ERDA-116

RECEIVED
FEB 19 1976
LMEC LIBRARY

Balanced Program Plan

Volume 1
Overview & Summary

Analysis For Biomedical & Environmental Research

U.S. Energy Research & Development Administration
Division Of Biomedical & Environmental Research

October 1975

LR-03520

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

Available from:

National Technical Information Service (NTIS)
U.S. Department of Commerce
5285 Port Royal Road
Springfield, Virginia 22161

Price: Printed Copy: $ 8.50
Microfiche: $ 2.25

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Energy Research and Development Administration, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

ERDA-116
UC-11, 41, 48, 90i

Balanced Program Plan

Volume 1
Overview & Summary

October 1975

Analysis For Biomedical & Environmental Research

Prepared For:
U.S. Energy Research & Development Administration
Division Of Biomedical & Environmental Research

Prepared By:
The Mitre Corporation
Mclean, Virginia 22101

Under Contract Number:
E(49-1)-3764 (Mod 1)

ABSTRACT

For ERDA's Division of Biomedical and Environmental Research, an analysis of requirements has been performed to identify the key environmental problems associated with the development of nine energy technology alternatives and to define the necessary health and environment research activities. In this document, an overview of the technologies is given, with a summary of key environmental problems and research needs. The interrelationships of the research activities are defined, and a preliminary allocation, based on resource estimates derived from the identified research needs, is given.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the many individuals and groups whose assistance and contributions to the Balanced Program Plan (BPP) Analysis were essential to the compilation of this overview report. Mr. H. Hollister, Deputy Assistant Administrator for Environment and Safety, provided overall guidance to the planning process and direction, as technical representative, to the MITRE contract. Dr. R. Cooper, Division of Biomedical and Environmental Research (DBER), had overall responsibility for the BPP activity and, together with Dr. R. Rabin, DBER, supplied the continuing focus required by a large scale planning project. The following DBER staff members participated in the definition and refinement of research project units: R.E. Franklin, H. Moses, M. Schulman, D. Slade, G.E. Stapleton, J. Olson and H. Wasson. Staff members from the following National Laboratories developed the basic energy technology descriptions and their associated health and environmental problems and research requirements: Argonne, Brookhaven, Holifield, Lawrence Berkley, Lawrence Livermore, Los Alamos, and Pacific Northwest. The authors extend their appreciation to these individuals and organizations for their comments and constructive criticism of an earlier draft version of this report, in addition to preliminary input materials and data. Comments from the offices of the other ERDA Assistant Administrators were also most useful in the final preparation of the document.

PREFACE

In order to achieve its objective of ensuring the safe and socially acceptable development of energy technologies, the Division of Biomedical and Environmental Research (DBER), Energy Research and Development Administration, is formulating a Balanced Program Plan to distribute its research efforts among nine energy technologies.

An analysis has been performed to identify key environmental problems associated with the development of energy technologies and the necessary health and environmental research activities. Although not a definitive statement of program content and budget, this analysis will serve as a basis for the continued development of a Balanced Program Plan. The results of this analysis are presented in this multi-volume document in the following format:

VOLUME I BPP: Overview and Summary	An overview of the energy technologies and research categories is given with a summary of key environmental problems and research needs. The interrelationships of the research activities are defined and additional factors to be considered in allocating research efforts are identified.
VOLUME II BPP: Categorical Research	Specific research activities in the form of research project units, are presented in terms of the biomedical and environmental research category into which the activity is grouped.
VOLUME III BPP: Coal Extraction, Processing, and Combustion	
VOLUME IV BPP: Coal Conversion	Each volume contains a detailed technology description and discussion of associated environmental problems. Research needs, identified in terms of the specific technology, are also given.
VOLUME V BPP: Oil Shale	
VOLUME VI BPP: Oil and Gas	

VOLUME VII
BPP:
Energy Conservation

VOLUME VIII
BPP:
Solar Energy

VOLUME IX
BPP:
Geothermal Energy

VOLUME X
BPP:
Fusion

VOLUME XI
BPP:
Fission

Each volume contains a detailed technology description and discussion of associated environmental problems. Research needs, identified in terms of the specific technology, are also given.

EXPLANATORY NOTE

The text of this volume, except for the Summary, has been prepared in an outline format. Key concepts developed during the BPP analysis are highlighted in the initial sentence on each page, and supporting facts or amplifying statements are presented as bulleted items directly below. Graphical or tabular presentations prepared to illustrate a key concept are placed on a facing page. Discussion and elaboration of the many issues involved in the planning process are not presented in this volume. This outline format is utilized to facilitate covering the broad scope of technological and environmental issues considered during this initial BPP analysis. Further detail can be found in the accompanying volumes of this report.

A continuing effort will be required to synthesize a specific ERDA program plan for biomedical and environmental research. The initial results contained in this report will change as the needs for energy development mature, technology is developed, and ongoing environmental research efforts provide new information. The results presented herein provide initial guidance for shaping the ERDA biomedical and environmental research program and are expected to be modified as the planning research programs evolve.

