment of zooplankton. (TVA)

- Investigate and assess strip mine drainage water quality, with special emphasis on trace inorganics in acid mine drainage. Include an evaluation of wastewater treatment and reclamation processes. (TVA)

- Determine to what extent anthropod pests, chiefly mosquitoes, are breeding in coal strip mine pools. Focus is on age of pools, physical, chemical and biological characteristics, and evaluation of control methods. (TVA)

- Assess environmental impacts of strip mining in the Northern Great Plains, including related airborne pollutants. Emphasize water quality as it relates to forest, range and freshwater ecosystems. Evaluate technologies for redepositing and stabilizing mine spoils in terms of maintaining water quality at acceptable levels for aquatic organisms and wildlife. (Department of Agriculture, U.S. Forest Service)

- Determine existing environmental status of Northern Puget Sound and the Strait of Juan de Fuca in order to characterize, monitor, and predict pollutant impacts from adjacent refineries. (DOC, NOAA)

- Determine effects of revegetation and reclamation of land areas distributed by mining. Include development of a reclamation plan before initiation of mining operations to characterize properties of spoils and overburden material and to recommend soil and plant management practices, evaluation of the quantity of water leaving the mined land areas, use of reclaimed land for production of specialty or economically important crops such as buckwheat, alfalfa, clovers, and grasses, and evaluation of strip mine reclamation practices on the nutritional quality of crops grown on treated soil material. (Department of Agriculture, Agricultural Research Service)

- Describe existing ecosystem in active oil fields near Galveston, Texas, in order to determine changes in a natural marine ecosystem due to an oil field. An oil spill trajectory model capable of predicting the path and ultimate fate of a spill for particular conditions (wind, tides, currents, temperatures) will be developed. (DOC, NOAA)

- Determine the effect of mine spoils and pollutants on native vegetation in semiarid regions. (Department of Agriculture, Cooperative State Research Service)

- Assess and model the effects of surface mining methods, spoil characteristic and reclamation on surface and subsurface hydrology, with particular emphasis

on crops and tree growth. Conduct experiments with fast-growing trees to determine the economic feasibility of wood crops on mine spoils. (Department of Agriculture, Cooperative State Research Service)

## HEALTH EFFECTS

The health effects program examines possible carcinogenic mutagenic, teratogenic and respiratory effects on humans from increased energy production. New information about previously unanticipated pollutants related to fossil fuel combustion and their effects receives particular attention. Listed below are salient Interagency Program energy-related health effects program projects already underway:

### HEALTH EFFECTS PROJECTS WITHIN EPA

- Examine human exposure to aerosol pollutants from coal conversion and/or utilization. Develop instrumentation for measuring aerosol pollutants. Subsequent to implementation of measurement techniques, begin to determine health effects in communities where major pollutant emissions are expected to change greatly due to coal conversion or utilization. Examine exposure to pollutants such as sulfates, nitrates, and trace metals in terms of behavioral, physiologic, and metabolic effects. Special attention will be given to certain high-risk populations: asthmatics, high-risk patients in a metropolitan area (Chicago), communities in immediate proximity to a new coal-fired power plant before and during operation of the plant, communities in the immediate vicinity of a new coal gasification plant before and during operation of the plant, and populations with long-term exposure to emissions from coal combustion.

- Assess the effects on human health of exposure to various energy-related hazardous substances in the air, land, and water. Emphasis will be on pollutants from coal, oil shale, and synthetic fuel technologies. These substances are assessed singly and in combination. Studies address health effects of exposure to heavy metals--including nickel, cadmium, lead, arsenic, chromium, mercury, manganese, and vanadium--as well as toxic organic chemicals released from fuel combustion and conversion processes and present in water. Stress is on the toxicological, biological, genetic and other biomedical aspects of subchronic and chronic exposures to these substances.

- Determine the human health hazards of exposure to organic chemicals which reach man through the food chain of the marine environment.

- Determine, under controlled experimental conditions, human exposure-effects relationships. Research will assess the influence on the human cardiopulmonary system of sulfuric acid mist exposure, both alone and in combination with other environmental influences (such as oxidants). In order to conduct this research, a clinical exposure laboratory is being developed.

- Develop and apply certain indicators to determine biological damage from exposure to pollutants related to energy development.

Emphasis is on comparing the harmful effects of various gases and particulates--NO and $NO_2$, nitrates, and sulfuric acid--alone and combined with various known carcinogens (with the possibility of nitrosamine development). In addition, research will analyze whether the presence of environmental pollutants--such as fibrous amphibole, asbestos and fine particles--has a carcinogenic effect combined with effluents from coal gasification, liquefaction, and shale oil development. Other areas of research include an assessment of the effects of respirable particles, gases and mists to determine pulmonary irritation (using donkeys and bronchial casts of donkeys and man), the influence of inhalation of acid aerosols, sulfuric acid mist, $SO_3$, $HNO_3$, and particles on the production of chronic lung disease (using rats, guinea pigs, and primates), and the cytotoxicity of selected sulfates, including a determination of the effect of sulfuric acid and inhaled particles on a host's defense system against pulmonary infection.

- Evaluate health effects of exposure to indoor pollutants related to energy conversation measures in homes and offices. Research efforts focus on identifying health effects of indoor emission sources as well as pollutant infiltration in homes and offices subject to stringent energy conservation measures. Subsequently, the most hazardous pollutants will be determined in a priority order. In addition, specific attention will be focused on the health effects from $NO_2$, CO, and certain hydrocarbons.

- Identify the hazards to human health of chronic, low-level exposure to $^{85}Kr$ and $^{3}H$ related to nuclear energy production. Rats are used to assess the $^{85}Kr$ skin cancer dose-effect, dose-rate response. In addition, guinea pigs and rats are used to evaluate the effects of acute and chronic exposure to $^{85}Kr$ on lung function. Finally, the behavioral and neurophysiologic effects of chronic, low-level exposure to lead and tritium are being examined.

HEALTH EFFECTS RESEARCH WITHIN OTHER AGENCIES. The following projects, funded through the Interagency Program, are also underway as part of the energy-related health effects program.

- Identify carcinogenic, mutagenic, teratogenic and physiologically or metabolically toxic agents related to coal and oil shale extraction, conversion or utilization. This broad project uses existing and new biological screening and testing systems to identify the potentially most toxic agents, which will then be further tested in experimental animals to confirm the biological hazard. Resultant information will be used in assessing and predicting risks to man in both the occupational and general environment. (ERDA)

- Develop more sensitive and rapid indicators to determine damage to man from toxic agents associated with the fuel cycle for coal and oil shale. (ERDA)

- Determine movement--incorporation, metabolism, deposition and retention--in mammals of hazardous agents associated with coal and oil shale processes. Early work addresses inhalation as the

route of entry, but later projects will assess entry via the skin or gastrointestinal tract. (ERDA)

- Evaluate the mutagenic and teratogenic effects of different doses and combinations of biologically active agents associated with fossil fuel processes, especially hydrocarbons and trace and heavy metals. Mammalian studies will be conducted to determine the dose-effect relationships for normal, susceptible and stressed populations. (ERDA)

- Evaluate the short- and long-term hazards of exposure of normal, susceptible and stressed populations to different levels and combinations of biologically active agents associated with coal and oil shale processes, such as $NO_2$, $SO_2$, CO and fly ash. Analysis will focus on the dose-effect relationship for inhalation of gaseous and particulate pollutants from these processes in order to obtain information on respiratory and cardiovascular dysfunction. (ERDA)

- Evaluate the short- and long-term effects on various populations--normal, susceptible, stressed--of exposure to different levels and combinations of biologically active agents associated with coal and oil shale processes. The dose-effect relationship for carcinogenicity will be emphasized. (ERDA)

- Determine the fundamental molecular and cellular damage and repair processes in biological systems exposed to hazardous agents, chiefly toxic trace metals and hydrocarbons, associated with coal and oil shale processes. Emphasis will be on the capability of living human and animal cells to repair molecular lesions. (ERDA)

- Determine mammalian tissue repair processes after damage from exposure to energy-related pollutants. In addition, the project will attempt to develop methods to counteract cellular injury from such exposure or to remove the hazardous agents from exposed individuals. Research will focus on evaluating both the sensitivity of those mammalian tissues whose function is normally maintained by high cell turnover and replacement efficiency, such as the lining of the lungs and intestines, and interference with the cell replacement process as a function of exposure to doses of hazardous agents replaced in fossil fuel processes. (ERDA)

- Develop physiological indicators to measure genetic damage to man from toxic agents associated with non-nuclear energy technologies. Emphasis will be given to tests designed to identify and quantify a variety of toxic agents. (NIEHS)

- Determine how non-nuclear energy-related toxic agents are incorporated, metabolized, deposited and removed from mammals. Attempts will be made to correlate laboratory animal and human clinical data in order to predict toxic effects in humans due to exposure to hydrocarbons from coal and oil shale processes. (NIEHS)

- Characterize the processes involved in transfer of non-nuclear energy-related toxic agents from particulates to body tissues and fluids in mammals. The relationship between particle size and

chemical composition to deposition sites, persistence and removal rates will be emphasized. Initial studies will concentrate on lead, cadmium, nickel and benzopyrene in respirable aerosols. (NIEHS)