Blank Page

TABLE OF CONTENTS

		Page
LIST OF EXHIBITS		xiii
SUMMARY		1
	Background	1
	Energy Technologies	2
	Technology Descriptions	3
	Biomedical and Environmental Research Categories	6
	Category Descriptions	6
	Relationships of Biomedical and Environmental Research Activities	9
	Results of the Initial BPP Analysis	9
1.0	INTRODUCTION	15
1.1	ERDA Goals	16
1.2	DBER Objectives	18
1.3	Definition of the Balanced Program Plan	20
1.4	Purpose of BPP Documentation	22
1.5	Approach	26
2.0	ENERGY TECHNOLOGIES	31
2.1	Aspects of Energy Technology Research	32
2.2	Timelines and Energy Supply Potential	34
2.3	Pollutant and Nonpollutant Effects of Energy Technologies	36
2.4	Technology Descriptions and Key Health and Environmental Problems	40
	2.4.1 Coal Extraction, Processing, and Combustion	40
	2.4.2 Coal Conversion	44
	2.4.3 Oil Shale	50
	2.4.4 Oil and Natural Gas	56
	2.4.5 Energy Conservation and Efficiency	64
	2.4.6 Solar Energy	68
	2.4.7 Geothermal Energy	74
	2.4.8 Fusion	78
	2.4.9 Fission	82
3.0	BALANCED BIOMEDICAL AND ENVIRONMENTAL RESEARCH PROGRAM	87
3.1	Division of Research into Biomedical and Environmental Research Categories	88
3.2	Description and Definition of Research Program by BERC	90

TABLE OF CONTENTS (CONTINUED)

		Page
3.2.1	Characterization, Measurement and Monitoring	90
3.2.2	Physical and Chemical Processes and Effects	92
3.2.3	Ecological Processes and Effects	94
3.2.4	Health Effects	96
3.2.5	Integrated Assessment and Socioeconomic Processes and Effects	98
3.3	Relationships of Biomedical and Environmental Research Activities	102
3.3.1	Interrelationships and Characteristics of Biomedical and Environmental Research Categories	102
3.3.2	Baseline Characterization and Measurement	104
3.3.3	Physical Disturbances Characterization and Measurement	108
3.3.4	Pollutant Characterization and Measurement	112
3.3.5	Transport and Fate	116
3.3.6	Atmospheric, Hydrological and Geological Modification	120
3.3.7	Ecological Processes and Effects	124
3.3.8	Socioeconomic Effects	130
3.3.9	Health Effects	134
3.3.10	Occupational Health	140
3.3.11	Integrated Assessment	144
3.3.12	User Communities	148
3.4	Balanced Research Allocation	150
3.4.1	Research Effort by Technology	150
3.4.2	Research Effort by Biomedical and Environmental Research Category	152
3.4.3	Budget Allocation by BERC and Energy Technology	154
3.4.4	Relative Allocation of Research by Technology	156
3.4.5	Allocation of Effort by ERDA Feasibility Estimate	162
4.0	COORDINATION	165
4.1	Description of Additional Ongoing Health and Environmental Activities	166
4.2	Intra-ERDA Coordination	184

TABLE OF CONTENTS (CONCLUDED)

		Page
5.0	FUTURE PLANNING	187
5.1	Health and Environmental Data Needs of Technologies	188
5.2	Ranking Criteria	192

LIST OF EXHIBITS

Exhibit Number		Page
1	Relationships of Biomedical and Environmental Research Activities	10
2	Total Environmental Research Effort by Energy Technology	11
3	Distribution of Research Activities by Biomedical and Environmental Category	12
4	Preliminary Requirements Analysis for and Initial Budget of $272.9M	13
5	Division of Biomedical and Environmental Research Support of Energy Policy and Technology	19
6	Elements Affecting Structure of a Balanced Research Program	21
7	The Balanced Program Plan Planning Process	27
8	Generalized Energy Technology Fuel Cycle	33
9	Timelines of Energy Supply Potential	35
10	Pollutants and Physical Disturbances of Energy Technologies	37
11	Fuel Cycle for Coal Extraction, Processing, and Combustion	41
12	Key Health and Environmental Problems from Coal Extraction, Processing and Combustion	43
13	Fuel Cycle for Coal Conversion	45
14	Key Health and Environmental Problems from Coal Conversion	47
15	Generalized Fuel Cycle for Oil Shale	51

LIST OF EXHIBITS (CONTINUED)

Exhibit Number		Page
16	Key Health and Environmental Problems From Oil Shale	53
17	Fuel Cycle for Oil and Natural Gas	58
18	Key Health and Environmental Problems From Oil and Natural Gas	62
19	Energy Conservation and Efficiency Program Elements	65
20	Key Health and Environmental Problems in Energy Conservation and Efficiency	67
21	Fuel Cycle for Solar Technologies	69
22	Key Health and Environmental Problems from Solar Technologies	71
23	Fuel Cycle for Geothermal Energy	75
24	Key Health and Environmental Problems from Geothermal Energy	77
25	Fuel Cycle for Fusion	79
26	Key Health and Environmental Problems from Fusion	81
27	Fuel Cycle for Fission	83
28	Key Health and Environmental Problems from Fission	86
29	Biomedical and Environmental Research Categories	89
30	Components of Characterization, Measurement, and Monitoring	91
31	Major Components of Physical and Chemical Processes and Effects	93

LIST OF EXHIBITS (CONTINUED)