- Determine dose-response relationships for biochemical and toxic effects of energy-related agents from non-nuclear processes. Major organ toxicity will be assessed as well as predictive clinical signs and reversible toxic lesions. This project should assist in correlation of laboratory animal and human toxicity data and development of improved predictive toxicity tests. (NIEHS)

- Determine dose-effect relationships for mutagenic agents related to non-nuclear energy processes. Mutation tests on selected laboratory animals with proven sensitivity will be used to assess time-dose relationships. An additional aspect of this project will be compilation and critical evaluation of all existing data on mutagenicity of energy-related pollutants. (NIEHS)

- Develop and test models and concepts to extrapolate cellular and animal data to man for low dose risk estimates from all energy-related toxic agents. (NIEHS)

- Identify cellular damage from toxic agents associated with non-nuclear energy processes. Included in this project is a study to assess the effect of environmental pollutants on non-respiratory lung functions, such as its ability to modify a number of circulating vasoactive chemicals. (NIEHS)

- Determine the relationship of metabolism and fate and the toxicology of particulates and organic compounds as they affect workers associated with coal technologies. (NIOSH)

- Identify and evaluate occupational health problems relating to extraction, processing, and utilization of energy resources, and energy conservation. Areas for study include mortality of former oil shale workers and epidemiological studies of workers dealing with insulation materials, coal liquefaction and gasification, sulfates, coal-fired steam generating plants, etc. The project should result in recommendations for improved work practices or for exposure levels deemed safe for various employment periods. (NIOSH)

- Determine dose-effect relationships for nonlethal levels of some energy-related toxic pollutants which produce temporary or permanent changes in mental or physiological performance. (NIOSH)

- Develop and test engineering controls and work practices to protect workers from the effects of hazardous agents in the energy fuel cycle. (NIOSH)

## INTEGRATED TECHNOLOGY ASSESSMENT

Performing the crucial role of relating the outputs of each program area into a comprehensive whole, integrated technology assessment uses research results from all the other functional areas--pollutant identification, ecological effects and transport processes, health effects and control technology (as described in Chapter 3. Other

factors, such as socio-economic impacts, are included in the technology assessment process. The development of comprehensive environmental protection standards for energy-related activities will be based on coordinating information received under this program. These assessments include analyses of a specific component of a fuel source cycle as well as of all components for a particular source. Integrated technology assessments will also be performed on a large scale across several energy sources in order to provide an information base for broad policy decisions which must be addressed on an interagency basis. Four major tasks are currently underway in EPA's integrated technology assessment program:

- Develop new methods and adapt existing methods of integrating energy-related environment research information with relevent socio-economic factors in order to develop environmental policies to cope with new energy technologies and expanding resource development. Special emphasis will be given to the use of existant research on technology currently implemented by the Office of Technology Assessment, the Energy Research and Development Administration, the National Science Foundation, and other Federal agencies as well as by the private sector--in a methodology that can be used by Federal agencies in their decisionmaking functions.

- Assess the current state of knowledge about fine particulate/aerosol emissions, atmospheric chemistry and transport, and health and ecological effects. This assessment will determine the best strategies for reduction of ambient concentrations in a manner most protective of public health and welfare. A review will be conducted of the adequacy of present research efforts in the light of these strategies.

- Conduct Integrated Technology Assessments (ITA's) to cope with the broad problems associated with regional energy development and emerging energy technologies. There are currently two major ITA's dealing with western energy resource development and electric utilities. The objective of the regional ITA is to assess the environmental, social, and economic costs and benefits associated with various levels of development--and with relevant environmental controls--in terms of alternative energy resource development scenarios. The objective of the technology-oriented ITA is to determine the most effective environment controls necessary, as well as to identify the means for implementing these controls. Finally, each ITA will evaluate the ongoing and planned research program relevant to its concern and make recommendations for possible improvement. The western energy resource development and electric utility ITA's are underway. Other possible areas for study include: petroleum and natural gas production in Outer Continental Shelf areas, selected synthetic fuel conversion processes operating with varying levels of environmental controls, Ohio River Basin development as the coal conversion center for the central and eastern U.S., massive implementation of energy conservation measures, geothermal energy development and total impacts of surface and underground coal extraction techniques in all of the nation's coal areas.

- Utilize models and data for environmental assessment of energy supply/demand alternatives. Included in this effort is a modification of the Strategic Environmental Assessment System (SEAS) programming to assess the impact of alternate fuel trajectory mixes.

The interagency projects included in the integrated technology assessment program are:

- Determine and evaluate the economic, social and cultural effects of expanded coal and oil shale development, with particular emphasis on western development. The studies will focus on the impacts on employment, income and population, agriculture, non-metropolitan areas, rural people, communities and industries, the costs and techniques of reclamation, and local government finances and services. (Department of Agriculture, Economic Research Service)

- Assessment of human population growth related to energy development in the southwestern United States. Particular attention will be devoted to "new towns," impacts on wildlife in selected residential development and ecological situations, and extrapolation of results to encompass the entire Southwest with concommitant policy and institutional suggestions. (U.S. FWS, Office of Biological Services)

- Survey the extent and location of unallocated water in the eleven western states by specific location within each drainage. (U.S. FWS, Office of Biological Services)

- Historical summary and analysis of environmental aspects of the Trans-Alaska Pipeline. Emphasis will be given to both governmental and private institutions established to meet the environmental requirements of the pipeline. (U.S. FWS, Office of Biological Services)

- Set the value for fish and wildlife in each area of potential energy development. Current and potential status of fish and wildlife will be set, and waters in these areas will be ranked according to value in fish and wildlife terms. (U.S. FWS, Office of Biological Services)

- Coordinate the design of a national network for environmental research and development information. The specific objective of this project is to improve national use of existing facilities. (ERDA)

- Develop an economic projection model to assist in assessing an area's sensitivity to various national economic parameters; to quantify the impacts on population, the labor force, employment, etc. of an incremental expansion to the energy generating system; and to provide a macroeconomic data base on a regional level to support site specific analyses. (TVA)

- Develop a model--in conjunction with the regional economic simulation model described above--to predict the residual output of a power system on a plant-by-plant basis. The model will be capable of providing data for detailed dispersion models for evaluation of power system expansion. (TVA)

- Determine the energy, economic and social impacts of energy conservation measures for characteristic residences in ten geographical areas. (Department of Housing and Urban Development, Program Development Research)

- Integrated assessment of the mixed-oxide fuel cycle (recycling of plutonium in light water reactors) as the basis for comparison with other nuclear fuel cycles and equivalent non-nuclear electric power. Consideration will be given to semi-quantitative estimates of major uncertainties such as ecological effects of the entire fuel cycle, and to estimates of variations in population exposure to effluents in order to make a cost/risk/benefit analysis. (ERDA)

- Develop and demonstrate use of computer graphics for environmental analyses of single and combined nuclear, fossil, and hydroelectric energy generating systems. The demonstration should use both site-specific and regional applications of the computer graphics employing large data bases with a broad range of planning variables. Combined use of the three models on which TVA is working should provide rapid information for planning, siting and operating a regional energy system. (TVA)

# CHAPTER 3

# ENVIRONMENTAL CONTROL TECHNOLOGY PROGRAM

## CHAPTER 3

## ENVIRONMENTAL CONTROL TECHNOLOGY PROGRAM

The Office of Energy, Minerals, and Industry has initiated the implementation of an $81 million FY 1975 program based upon the interagency task force report on Environmental Control Technology for Energy Systems described in Chapter 1, and is now completing the process of giving final approval to the interagency plans for the $57 million FY 1976 program. In support of a streamlined planning process, the nine program categories examined by the task force working group have been simplified, by function, into four major subchapters--Extraction and Beneficiation, Fossil Fuel Combustion, Synthetic Fuels, and Advanced Systems and Conservation. These changes are illustrated below, with the Interagency Task Force categories on the left mapped into the new, functionally-oriented planning areas on the right.