Exhibit Number		Page
32	Major Components of Ecological Processes and Effects	95
33	Major Components of Health Effects	97
34	Major Components of Integrated Assessments and Socioeconomic Processes and Effects	100
35	Relationships of Biomedical and Environmental Research Activities	103
36	Relation of Baseline Characterization and Measurement Activities to Other Research Activities	105
37	Examples of Baseline Characterization and Measurement Research	107
38	Relation of Physical Disturbance Characterization and Measurement Activities to Other Research Activities	109
39	Examples of Physical Disturbance Characterization and Measurement Research	111
40	Relation of Pollutant Characterization and Measurement Activities to Other Research Activities	113
41	Examples of Pollutant Characterization and Measurement Research	115
42	Relation of Transport and Fate Activities to Other Research Activities	117
43	Examples of Transport and Fate Research	119
44	Relation of Atmospheric, Hydrological, and Geological Modification Activities to Other Research Activities	121

LIST OF EXHIBITIONS (CONTINUED)

Exhibit Number		Page
46	Examples of Atmospheric, Hydrological, and Geological Research	123
46	Relation of Ecological Effects Activities to Other Research Activities	125
47	Examples of Ecological Effects Research	127
48	Relation of Socioeconomic Effects Activities to Other Research Activities	131
49	Examples of Socioeconomic Effects Research	133
50	Relation of Health Effects Activities to Other Research Activities	135
51	Examples of Health Effects Research	137
52	Relation of Occupational Health Activities to Other Research Activities	141
53	Examples of Occupational Health Research	143
54	Relation of Integrated Assessment Activities to Other Research Activities	145
55	Examples of Integrated Assessment Research	147
56	Relation of Users Activities to Other Research Activities	149
57	Total Environmental Research Effort by Energy Technology	151
58	Distribution of Research Activities by Biomedical and Environmental Categories	153

LIST OF EXHIBITS (CONCLUDED)

Exhibit Number		Page
59		155
60	Relative Allocation of Effort by Technology for Characterization, Measurement and Monitoring Research	157
61	Relative Allocation of Effort by Technology for Physical and Chemical Processes and Effects Research	158
62	Relative Allocation of Effort by Technology for Health Effects Research	159
63	Relative Allocation of Effort by Technology for Ecological Processes and Effects Research	160
64	Relative Allocation of Effort by Technology for Integrated Assessment Research	161
65	Allocation of Research by Energy Technologies in BPP with Respect to Implementation Schedule	163
66	Coordination of BER Program with Technology Development	185
67	Environmental Data Needs for Technology Decisions	189
68	Health and Environmental Research Tasks Related to Sample Technology Development Cycle	191
69	Examples of Project Selection Criteria	193

SUMMARY

SUMMARY

Background

The energy crisis confronting this country has precipitated a national commitment to the development of new, domestic sources of energy and to the implementation of wide-scale conservation measures. In the National Plan for Energy RD&D submitted to congress on June 30, 1975, five national energy policy goals are defined related to ensuring the country of a wide range of energy options in the future.

Explicit in these goals, however, is another commitment: a commitment to protect and improve the nation's environmental quality by ensuring that the preservation of land, water, and air resources is given high priority. Thus as new energy systems evolve, a careful examination of their concomitant environmental effects and health implications will be required. It is the objective of the Division of Biomedical and Environmental Research (DBER), Energy Research and Development Administration (ERDA), to provide this examination - to determine, through scientific research and assessment, the adverse health and environmental effects of energy-related effluents and pollutants; to explore methods of mitigating these effects; and to provide the basis for formulating and implementing policies to ensure the safe and socially acceptable development and use of energy technologies.

In order to achieve this goal, DBER has begun a planning activity designed to develop a comprehensive Balanced Program Plan (BPP) to define an integrated set of health and environmental research and assessment activities supporting all of the energy supply and conservation options under development by ERDA. The objective of the BPP is to distribute the research effort among the nine technology alternatives currently under investigation by ERDA, and across five categories of biomedical and environmental research in a manner to achieve a Balanced Program Plan.

The BPP effort, initiated in March, 1975, has involved the active participation of DBER staff, researchers from the seven multidisciplinary ERDA National Laboratories, and outside advisors and consultants.

Task forces from the ERDA National Laboratories prepared assessments of nine alternative energy technologies, identified major environmental problems for each alternative, and suggested research program units and dollar resources to be applied to the investigation of these problems. An independent examination was conducted at the same time by members of the DBER Headquarters staff, assessing research needs in the five environmental categories for the same nine technologies.

A week-long workshop was held at ERDA headquarters June 23-27, 1975, to coordinate these efforts and to consider other elements affecting the BPP. The workshop was structured to allow discussions between those groups focusing on the health and environmental problems of each technology, and the headquarters personnel responsible for each of the Biomedical and Environmental Research Category (BERC) research areas. The workshop resulted in a synthesized list of the health and environmental problems associated with each technology, and sets of proposed research projects designed to investigate these problems. Subsequent refinement of these efforts has resulted in preliminary guidance for the biomedical and environmental research in support of energy technology development.

The results of this initial BPP analysis, set forth in this multi-volume document, provide a basis for continuing efforts to develop and implement a DBER program which is responsive to ERDA technology development activities. The status and needs of each technology will be considered, and timely and effective research and assessment projects will be specified to address the identified and potential health and environmental problems. To date, major biomedical and environmental issues have been identified and research activities defined and placed within the categorial research programs. Key relationships between research programs supporting technology development have also been defined.

Continuing efforts related to the Balanced Program Plan will focus on relating research efforts directly to the timelines and milestones associated with each energy technology. Techniques for determining research priorities will be investigated so that the results of the planning efforts can be applied to the annual DBER programming and budgeting exercises.