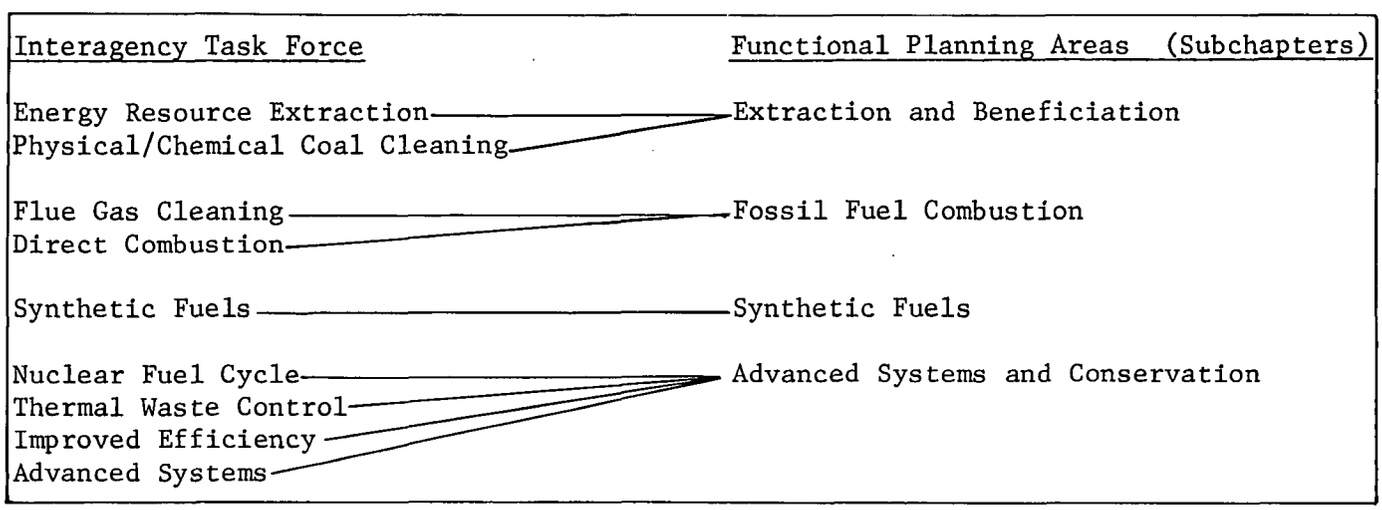
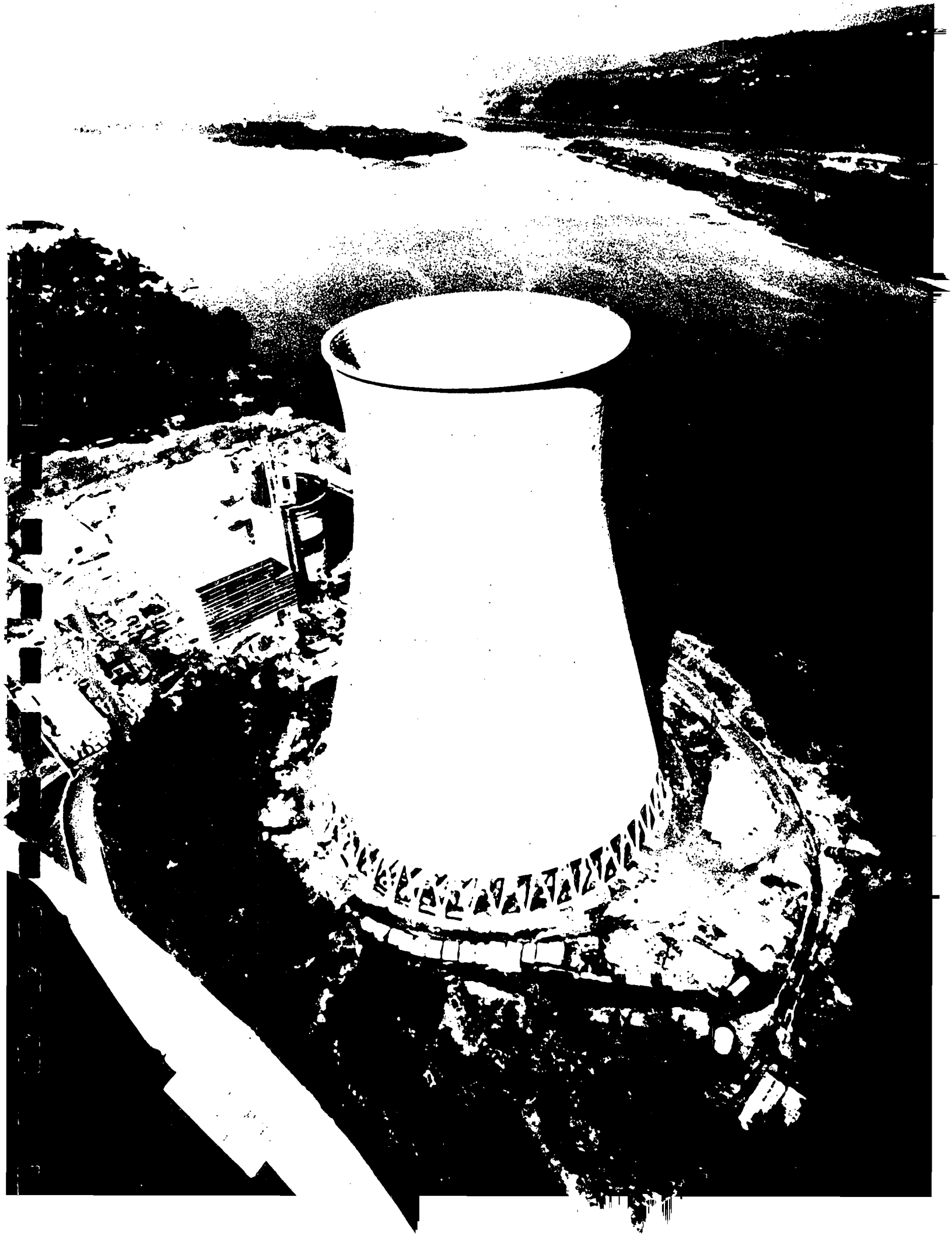



Figure 8 shows proportional distribution of FY 1975 funding allocations for the $81 million control technology budget.

As illustrated, the nine categories originally used by the task force have been telescoped into the four new program areas. The importance of R&D to ensure environmentally sound near-term coal development and use is evident; nearly 75 percent of FY 1975 control technology funds were allocated for research in coal or coal-related areas. Figure 9 shows the comparable funding distribution for the FY 1976 program.

As can be seen from the two figures, the $55.8 million FY 1976 control technology program, relative to FY 1975, reflects a considerable shift of emphasis within major program areas. For instance, within the fossil fuel combustion area, resources are being shifted away from flue gas desulfurization (FGD). This is due to the fact that the FY 1975 funds supported two major FGD demonstration projects. These projects should adequately demonstrate proven FGD technology in both the regenerable and the



non-regenerable areas. Emphasis in FY 1976 shifts toward $NO_x$ control technology, especially combined ($NO_x$, $SO_x$) systems, and toward fluidized bed combustion and synthetic fuels. Emphasis on $NO_x$ control for stationary sources is increasing in order to adjust for the relaxation of the $NO_x$ automotive standards. Both fluidized bed combustion and synthetic fuels environmental research and development are being increased due to the probability that these technologies will see widespread use in the U.S. over the midterm period.

Details of the Interagency Program including accomplishments planned for FY 1976 and beyond, both within the EPA and in other Federal agencies receiving Interagency funds, follow:

## EXTRACTION AND BENEFICIATION

The overall objectives of this program are to enable a rapid increase in extraction of domestic energy resources and to enable these energy sources to be utilized effectively in an environmentally compatible manner. This subchapter is divided into the two Interagency Program areas--resource extraction and physical/chemical coal cleaning.

RESOURCE EXTRACTION. The resource extraction program assesses potential environmental problems and control methods for underground and surface coal mining, oil shale extraction, and exploration for and recovery of domestic inland and offshore oil and gas. The chief goal of this program is to provide data and analysis to assure that commercial extraction operations can be conducted with adequate land reclamation and minimal damage to water quality and supply. Offshore oil and gas efforts focus on projecting pollutant discharges, assessing control technologies, and ensuring the protection and restoration of ocean shorelines. Problems of western surface coal and oil shale mining are receiving particular attention because of both the profound impact such mining may have on arid lands and the enormous potential energy reserves in the West. The program examines problems of revegetating arid mine land in the West, and the impact on ground water of disruption of natural drainage contours and of aquifers in the coal seams. Program efforts also focus on problems of underground coal mining such as acid mine drainage and methods for closing down abandoned mines.

Portions of the overall program are being carried out with assistance from and in coordination with other agencies, including the Bureau of Mines and the Department of Agriculture.