Energy Technologies

The BPP focuses on the nine energy-related technologies described below. The identification of health and environmental problem areas for each technology and proposed research in these problem areas were assigned to personnel from the ERDA National Laboratories. Problems and research programs were described and preliminary priority ratings were developed based on four criteria:

- Severity of the health and/or environmental impacts;
- Geographical extent of the problem;
- Existing knowledge (or lack of information) related to the problem; and
- Urgency of the problem.

Research activities identified for each energy technology and problem area were related to specific Biomedical and Environmental Research categories and a plan for a balanced research program was developed during the workshop and through subsequent analyses.

Technology Descriptions

Coal Extraction, Processing and Combustion: Coal, which has been a major energy source in this country for over 100 years, occupied a key position in terms of the nation's future energy supply, due to the immense reserves of coal in the U.S. and the advanced state of coal technology. New means of processing and transport are becoming available to assist in the exploitation of coal, and new techniques are under development for more efficient conversion of coal to electrical energy.

Health and environmental concerns have been a major constraint to the use of coal, and a major expansion of this resource will depend on the development and application of environmentally acceptable processes and techniques. Major problems identified for coal extraction, processing, and combustion include health hazards associated with atmospheric emissions at all stages of the fuel cycle; impairment of water quality and availability of water near mining operations; and land disturbance and land use disruptions associated with surface mining. The atmospheric emissions due to coal combustion represent a particularly important and widespread health and environmental problem.

Coal Conversion: Current and impending shortages of liquid and gaseous fossil fuels lend tremendous emphasis to the development and commercialization of those technologies which can produce such fuels from coal. Processes to liquify and/or gasify coal are currently under various stages of development and extensive commercialization is anticipated by the mid 1980's.

In the coal conversion processes, large quantities of complex organic materials are handled. These materials may result in unique substances released to the environment, the effects of which have not yet been fully defined. Of particular concern will be the ecological and health effects of complex organic pollutants and the fate of coal conversion effluents.

Oil Shale: Oil shale also represents a major potential energy source for the U.S., and efforts have begun on the development of extraction and retorting processes for recovering a liquid fuel from this resource. The resultant petroleum products, obtained from either surface or in-situ recovery methods, can be readily utilized in existing fossil fuel systems.

Many of the effects associated with oil shale will be similar to those of other mining or petroleum refining operations. However, shale retorting may result in the production of unique gaseous and liquid effluents containing potentially hazardous organic and inorganic pollutants. Disposal of the large quantities of spent shale produced will certainly be a significant waste management concern. The competition for limited water resources in the oil shale regions also poses a particular problem for development of this resource.

Oil and Natural Gas: Supplies of oil and natural gas, currently the main source of energy in the U.S., are dwindling. New techniques in stimulation and recovery are therefore necessary to extend these resources until alternative energy supplies can be developed and employed.

The existence of major data bases on all aspects of the oil and gas industry make it possible to identify those areas in which further health and environmental research is required. These include effects of oil spills on the environment; health effects of refinery operations and direct combustion on exposed populations; effects of petroleum short-falls on social structure; and geological and hydrological implications of tertiary recovery techniques.

Energy Conservation and Efficiency: An integral part of the nation's energy plan is the implementation of a variety of techniques, procedures and devices to effect energy conservation and improve efficiency of energy systems. Program areas under consideration include conservation in the heating and cooling of buildings, electric conversion and power transmission efficiency; improved electric storage capabilities; transportation efficiency and conservation; and conversion of waste materials to usable energy.

Because of the diversity of technologies and techniques involved in conservation and energy efficiency, it is difficult to generalize potential health and environmental effects. Specific concerns include the socioeconomic effects of reduced fuel use; potential hazards accompanying the production of energy from urban and industrial wastes; possible adverse health effects from energy conservation in buildings; and potential ecological imbalances due to nutrient management techniques.

Solar Energy: Energy from the sun can be converted into usable forms of energy by means of several conversion technologies. Those actively supported by ERDA are:

- Direct thermal applications, involving the collection of sunlight through thermal collectors for heating and cooling buildings or for industrial or agricultural applications;

- Solar electric applications, in which energy from the sun is transformed into electricity via solar thermal, ocean thermal, photovoltaic, or wind conversion systems; and

- Fuels from biomass, in which fuels such as hydrogen or methane are produced from organic materials grown specifically as an energy crop or resulting from agriculture or forestry operations.

Although solar conversion is generally considered a relatively clean technology, large-scale implementation may produce significant health or environmental impacts. Bioconversion techniques, for example, are of particular concern, as are potential releases of toxic materials into the environment from solar devices and the possibility of climatic or ecological alterations caused by large solar energy facilities.

Geothermal: Domestic geothermal resources represent a significant potential source of energy for both electric and non-electric power outputs by tapping the heat of the earth. Four major types of geothermal resources have been identified; two of these, vapor-dominated and hydrothermal, are under active investigation and development at this time.

Several key problems associated with geothermal energy systems have been identified. These include the emission of non-condensable gases and trace elements with potentially adverse health and ecological implications; disposal of waste water and the effects of liquid effluents and cooling tower drift; and possible induced seismicity and subsidence due to geothermal operations.