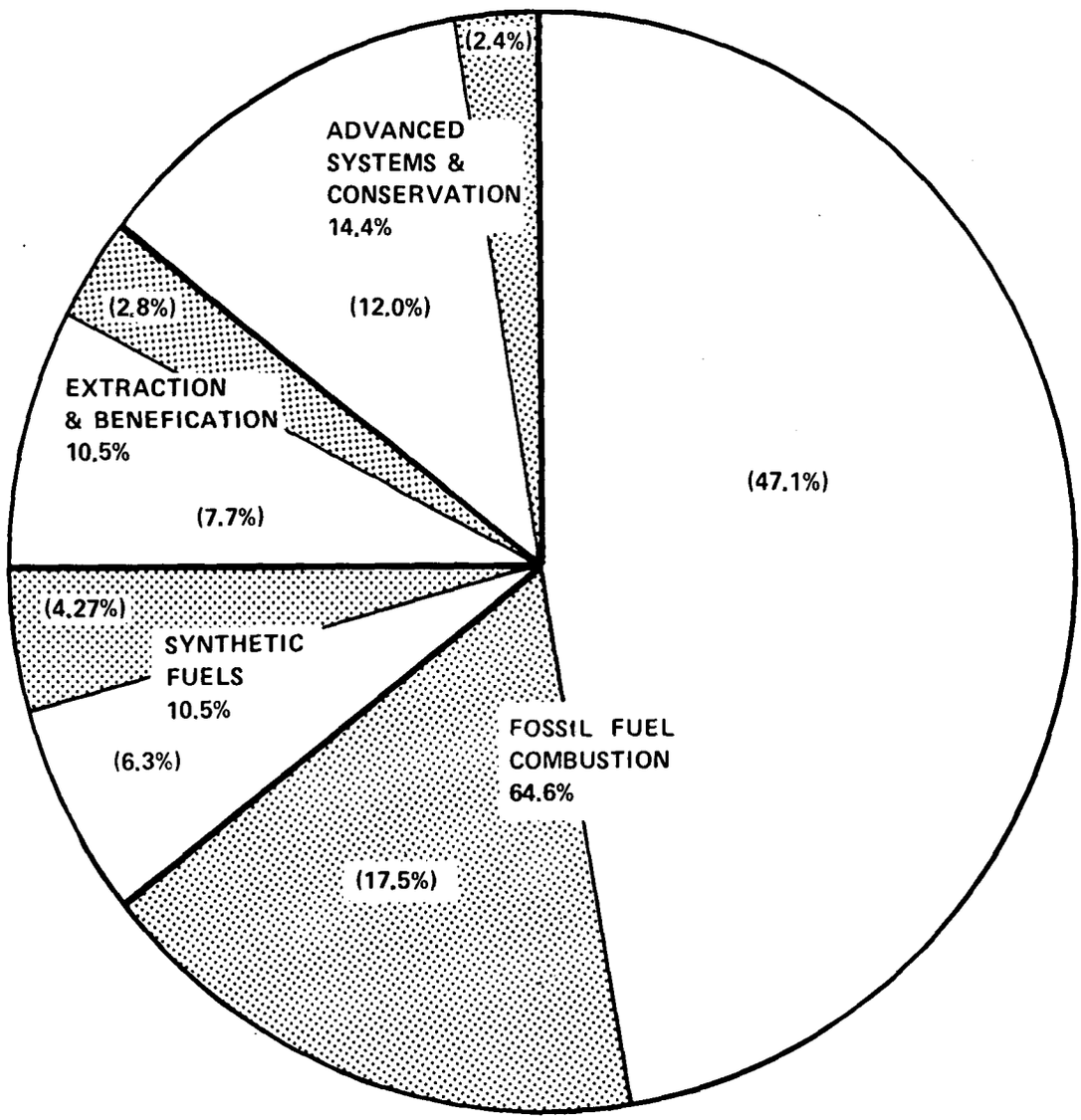
RESOURCE EXTRACTION PROJECTS WITHIN EPA. The EPA energy resource extraction program already underway includes these areas:

- Demonstrating and evaluating new surface mining technology for the eastern United States. In addition, research is being conducted on available technology to reduce environmental damage from abandoned coal surface mines. A result of this effort will be a manual of practice to be used by industry, state and federal agencies, and training institutions.

- Developing effective methods for reducing or preventing harmful environmental effects caused by underground coal mining in the eastern U.S. The objective of this research is to create permanent solutions to prevent environmental damage as opposed to relatively short-term treatment technology. Emphasis is

FIGURE 8

# FY 1975
# ENVIRONMENTAL CONTROL TECHNOLOGY FOR ENERGY SYSTEMS



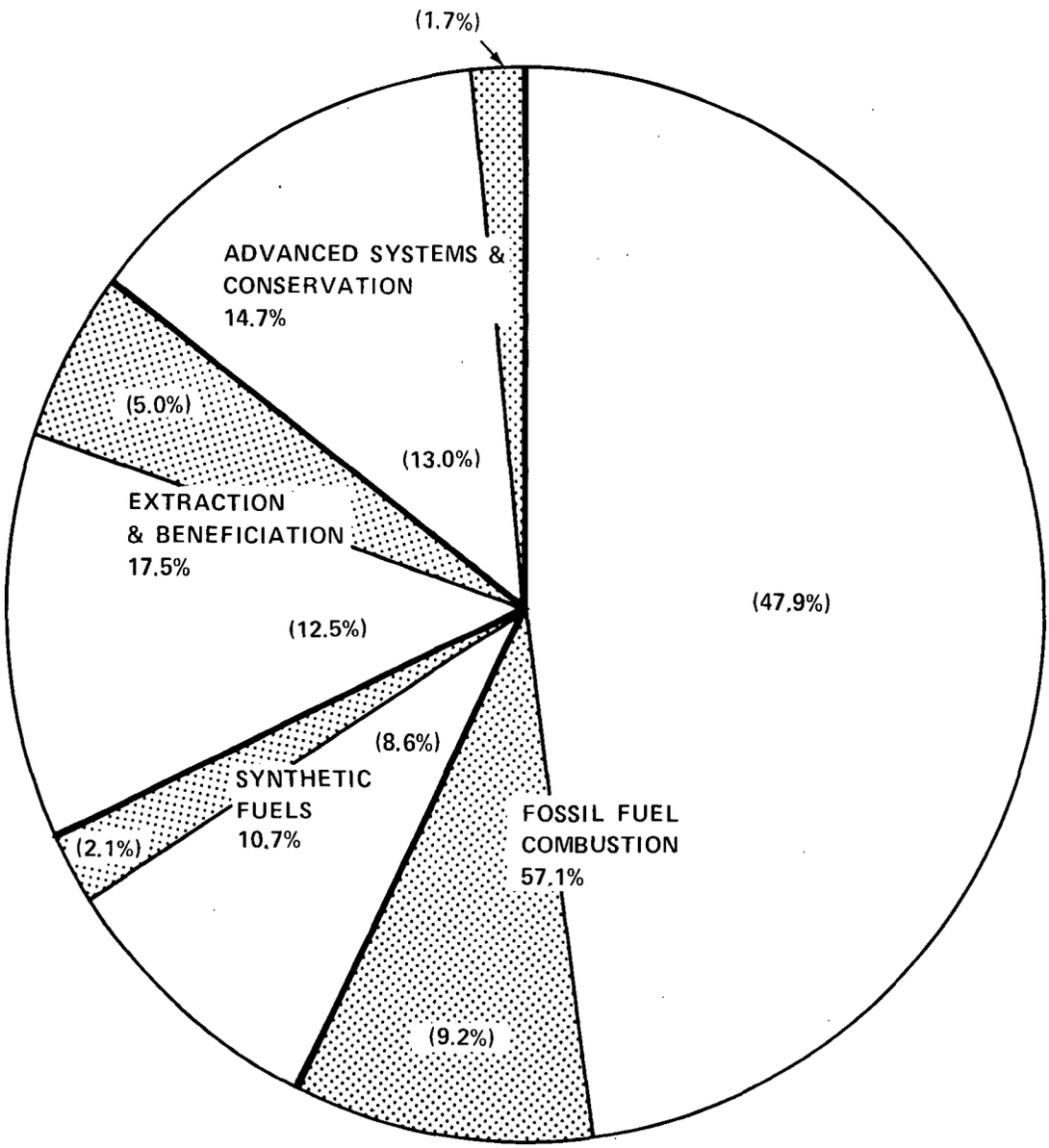

INTERAGENCY
R&D PROGRAM ($81 MILLION)

EPA

INTERAGENCY

FIGURE 9

# FY 1976
# ENVIRONMENTAL CONTROL TECHNOLOGY FOR ENERGY SYSTEMS




INTERAGENCY
R&D PROGRAM ($55.8 MILLION)

EPA

INTERAGENCY

being given to effectiveness of permeable seals, prevention of acid mine drainage, groundwater pollution problems associated with underground coal mines, and development of a manual of practice for both abandoned and active eastern underground mines. Results of this effort will also be extrapolated, when feasible, for treatment techniques for mine drainage from discharges from oil shale, uranium, tar sand, and other energy-related solid fuels extractive industries.

- Assessing and developing methods to control environmental damage resulting from transport of solid fuels, such as unprocessed coal removed from a small strip mining operation and stockpiled before delivery to a cleaning facility. Rain water seeping through this coal may produce sulfuric acid, thus producing a highly acidic effluent which can damage the ecosystem of a receiving stream. Other problems may arise at barge loading facilities, where mechanical conveyors moving processed coal (with significant amounts of finely ground particles) can create large enough quantities of dust to constitute an important air and water pollution problem. This program is expected to produce techniques to minimize the environmental disruption caused by solid fuel transportation problems, such as those just described. A manual of practice to be used by government and industry, with economic and technological descriptions of the various control measures, will be developed.

- Developing methods to prevent pollution from active and abandoned western U.S. coal surface and underground mines. Stress is placed on techniques to establish vegetation, control surface and subsurface water, reclamation in semiarid areas, control of fugitive dust and other air emissions, disposal of solid waste, and treatment of air and water discharges.

- Evaluating and demonstrating methods to control environmental damage resulting from development of oil shale and tar sands. The Agency is working with other federal, state, and local agencies and industry to obtain relevant information regarding dust, water pollution, and solid waste disposal, with special emphasis in the near-term on the problems of disposal of spent oil shale. EPA's objective in this program is to have on hand sufficient environmental information on oil shale and tar sands development so that, as economic and technical decisions are made regarding these technologies, proper consideration will be given to environmental difficulties.

- Developing methods to control and to clean oil spills on land and water, including limiting the extent of contamination and lessening environmentally damaging effects. The project includes evaluations of booms and skimmers for inland spills, available open ocean spill control equipment for use at offshore platforms and deepwater port facilities, new spill control equipment, proper disposal of oil spill generated debris/sorbents, incineration of oil-soaked debris/sorbent and dispersant, and surface collecting agents for oil spill control. An annual national conference on

oil spill control is being organized in order to disseminate information.

- Developing techniques to protect and restore shorelines contaminated by oil spills, including ocean, estuarine, inland river and lake, and cold climate (chiefly Alaska) waterfronts.

- Developing and demonstrating control technology to minimize adverse environmental effects from the installation and operation of offshore oil and gas production facilities, including offshore platforms, pipelines, and other transportation systems, and onshore termination facilities.

- Developing cost-effective methods to treat recovered oil/water mixtures, bilge and ballast water at onshore reception facilities, including existing ports and planned deepwater ports.

- Developing guidelines to minimize environmental harm during secondary and tertiary oil and gas production. Although the guidelines are being developed primarily for onshore operation, they will have offshore applications as well.

- Developing spill control techniques and equipment for the onshore storage and transport of LNG and LPG.

- Developing techniques to control environmental damage from uranium extraction by expanding existing mining control technology and by developing controls unique to uranium mining. Problems of abandoned as well as active mines are being addressed, and the resulting information will be disseminated in a manual of practice for government and industry use.

RESOURCE EXTRACTION PROJECTS WITHIN OTHER AGENCIES. Those parts of the resource extraction control technology program to be carried out through interagency agreements are:

- Developing a report on alternative technologies which may effectively control effluents and wastes from eastern U.S. coal strip mining operations, with emphasis on groundwater effects and sedimentation problems. The project will include development of a statistical and descriptive correlation between sites for testing these environmental control technologies and their effectiveness in order to delineate specific controls for specific site needs. (ERDA)

- Developing a report on plant materials to improve technologies for reclamation of surface mined lands. The effort includes preparing a technical handbook on revegetating surface mined lands and spoils in the eastern U.S. Particular emphasis is being given to arid and semiarid regions of the West, including investigations of plants best suited for mine spoil reclamation under various site conditions, plants for erosion control and mined land reclamation, and equipment for seed collection, processing, and planting. (Department of Agriculture, Soil Conservation Service)

- Developing guidelines and criteria for technologies to control harmful effects of mining on forest, range, and related

freshwater ecosystems. The project is to include recommendations for overburden drilling, analysis, and placement in relation to the ecosystem; revegetation following coal and oil shale mining; use of nonmine wastes to enrich the soil on coal and oil shale spoils; and publication of a technical handbook on revegetation on eastern mined lands. (Department of Agriculture, Forest Service)

- Demonstrating and assessing revegetation and reclamation of mined lands. The project evaluates the following control technologies: (1) utilization of waste material such as sewage sludge, composted garbage or sewage, and fly ash in revegetation and reclamation of strip mine areas, with special attention devoted to the effects of these wastes on water quality, reclamation efficiency, plant growth and quality; (2) development of practices to counter instability on mined lands due to high levels of exchangeable sodium (West) and steepness of terrain (East), including methods such as regrading and revegetation; (3) development of stabilization and restoration methods for areas disturbed by oil shale and coal mining in western Colorado and Wyoming, with emphasis on grade stabilizers, small dams, and basins to hold water for irrigating selected areas; and (4) development of methods of restoring and maintaining a desirable microbial activity in soil disturbed by strip mining, including studies on deep placement of fertilizers and other soil enhancers. (Department of Agriculture, Agricultural Research Service)

- Providing quantitative information on spoils from mining operations. The project includes classification of topsoil, test methods for useful classification, determination of topsoil reactions when placed on spoils, and development of systems for raising superior planting stocks for use in spoil revegetation. (Department of Agriculture, Cooperative State Research Service)

- Developing methods of soil and water management and revegetation technology in arid and semiarid climates. Emphasis is given to hydrologic effects and simulations and to successful establishment of vegetation needing minimal amounts of water. Department of Agriculture, Cooperative State Research Service)

- Assessing use of spoil deposition, topsoiling, and soil enhancers in strip mmine reclamation operations. Emphasis is placed on determining the best use of sewage sludge for revegetation and the subsequent impact on heavy metal content of related ecosystems. (Department of Agriculture, Cooperative State Research Service)

- Developing reclamation control technology using spoils to promote revegetation. (Department of Agriculture, Cooperative State Research Service)

PHYSICAL/CHEMICAL COAL CLEANING. Physical/chemical coal cleaning involves methods of physically and/or chemically cleaning coal having a moderate sulfur content (1 to 2 percent) in order to allow it to be burned in conformance with clean air standards. The objectives of the program are to develop commercially

available coal-cleaning processes which remove inorganic sulfur and ash from medium sulfur coal, while treating coal cleaning wastes so that they ca reclaimed or disposed of in an environmentally acceptable manner.

Basic research on coal characteristics is as essential to a successful coal cleaning program as it is to most of the coal-related research areas. In this case, however, information on the chemical composition of medium sulfur coals and the behavior of inorganic and trace element impurities is particularly important.

The coal cleaning program addresses several technologies including a Meyers process coal cleaning pilot plant (which could have higher potential efficiencies for pollutant removal than standard coal washing processes), a two-stage froth-flotation coal washing process (with the Bureau of Mines), and advanced, low-polluting dewatering and drying technologies.

COAL CLEANING PROJECTS WITHIN EPA. Coal cleaning projects now underway as part of the Interagency Program are:

- Characterizing completely the environmental problems of existing coal cleaning plants and coal handling methods, including an evaluation of existing controls. A manual of practice to accomplish definite near-term goals is being produced, and an assessment is being made of coal cleaning applicability on a national and regional basis.

- Characterizing current technology and developing and demonstrating advanced technology to clean coal of sulfur, nitrogen, ash, and potentially hazardous trace pollutants. The program evaluates the effects of cleaned coal on coal conversion processes and related pollution control methods (for example, what effect does washing coal prior to scrubbing have on combustion efficiency and waste). It is developing the best available technology for control of pollutants from coal cleaning plants, coal storage, and coal transporation systems.

COAL CLEANING PROJECTS WITHIN OTHER AGENCIES. The coal cleaning projects formulated through interagency agreements include the following:

- Reporting developments in physical and chemical coal cleaning technology for sulfur and ash removal. Areas for study include sulfur and ash release potential when coal is crushed and float-sink tested, development of a physical coal cleaning computer model, testing and assessment of the first commercial process for removal of inorganic sulfur from crushed coal, mechanical dewatering of fine size desulfurized coal, and evaluation of new or novel techniques for physical or chemical coal cleaning. (DOI, Bureau of Mines)

- Developing and demonstrating in a pilot plant, a process to recover coal and other marketable materials from coal refuse ponds. Emphasis is on dewatering, agglomerating, and pelletizing the waste from the coal cleaning process into a coarse refuse or construction material. (DOI, Bureau of Mines)

- Constructing and operating a coal washing test facility in Pittsburgh to test new techniques and equipment for sulfur and

ash removal and to prepare the desulfurized coal for transportation with minimum dust losses. The test facility will also assist EPA in tests on combustion, flue gas scrubbing, fluidized bed combustion, and cleanup of raw and acid gas from synthetic fuel processes. (DOI, Bureau of Mines)

- Characterizing trace elements in wastes from coal extraction and processing and evaluating new physical/chemical processes for removal and recovery of trace elements which are either environmentally harmful or economically valuable. (ERDA)

## FOSSIL FUEL COMBUSTION

The Fossil Fuel Combustion section covers two related Interagency Task Force program areas--flue gas cleaning and direct combustion. Cleaning of flue gases from coal-fired utility and industrial boilers has highest priority within the Federal environmental control technology R&D program. First, flue gas cleaning technology in general (and flue gas desulfurization processes in particular) are important in terms of national energy self-sufficiency. The only way near-term coal use can be significantly increased without severe environmental impacts is to employ air pollution control technology compatible with Clean Air Act requirements. Although coal conversion (gasification and liquefaction) processes appear promising, they will not have a truly significant impact until the mid-1980's; thus, flue gas desulfurization offers the most viable coal combustion control technique available for the next decade.

In addition, flue gas desulfurization (FGD) systems, many of which are now in commercial operation or on order, are in the final stages of demonstration. R&D efforts are directed toward the remaining problems such as upgrading operating performance and reliability, minimizing costs, and improving waste product disposal techniques and by-product recovery.

Funding for the FGD program was expanded significantly in FY 1975 to provide funding for two advanced stack gas cleaning demonstration plants. Funding levels are decreasing in FY 1976 and in subsequent years since additional full-scale utility demonstrations are not anticipated. The increase in FY 1975 funds should produce major national benefits as the advanced systems provide improved operating characteristics, lower costs, and improved byproducts.