Fusion: Nuclear fusion power from controlled thermonuclear reactors (CTR) is expected to make a major energy contribution in the post-2000 period. The technology for producing a controlled thermonuclear reaction has not been developed as yet, but vigorous research projects are being carried out toward this end.

Because of the nature of the fusion reaction, radiation poses the most significant health and environmental problem in the development and use of fusion power. The chronic and possibly accidental release of tritium, used as fuel, is of particular concern, as is neutron irradation of the containment structure and the possible subsequent release to the environment of the activation products formed. In addition to radiation exposure of workers, occupational health hazards may include exposure to high magnetic fields.

Fission: Commercial electric power generation based on nuclear fission has been a reality for almost two decades. Although nuclear power currently provides only about two percent of the nation's energy supply, this fraction is expected to increase rapidly. Breeder reactors are expected to make a major contribution to the nation's energy supply in the post-2000 period.

Many of the environmental and health hazards of fission have been identified; however, significant problems still remain which must be resolved in order to increase public understanding and acceptance of nuclear power. These problems include the release of radioactive isotopes from fuel processing and waste storage; the resolution of radiation dose-effects relationships; and the environmental effects of power plant cooling systems. Cost/risk/benefit studies relating nuclear power production to alternative energy sources are urgently needed as guidelines for the development and implementation of energy technologies.

Biomedical and Environmental Research Categories

Research activities described in terms of energy technology categories have been considered by grouping them into five biomedical and environmental research categories described below. These categories, which resulted from various energy/environmental research planning exercises (including the Ray report, December 1973, and the King-Muir Inter-agency Study, November 1974) provide a planning and organizational framework for health and environmental research. Redundant research projects can be identified and eliminated by the organization of activities into these categories.

Category Descriptions

Characterization, Measurement, and Monitoring: Within the characterization, measurement, and monitoring (CMM) category, research activities focus on identifying quantities and characteristics of potentially hazardous agents released from energy technology development, and ensuring the availability of requisite measurement tools and procedures for essential biomedical and environmental research.

Characterization programs are developed into three major categories including development of baseline information for energy technology development sites; identification of physical phenomena, potentially hazardous chemicals, and infectious organisms; and characterization of various technology processes.

In measurement technology programs, new materials, equipment, and systems concepts will be developed for advanced measurement capabilities. Current instrumentation will be improved to meet immediate research needs

(applied systems development). Also included in measurement technology is the development of quality assurance capabilities and the establishment of standard reference procedures and materials for the collection and storage of samples and their subsequent chemical and physical analysis.

The monitoring program will carry out dose-level studies, personnel and site monitoring for occupational health protection, and area and source monitoring of environmental and population exposures.

Physical and Chemical Processes and Effects: Two major objectives of research in the physical and chemical processes and effects category are investigations into the transport, diffusion, transformation, and fate of pollutants in all environmental media; and the investigation of atmospheric, hydrological and geological modifications due to energy technologies. Programs within this category can be divided into three groups.

Transport and fate studies include the development of ambient physical and chemical sensors, development of transport models in all media, and physical and chemical studies of pollutant transformation and deposition.

Physical disturbance characterization and measurement programs will focus on albedo changes, subsidence and seismic events, and erosion studies.

Atmospheric, hydrological and/or geological modification studies encompass development of models and experiments on the regolith, habitats, weather and climate modification, and aquifer modification.

Ecological Processes and Effects: Within the ecological processes and effects research category are programs designed to evaluate the ecological effects of energy technology development. Procedures for mitigating adverse ecological impacts of terrestrial, freshwater, and marine environments will be developed, and biological pathways and transformations for important residuals of energy production will be examined. The major components of the ecological processes and effects program are baseline information studies, effects research, and ecosystem management investigations.

Both the baseline studies and the effects research are concerned with the behavioral and physiological characteristics of organisms, populations, and communities; with habitat characteristics; with biological processes, pathways and fates; and with biological productivity. Ecosystem management research includes those studies on vegetation and

and faunal protection and restoration; on soil and water protection and restoration; and on the maintenance and restoration of agricultural productivity.

Health Effects: The objectives of the health effects research are threefold: to define and quantify the impacts of energy technologies in terms of their risk to human health, to develop methods for early detection and diagnosis of energy-related health effects; and to develop improved modes of protection from and remediation of health hazards.

Within the health effects category, at least five types of research studies will be carried out. These include:

- Identification of hazardous agents by rapid biological screening and/or chemical characterization;
- Determination of the metabolism and fate of hazardous agents;
- Development of dose-response relationships in a variety of laboratory animal species;
- Development of models to predict risk to man; and
- Epidemiological and clinical studies on occupational and general populations.

In addition, general supportive research in such areas as animal disease models or improved bioassay procedures will be conducted.

Integrated Assessment and Socioeconomic Effects: Integrated assessment provides the mechanism for ensuring that health, ecological and socioeconomic issues are comprehensively and consistently considered in decisions to develop, demonstrate, and commercialize new energy technologies. Ongoing research programs and the needs of various user groups will be monitored to ensure that research priorities match real and perceived social needs.

Three major research and assessment areas are included in this category. In the health and environmental data area, research studies in the handling and management of health, environmental and social data will be carried out. Social processes and effects studies will include the identification, assessment and quantification of energy-related activities. The assessment and analysis area will include several different kinds of studies including bioenvironmental assessments, cost/risk/benefit tradeoff analysis, and siting and implementation analysis.