In addition to R&D on advanced scrubber systems and waste disposal techniques, the flue gas cleaning program is contributing to the characterization of fine particulates, hazardous pollutants (such as trace materials from coal combustion and metallic acid sulfates), and nitrogen oxides. The program is also supporting R&D on potential advanced control techniques.

Flue gas cleaning program plans include continued work on the two full-scale advanced FGD demonstration plants--one producing an improved throw-away product (sludge) and the other producing marketable byproduct (elemental sulfur). In addition, a third smaller regenerable demonstration plant may be initiated on an industrial-scale boiler which cofires fossil fuels and municipal wastes. High priority is also given to an agressive technology transfer program so that expertise generated via the Interagency Program can be commercially applied.

<u>FLUE GAS CLEANING PROJECTS WITHIN EPA</u>. EPA projects for which funding has already been approved are:

- Developing particulate collection technology to ensure that advanced energy processes meet

new source performance standards. In order to reach this objective, (and because so little information exists at present) the high-temperature, high-pressure particulate control program is initially developing primary information on emission and process cleanup requirements for advanced energy processes and on the mechanics of aerosols at high temperatures and pressures. Various companies have proposed particulate collection devices (such as grandular bed filters and high-pressure drop cyclones) for which reliable performance data will be needed before adequate testing can be carried out.

- Developing disposal methods for wastes from utility and industrial flue gas cleaning processes. Special attention is being given to determining the extent to which the migration of chemicals from such wastes can be attenuated by soils in land disposal sites, the compatibility of various liner materials (for ponding) when exposed to these wastes, and the leachability and durability of products from first generation flue gas cleaning waste treatment processes. In addition, a field evaluation of current waste disposal technology is being conducted and second generation processes (fixation and stabilization) are being evaluated. The objective of the program is to establish a data base for the future development of standards for disposal of flue gas cleaning wastes and to identify further areas for research in order to develop such standards.

- Improving the performance and economics of lime and limestone flue gas desulfurization (FGD) systems. Emphasis is given to continuing the advanced testing program (through June of 1977) of the EPA prototype facility at TVA's Shawnee plant, with attention devoted to improving the reliability of mist eliminators, minimizing sludge production by maximizing alkali utilization and minimizing capital and operating costs. A computer program for performing economic tradeoffs is being developed. In addition, an intensive program at Louisville Gas and Electric's Paddy's Run Station (a full-scale lime scrubbing operation) has begun to evaluate its record of reliable, unsaturated operation. An assessment of a lime scrubbing process (Bahco) for industrial coal-fired boilers is being performed at Rickenbacker Air Force Base. Development and demonstration of double alkali FGD systems as reliable second generation alternatives to lime/limestone processes is being continued. Pilot-scale studies supported by the Agency will be completed in spring 1976; they will support the EPA test program at Gulf Power's 20-MW prototype double alkali system. Subsequently, a full-scale demonstration of a competitively selected double alkali process is being initiated through an industry/EPA cost-shared contract with a test program prepared and conducted by an independent third party. Industrial application of the double alkali process for $SO_x$ control is being assessed by completing tests currently underway at the General Motors 32-MW Parma facility.

- Continuing development and demonstration of environmentally acceptable, cost-effective

techniques for disposal and utilization of wastes from flue gas cleaning operations with special emphasis on FGD sludge. In addition, efforts are being devoted to demonstrate systems for maximizing power plant water reuse/recycling capabilities. Program results will be published annually.

- Disseminating and applying information generated by EPA, utilities and industry regarding flue gas cleaning development and demonstration efforts. The program is to provide users with assistance regarding flue gas cleaning system decisions, operational problems, emission impacts on air quality byproduct marketing, and secondary effects on water quality.

- Working with TVA on preparing an overall evaluation of the pollution control problems associated with a coal-fired electric power plant and an assessment of the options and costs related to possible solution. In addition to the specialized expertise and/or required facilities that TVA is providing at the Shawnee facility, TVA will assist EPA in evaluating advanced FGD processes, preparing detailed FGD cost studies and byproduct evaluations, improvement of lime/limestone operability, sludge fixation and disposal, and chemical characterization analyses of all effluents from coal-fired power plants.

- Demonstrating regenerable FGD processes which produce marketable sulfur byproducts. Systems to be tested and evaluated include: Wellman-Lord, magnesium oxide, citrate, and ammonia-ABS. In addition, an evaluation is being made of processes capable of removing both $SO_x$ and $NO_x$. Current activities supporting expansion of magnesia scrubbing and generation and use of reductant gases for production of elemental sulfur are being continued.

- Characterizing the environmental emissions of $NO_x$ and other combustion-related pollutants from stationary source combustion processes and evaluating the environmental effectiveness and impact of controls (compared to the uncontrolled state), including alternative operating conditions, retrofit controls, maximum stationary source technology for existing units (requiring extensive retrofit), and maximum stationary source technology for new units (using optimized design for alternate processes).

- Developing and demonstrating combustion modification technology to control stationary source emissions of $NO_x$ and other combustion-generated pollutants. Because more than 98 percent of $NO_x$ from stationary sources is generated during fuel combustion, interest here focuses on modifying conditions under which combustion occurs. It appears that combustion techniques can be optimized to reduce or eliminate emissions of other pollutants (such as CO, unburned hydrocarbon, and carbon particulates) and to increase the efficiency of system design and operating characteristics. Field application is being carried out for a variety of sources, including utility, industrial and commercial boilers, residential furnaces, industrial process furnaces, stationary engines and

advanced processes. Applications range from minor hardware changes on existing sources for short-term controls to complete system redesign for optimizing all energy and emission aspects of specific equipment categories.

- Preparing a state-of-the-art assessment of $NO_x$ flue gas treatment, emphasizing $NO_x$ removal in the presence of low $SO_x$ concentrations, removal of both $NO_x$ and $SO_x$, evaluation of both U.S. and Japanese $NO_x$ removal technologies leading to modification of the U.S. program where necessary, and undertaking larger scale prototype and demonstration efforts.

- Developing and demonstrating control technologies to remove large quantities of waste gas particles smaller than three micrograms in size. Capabilities of existing equipment (electrostatic precipitators, scrubbers, filters, and proprietary devices) are being evaluated in order to determine design and operating procedures deficiencies.

FLUE GAS CLEANING PROTECTS WITHIN OTHER AGENCIES. Projects which are being conducted through interagency agreements between OEMI and participating agencies under the flue gas cleaning program include:

- Testing of advanced concepts on TVA's 1-MW pilot wet lime/limestone pilot plant to evaluate methods for washing the vertical mist eliminator without exceeding the water balance necessary for the close-loop limestone process. Studies are being done on the best washing techniques and/or additives needed to prevent scaling and plugging in the mist eliminator. (TVA)

- Evaluating the feasibility of producing fertilizer from sludges from wet lime/limestone scrubbers. The project also correlates scrubber operation to sludge characteristics and determines disposal methods for wastes from fluidized best combustion processes. (TVA)

- Characterizing effluents from coal-fired utility boilers, including coal pile drainage, ash pond effluents, chlorinated water effluents, and their effects on ground water quality. (TVA)

- Expanding characterization studies on coal, wet and dry fly ash, and ash effluent focusing on trace elements and heavy metals. The project includes comparison of design and costs for dry and wet fly ash handling systems and recommendations of treatment methods for water reuse. (TVA)

- Developing a report on energy requirements of selected $SO_2$ removal processes for power plant emissions, with an evaluation of the feasibility and economics of process modifications to reduce and optimize energy requirements. (TVA)

- Developing a report on comparative economics for major $SO_2$ removal processes for power plant emissions. The project identifies major developing $SO_2$ removal processes capital investments and operating costs, and sensitivities of major design and economic factors. Primary consideration is being given to those regenerable systems which produce elemental sulfur as a byproduct. In addition, a cost study report is being conducted on alternative sludge disposal methods for lime/limestone flue

gas desulfurization systems. (TVA)

- Conducting a marketing study on by-products from regenerable flue gas desulfurization systems. The report quantifies by-product sulfuric acid or elemental sulfur which could be produced at point sources of sulfur emissions in the U.S. The study assesses the following aspects of byproduct marketing: the most economical market, distribution, and transportation system; competitive costs of existing processes which use elemental sulfur; and possible net sales revenue from the existing sulfur market and growth markets. The study recommends the most practical byproduct for the specific sources, based on this information. (TVA)

- Conducting and evaluating pilot-plant study of the ammonia absorption-ammonium disulfate regeneration process for removal and recovery of $SO_2$ from power plant stack gases. After review of the pilot-plant operation, a decision will be made on a demonstration-scale plant. (TVA)

- Conducting advanced testing of the Shawnee lime/limestone non-regenerable stack gas scrubbing program. Tests are being conducted in these areas: short-term fly ash free, maximum utilization, unsaturated mode operation; long-term reliability; sludge disposal; and fixation. (TVA)

- Developing a report on laboratory and bench-scale studies to evaluate advanced flue gas desulfurization processes improvements to reduce energy requirements. Emphasis is being given to absorption and regeneration in a potassium-based scrubbing system and to oxidation in both solution and slurry scrubbing systems. (TVA)

- Designing, constructing and operating pilot plant to test advanced processes for fly ash scrubbing. The Center, North Dakota, plant will be the subject of a 1-year test program focusing on diluted sulfuric acid scrubbing with ash neutralization and sodium-magnesium and calcium double alkali scrubbing with ash neutralization. (ERDA)

- Developing conceptual designs to compare capital and operating costs for each of the following new power plants: (1) conventional coal-fired steam power plant with flue gas desulfurization system; (2) atmospheric fluidized-bed steam power plant; and (3) pressurized fluidized-bed, combined cycle power plant. (TVA)

- Demonstrating two citrate process flue gas desulfurization systems (coal-fired and oil-fired). The demonstration systems, about 30 to 60 MW, are being evaluated for process design, construction cost estimates, detailed plant designs, and operating data. [Department of Interior (DOI), Bureau of Mines]

DIRECT COMBUSTION. This program concentrates on the environmental impact of fluidized bed combustion (FBC) processes, which optimally would use coal, coal-derived products, and residual oil efficiently and with minimal environmental harm. As part of the National Fluidized Bed Combustion Program coordinated by ERDA, EPA is conducting R&D to

determine potential environmental problems arising from alternative designs use of fluidized bed combustors. EPA's participation in the Interagency Program consists of conducting environmental assessments of future FBC systems by testing a pilot-scale flexible environmental test facility and by continued testing of EPA's small (0.63-MW) FBC mini-pilot plant.

Fluidized bed combustion program plans for the next few years include designing and testing of an environmental test facility to evaluate environmental and performance problems and control methods, initiating work on the use of low-sulfur western coal for industrial boilers, beginning sorbent regeneration studies to minimize solid waste at the FBC facility at ERDA's Argonne National Laboratory and at the EPA's mini-pilot plant, conducting laboratory and bench-scale studies of operating conditions to minimize pollutant formation at the Argonne facility, and demonstration, on a 50-MW existing utility boiler, of the Chemically Active Fluidized Bed Process for converting extremely "dirty" residual oils into clean gaseous fuel.

DIRECT COMBUSTION PROJECTS WITHIN EPA

- Identifying air, water, solid waste, and other environmental problems associated with fluidized bed combustion processes. Doing complete characterization studies on all available atmospheric and pressurized systems, with near-term emphasis on the effects of scale on emissions from fluid bed units, providing sampling and analytical manuals, the problems of special liquid and solid wastes, and the applicability and problems associated with industrial-scale fluid bed boilers.

- Developing both laboratory and bench-scale multi-media control technology for $SO_x$, $NO_x$, total particulates, hydrocarbons, carbon monoxide, and trace hazardous and other pollutants from fluidized bed combustion systems as well as treatment and final disposal techniques for spent sorbent and ash. Complete demonstration testing is being conducted on the miniplant combustor/regenerator operation.

- Developing technologies for the removal of sulfur, nitrogen, and potentially hazardous trace pollutants from petroleum, petroleum derivative, and other liquid fuels. Stress is being placed on: the thermodynamics, kinetics, and mechanisms involved in sulfur and nitrogen release by catalyzed hydrogen attack, and on development of existing demetallization-catalytic hydrotreatment technology to maximize sulfur and nitrogen removal. A cooperative effort between the U.S. and the USSR is being undertaken in order to evaluate the USSR catalyst.

- Demonstrating at small to moderate commercial scale the Chemically Active Fluid Bed (CAFB) process for converting heavy high-sulfur, high-metal-content residual oils to clean, high-temperature gaseous fuel.

- Characterizing waste streams from and evaluating the applicability of alternate advanced oil processing methods for utilization of petroleum residuals. Assessing environmental problems and controls for the CAFB process, including solid and liquid wastes and residual oil disposition.

DIRECT COMBUSTION PROJECTS WITHIN OTHER AGENCIES. In addition, OEMI has interagency agreements covering the following fluidized bed combustion projects:

- Developing a report on various studies being conducted to reduce pollutant emissions from fluidized bed combustion/regeneration systems. The studies include analysis of sorbent performance for $SO_2$ control, sorbent alternaatives, disposal and use of spent sorbent, $NO_x$ formation and emission controls, trace element emissions controls, particulate emissions and controls, and regeneration schemes. (ERDA)

- Sampling and analyzing emissions from selected fluidized bed combustion units. The emissions are being characterized, and samples are being sent to EPA for further analysis. (ERDA)

- Analyzing applications of fluidized bed technology for industrial boilers emphasizing environmental, economic, and energy implications of such use. (Federal Energy Administration)

## SYNTHETIC FUELS

The Interagency Program for synthetic fuels (high- and low-BTU gasified coal and liquefied coal) has two main objectives--to determine the potential environmental impacts of synthetic fuel processing operations and to develop control technology to minimize the negative aspects of these impacts.

Optimally, the realization of the two major objectives would require sequential R&D following the logical functional area progression (i.e., from pollutant identification, to transport processes, to health and ecological effects, to pollution control technology, 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 plans. Development and/or assessment of appropriate control technology must be accelerated to permit early commercialization and to minimize the diseconomies associated with retrofitting of pollution controls.

Environmental assessments focus on characterization of feedstock materials as well as on the environmental impacts of shale oil recovery, coal liquefaction, and high- and low-Btu coal gasification. Technology to control air, water and solid waste pollution from conversion processes are being developed or promoted concurrently with fuel processing technology R&D being conducted by other agencies. To facilitate its testing procedures, EPA is constructing a small and flexible coal gasifier to develop and evaluate control technology at the bench-scale. Finally, ongoing work is being continued on high temperature cleanup of low-Btu gasified effluents.

SYNTHETIC FUELS PROJECTS WITHIN EPA. Titles of synthetic fuel programs now underway as part of the Interagency Program are:

- Evaluating the environmental problems associated with conversion of fossil fuels into synthetic fuels, using a multimedia approach to characterize all potential pollutants which could be generated during synthetic fuel development. Initial efforts are being devoted to low-Btu gasification, high-Btu gasification, and coal liquefaction.

- Developing and demonstrating technology to control multi-media

pollutants resulting from synthetic fuel development. Special attention is being given to problems of raw and acid gas cleanup, coal preparation and feeding, and fuel products and byproducts.

SYNTHETIC FUELS PROJECTS WITHIN OTHER AGENCIES. The following projects in the synthetic fuels area have been formulated through interagency agreements:

- Defining problems and quantifying environmental effects of coal conversion processes. Studies under this project include: (1) Classifying processes in terms of all pollutants generated (air, water, solid waste) and any secondary pollutants; (2) Surveying coal processing programs funded by ERDA to assess environmental studies planned and needed; (3) Surveying available pollution control technology from existing and planned pilot plants, (Controls in related industries are being considered for adaptation to coal-processes); (4) Developing test programs for analysis of pollutants from each synthetic fuel process; (5) Selecting, installing, and testing pollutant monitoring instruments; (6) Analyzing and interpreting resulting data on pollutants from these coal conversion processes. (ERDA)

- Identifying the refractory organic pollutants in treated petroleum refinery wastewaters. Research focuses on the Calumet District of Illinois and Indiana, sited at the southwestern tip of Lake Michigan, and is being coordinated with ongoing research to study the dynamics, fate, and effects of organic pollutants from petroleum refinery wastes. (ERDA)

## ADVANCED SYSTEM AND CONSERVATION

The advanced systems and conservation subchapter is divided into the four Interagency Program Categories of: (1) nuclear waste control; (2) thermal control; (3) improved efficiency, which is subdivided into the categories of wastes as fuel, industrial conservation and advanced power systems (fuel cells); and (4) advanced systems, which are subdivided into solar and geothermal sources.

NUCLEAR WASTE CONTROL. The objective of the Interagency Program effort in nuclear technology is to minimize environmental hazards from processing and disposal of nuclear wastes at various stages in the nuclear fuel cycle. Impacts of mining and milling wastes are the main focal point, with most of the efforts aimed at expanding environmental and technological assessment.

Under the Interagency Program, systematic environmental assessments of uranium fuel cycle, concentrating on mining and water pollution problems, are being conducted. Currently underway as part of the program are these projects:

WITHIN EPA

- Evaluation of the concentration of plutonium in human residing near Rocky Flats nuclear test facility.

- Determination of the environmental impact of the uranium mill tailings dump in Salt Lake City.

WITHIN OTHER AGENCIES. An interagency effort is underway to reduce environmentally hazardous effects from uranium mill wastes. The project includes an engineering assessment of

existing tailings sites with concurrent research conducted on control of radon release, development of instruments to reliably measure concentrations of radon, criteria for storage and stabilization of uranium tailings, and environmental standards for active and new tailings areas. (ERDA)

THERMAL CONTROL. Power plants discharge large amounts of heat into cooling water (from 48 percent of total heat input for fossil fuel-fired plants to more than 60 percent for light-water nuclear reactors). Even if energy demand decreases somewhat in the next few years, construction of new coal-fired and nuclear electrical power plants will increase 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 objectives of the thermal control program are: (1) provide design and performance data for improved cooling systems; (2) reduce the dependence upon use of rivers and lakes as heat sinks; and (3) assess the potential for waste heat reuse for agriculture, greenhouses, agriculture, and cyclical storage.