Relationships of Biomedical and Environmental Research Activities

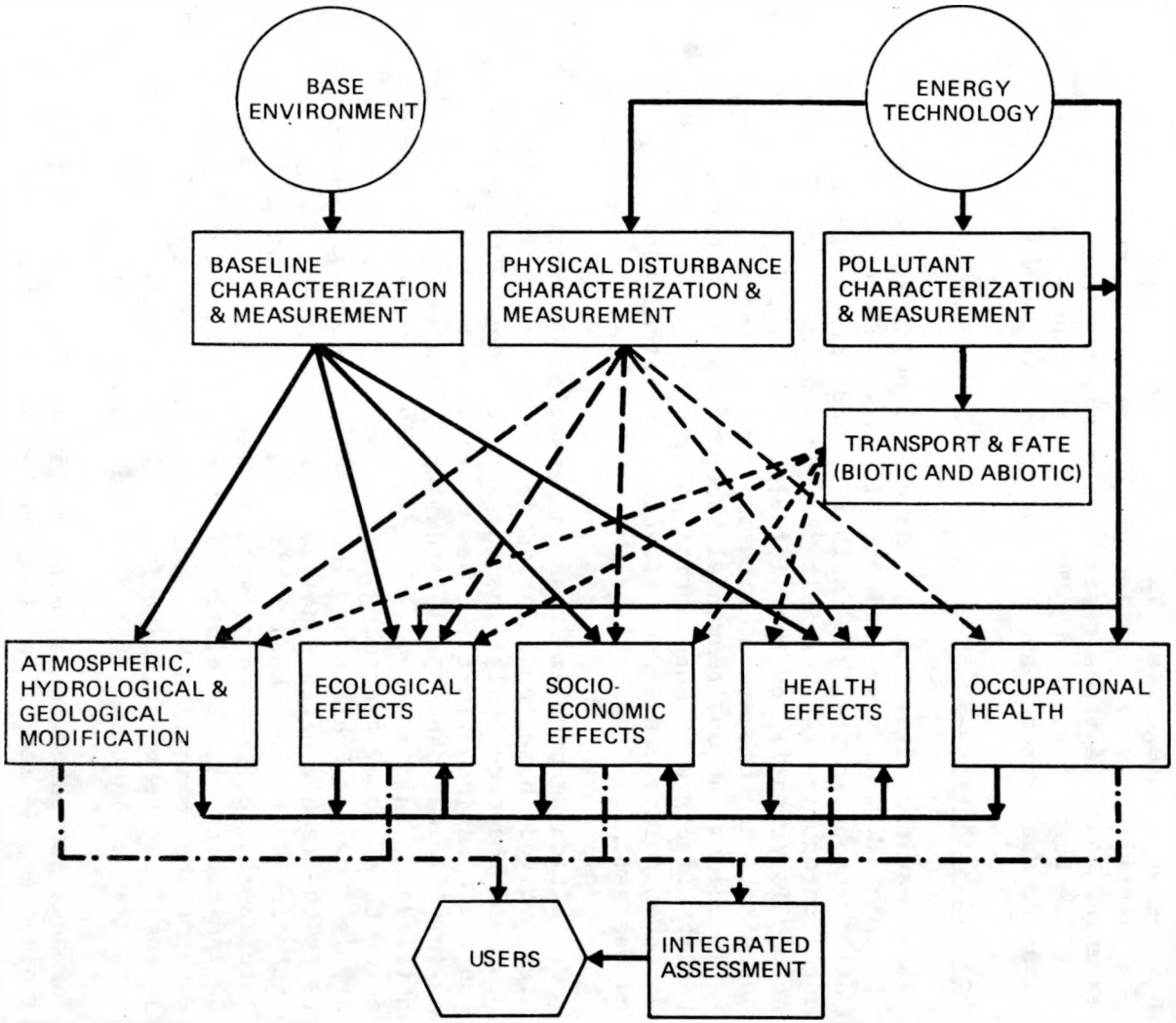
To ensure the preparation of valid comprehensive assessments of the health and environmental implications of energy technology development, the research activites being performed must be integrated and related to an overall plan. The interrelationships of the research activities as defined for the BPP are shown in Exhibit 1, which demonstrates the flow of research data between categories. The data needs for each type of research can be identified by examination of the antecedent research areas. For example, health effects research projects may require data inputs from Baseline Characterization, Physical Disturbance and Pollutant Characterization and Measurement, and Transport and Fate studies.

Results of the Initial BPP Analysis

The analysis resulting from the initial BPP planning activities and subsequent refinements defines a preliminary allocation of research efforts both across technologies (see Exhibit 2) and across biomedical and environmental categories (see Exhibit 3). The emphasis for allocation by technology is primarily on fossil fuels, particularly coal extraction, processing, and combustion, with fission ranking second. For allocation by biomedical and environmental category, primary emphasis is given to health effects with substantial and roughly equal efforts in physical and chemical processes and effects, ecological effects, and integrated assessment.

From the definition of problem areas and associated research needs, dollar estimates evolved, based on informed judgments concerning the cost of the proposed research activities (no a priori cost limitations were imposed on the planning effort). These estimates total $272.9 million for an initial year based on 1975 dollars. However, no specific year was identified for initiation of the research recommendations. The allocation of this sum by technology and by biomedical and environmental category is shown in Exhibit 4. The reported allocation of research efforts is the result of the analyses conducted by the ERDA National Laboratories staff, the DBER staff, the workshop teams, and by subsequent refinement efforts as previously described. These estimates serve as indicators of the relative levels of effort recommended, but are not meant to be definitive budgetary projections. Several additional analyses must be performed before this assessment of research needs can be implemented in terms of a budgeted research program.