The program includes assessment of the implications of ecological effects of thermal effluents for engineering and economic design, leading to the effective expansion of R&D on advanced cooling tower technology (e.g., dry cooling towers) and on increased waste heat recovery and utilization. Under the Interagency thermal program, the following tasks are underway:

WITHIN EPA

- Evaluating the performance and economics of cooling system technology, with emphasis on advanced cooling technology such as dry and combined wet/dry cooling systems. A study of the application of wet/dry cooling technology to power plants for water conservation and fog control is being undertaken, and work is continuing on development of control for secondary waste streams from cooling systems. In addition, application of the technology for pretreating industrial and agricultural wastewater for cooling-tower use is being studied, as is alternatives to chlorine for the control of algae and fungi in condenser cooling systems.

- Continuing development and demonstration of environmentally acceptable, cost-effective means of utilizing waste heat and water resources from utility and industrial plants. Emphasis is being placed on identification and demonstration of integrated energy use facilities, use of residual heat, and evaluation of the associated environmental benefits and costs.

- Coordinating with TVA on developing thermal and wastewater treatment techniques for utilities by evaluating the performance, economics, and environmental aspects of cooling systems and waste treatment systems. Tests are being conducted on a wet/dry cooling tower specifically designed and fully instrumented for such testing.

WITHIN OTHER AGENCIES. The following interagency agreements have been formulated in the area of thermal control:

- Testing and evaluating advanced waste heat control technologies. The project includes studies on

application of membrane technology to power plant wastewaters, evaluating fish pumps and other concepts to direct fish away from intake channels at power plants, and assessing the environmental performance of a rotor spray cooling device. In addition, the project compares the performance, economics, and water quality of wet and dry cooling towers. (TVA)

- Determining the technology needed to recover heat energy from power plant condenser discharge waters for use in food and fiber production. Areas of emphasis include: soil heating to extend the crop growing system, optimizing the biological recycling of nutrients in livestock waste, and environmental controls for confined livestock operations. (TVA)

- Determining the feasibility of high density raceway production of catfish using waste heat discharges from steam-electric power plants. The project includes a state-of-the-art review and designation of areas for further research. Results of the research are being applied to studies on warm fish culture. (TVA)

IMPROVED EFFICIENCY. Improved efficiency in fuel utilization offers a potentially attractive means of helping to achieve energy self-sufficiency. Work is needed to assess the potential environmental impacts of improved or advanced energy systems. Research efforts will concentrate on three program areas:

WASTE AS FUEL. EPA experience in R&D on energy recovery from solid waste is based on the Agency's responsibilities under the Resource Recovery Act. EPA has funded a number of demonstration grant projects, including the combination coal- and garbage-fired utility boiler project in St Louis. This technology is being developed and applied to other types of utility and industry boilers. Environmental problems caused by waste used in energy processes are being studied. Another research area is the use of animal and agricultural wastes as sources for energy value reclamation. Specific tasks currently underway include:

- Developing long-term capabilities to provide continuing services in the development of environmental assessment criteria, sampling and analysis techniques, and formulating and acquiring pollutant emission data for new and existing processes for recovery of energy from waste processes.

- Performing surveys of waste streams for major sources of waste other than industrial with initial emphasis on municipal, construction, and demolition streams.

- Publishing technical assistance reports based on the waste-to-energy systems at St. Louis, Baltimore, San Diego, Chicago and other projects.

- Evaluating existing equipment and techniques for preparing refuse-derived fuels and feedstocks for energy recovery, with special attention given to performance and cost data.

- Evaluating the concept of coincineration of sewage sludge with waste (St. Paul). Particular emphasis is being given to the technical, economic, and environmental aspects of supplying the heat required to thermally degrade sewage sludge with the waste (such heat is now provided

by increasingly scarce conventional fuel oil).

- Evaluating major bioconversion waste-to-energy processes, considering waste type, preprocessing requirements, health considerations, processing variables, and emission and pollution control needs.

- Demonstrating and evaluating major waste-as-fuel technologies and methods, with particular emphasis on their environmental impact. Systems being examined include: waste as fuel in large pulverized coal-fired boilers, other types of coal-fired boilers, oil-fired boilers, and industrial and smaller institutional boilers.

- Evaluating major competing waste-as-fuel processes in terms of technical, environmental, and economic considerations (for example, compare supplementary fuel options to direct conversion to electricity to pyrolytic conversion to bioconversion, etc.). Developing and assessing different waste-as-supplementary fuel projects in which the EPA has been conducting R&D for some time. Reports are being prepared on performance and environmental impacts of the systems at St. Louis; Ames, Iowa (cofiring of waste); Columbus, Ohio (combined firing of waste with coal); and the D.C. area (cofired densified waste).

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

- Demonstrating and evaluating pyrolytic processes for thermochemical conversion of waste to fuel. A pilot scale research facility is being tested for the pyrolytic conversion of mixed waste (e.g., selected industrial wastes, municipal solid waste, agricultural waste, sewage sludge, and possibly, waste tires and oils). In addition, a report is being prepared on the concept of bringing portable pyrolysis units to unconnected agricultural and small industrial waste sites and on the feasibility of pyrolyzing waste tires, waste oils, and selected rubber industry wastes to useful energy forms. A report on the environmental effects of upgrading pyrolysis gases/liquids to gasoline is being prepared based on the research facility at the Naval Weapons Center at China Lake.

INDUSTRIAL CONSERVATION. Energy-saving industrial process changes due to increased energy costs and governmental regulations or incentives may cause unanticipated pollutant emissions. Environmental assessment work is underway to identify these effects, if any. These include the following projects:

- Surveying all literature and ongoing research regarding indoor air quality measurements and the effects of energy conservation on indoor air quality.

- Evaluating systems which simultaneously conserve energy and reduce pollutants.

- Addressing energy conserving industrial process changes and practices for major energy consuming industries and characterizing the overall environmental

impact of these changes. Subsequent work will examine the adequacy of available control technology and identify areas where additional R&D is needed.

- Developing and evaluating various industrial energy conservation practices which have already been initiated by industry in order to encourage development and application of the most environmentally beneficial technology.

ADVANCED POWER SYSTEMS. Work on advanced power cycles such as gas turbines, magnetohydrodynamics and fuel cells must be accompanied by identification, measurement, and analysis of the health and ecological effects of pollutants emitted.

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

An interagency agreement was signed to analyze the potential markets for fuel cell applications and the resulting national benefits of a large-scale government effort to develop them for commercial use. Emphasis is on near-term application, and the analysis considers fuel availability for fuel cells as well as flexibility. In addition, the project will include a technical evaluation of a first generation fuel cell to determine if it can meet utility company specifications and time schedules. The evaluation will also assess performance and cost. This project must be completed before a large Federal effort is committed to fuel cell R&D. (ERDA)

ADVANCED ENERGY SYSTEMS. In keeping with its general philosophy of anticipatory R&D for those energy systems which will be developed over the long term, EPA is initiating assessment studies to provide baseline information about the potential environmental impact of geothermal and solar energy systems. The geothermal research program focuses on predicting and controlling pollutant buildup in ground and surface waters. Solar energy systems research characterizes pollutants resulting from construction, installation, and operation of solar energy recovery systems. It also examines land use and siting difficulties associated with such systems and their resultant social, economic, and institutional implications. The Interagency's advanced energy systems program is:

- Evaluating geothermal development control technology by assessing pollution control systems at existing sites (Geysers, Imperial Valley, Klamath Falls) and by identifying wastes and treatment methods for water, land, and air discharges.

- Identifying and assessing the environmental impacts of solar energy technology and systems. Potential pollutants which might be released to the air, water, and land are being characterized (based on NASA, ERDA, and NSF programs). A model is being developed to evaluate the average improvement in air quality which might be expected in medium to major urban areas as a function of the number of residential and commercial facilities using solar heating and cooling systems.

## CONCLUSION

Since its inception with the two Task Forces almost two years ago, the

Interagency Energy/Environment Research and Development Program has produced a notable series of achievements. Underneath the procedures established via 16 interagency "umbrella" agreements, a grand total of more than 250 separate projects has been initiated. Coordination of those efforts is yielding significant information transfer benefits in terms of highlighting research needs and avoiding unnecessary duplication. Problem-oriented interagency sector groups are focusing on providing the type of information synthesis most useful to support the important energy development policy decisions which must be made over the next few years. A major seminar (The Conference on Health and Environmental Effects of Energy Use, Including Control Technology, February 9-11, 1976) is bringing together participants in the program to share data on problems and progress.

The end products of the program--the scientific and technical achievements upon which domestic energy resources can be developed in an environmentally sensitive manner--are already becoming visible. Many of these milestones will emerge in the next few months. Other longer-term projects, funded under the Interagency Program will not be completed for several years. On all of these projects, however, periodic progress reports will be available. As this information becomes available, it will be presented to energy policy decisionmakers with both format and timing geared to assuring that the development of energy resources and the protection of health and environment are accomplished in harmony.