The references indicated in Exhibit 4 refer to the pages in this report which provide the background information and research descriptions used to generate the dollar estimates shown. The references for each energy technology (listed directly under the technology name) list the pages in which the technology and its key health and environmental problems are described. The research programs in each categorical area are discussed on the pages indicated adjacent to the Biomedical and Environmental Research Category title.

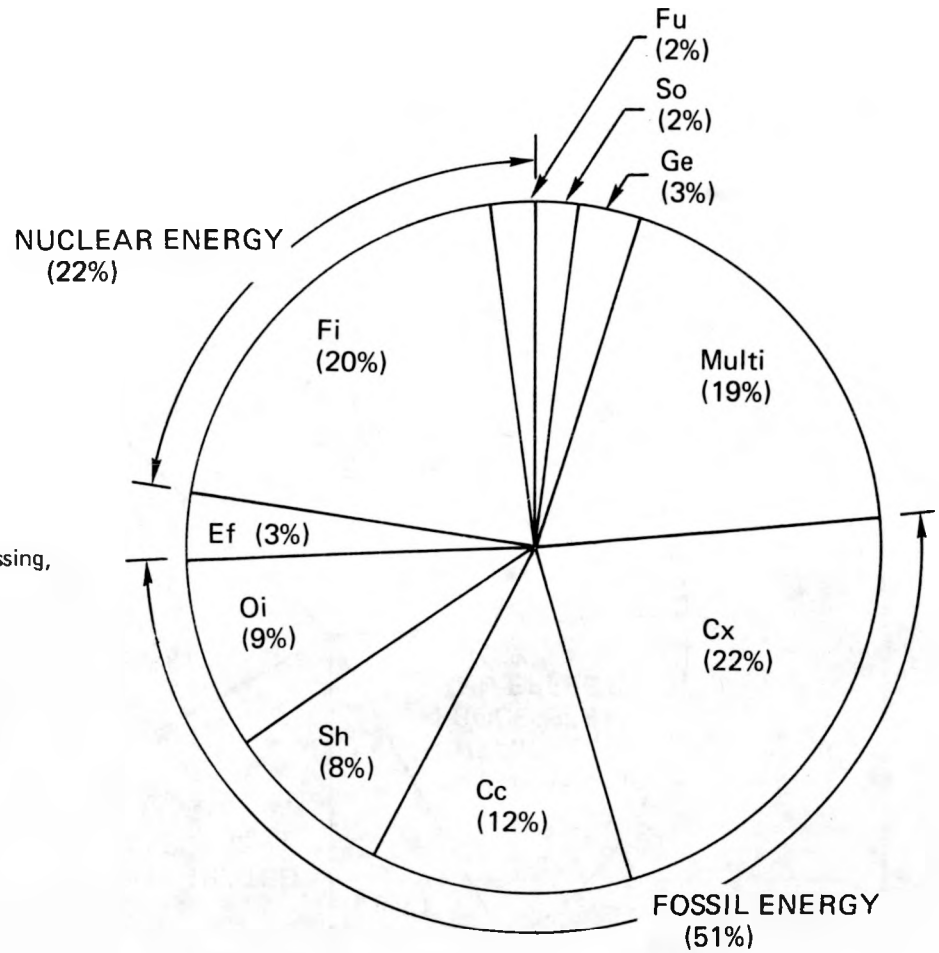


NOTE:

BECAUSE OF THE COMPLEXITY OF THE INTERRELATIONS DEPICTED IN THIS DIAGRAM, DIFFERENT TYPES OF LINES (SOLID, DASHED, DOTTED) ARE USED TO IMPROVE CLARITY IN INDICATING RELATIONSHIPS.

EXHIBIT 1

RELATIONSHIPS OF BIOMEDICAL AND ENVIRONMENTAL RESEARCH ACTIVITIES. Complex interrelationships exists between research activities.



KEY

Cx	Coal Extraction, Processing, & Combustion
Cc	Coal Conversion
Sh	Oil Shale
Oi	Oil & Gas
Ef	Energy Conservation & Efficiency
Fi	Fission
Fu	Fusion
So	Solar
Ge	Geothermal
Multi	Multi-technology

EXHIBIT 2

TOTAL ENVIRONMENTAL RESEARCH EFFORT BY ENERGY TECHNOLOGY. The majority of the environmental research effort is directed toward fossil energy technologies.

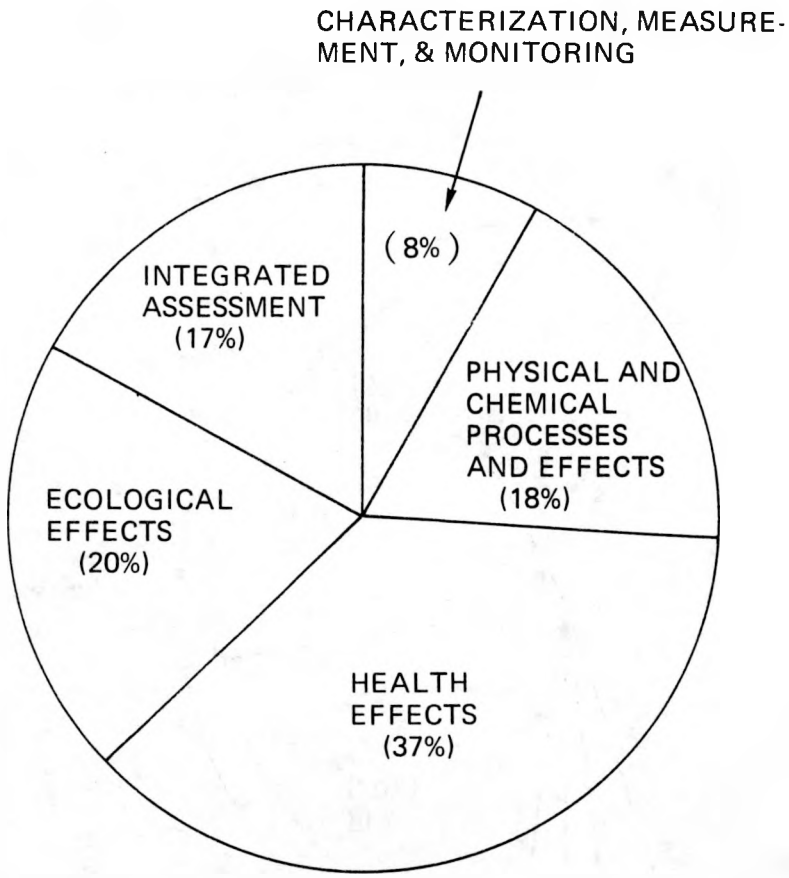


EXHIBIT 3

DISTRIBUTION OF RESEARCH ACTIVITIES BY BIOMEDICAL AND ENVIRONMENTAL CATEGORY. The research effort distribution shown represents a somewhat arbitrary assignment of projects.

ENERGY TECHNOLOGIES / BIOMEDICAL AND ENVIRONMENTAL RESEARCH CATEGORIES		FOSSIL ENERGY				CONSERVATION	SOLAR, GEOTHERMAL AND ADVANCED ENERGY SYSTEMS			NUCLEAR ENERGY		
		COAL EXTRACTION PROCESSING AND COMBUSTION	COAL CONVERSION	OIL SHALE	OIL AND GAS	ENERGY CONSERVATION AND EFFICIENCY	SOLAR	GEO-THERMAL	FUSION	FISSION	MULTI-TECHNOLOGY	TOTAL
	Page Ref.	40-43	44-48	50-54	56-63	64-67	68-72	74-77	78-81	82-86		
Characterization Measurement and Monitoring	90-1 104-15	4.9*	4.9	1.7	1.1	2.6	0.3	2.9	0.3	2.7	0	21.4
Physical, Chemical Processes and Effects	92-3 116-23	15.9	2.3	3.6	11.8	0.5	1.3	1.8	4.1	4.1	2.7	48.1
Ecological Processes and Effects	94-5 116-19 124-8	14.5	2.9	2.6	6.1	0.4	1.5	2.0	0	10.4	15.0	55.4
Health Effects	96-7 139-8 140-3	18.7	20.3	11.2	1.6	0.5	0.3	0.7	1.2	30.6	16.3	101.4
Integrated Assessment and Socioeconomic Process and Effects	98-100 130-3 144-7	6.2	3.4	1.4	2.6	4.1	3.0	1.4	0.4	6.9	17.2	46.6
TOTAL		60.2	33.8	20.5	23.2	8.1	6.4	8.8	6.0	54.7	51.2	272.9

*Table entries are millions of dollars

EXHIBIT 4

PRELIMINARY REQUIREMENTS ANALYSIS FOR AN INITIAL ANNUAL BUDGET OF $272.9M. Health and Environmental implications of each energy technology are described in Section 2 while research efforts related to these problems are presented in Section 3.

The definition and execution of a comprehensive non-redundant program requires that the BPP undergo continual review and updating. Cognizance of the mission and programs of other agencies involved in health and environmental research can be of assistance in preventing overlap with other research efforts, and intra-ERDA coordination will provide for relevance and compatibility with the developing technologies. As energy alternatives are selected for future development, more extensive research efforts in those areas will be required; the continuing surveillance of the developing technologies can ensure that a lack of health or environmental data does not limit or delay their commercialization.

1.0 INTRODUCTION 15

1.1 ERDA Goals 16
1.2 DBER Objectives 18
1.3 Definition of the Balanced Program Plan 20
1.4 Purpose of BPP Documentation 22
1.5 Approach 26

1.1 ERDA Goals

A SET OF EIGHT SPECIFIC GOALS WAS FORMULATED BY ERDA TO SHAPE THE FRAMEWORK FOR A NATIONAL PLAN FOR ENERGY RESEARCH, DEVELOPMENT AND DEMONSTRATION:* THE SEVENTH OF THESE IS A MAJOR FOCUS OF DBER RESEARCH AND ASSESSMENT.

- EXPAND THE DOMESTIC SUPPLY OF ECONOMICALLY RECOVERABLE RAW MATERIALS USED FOR PRODUCING ENERGY.
- INCREASE THE UTILIZATION OF ESSENTIALLY INEXHAUSTIBLE DOMESTIC ENERGY RESOURCES.
- EFFICIENTLY TRANSFORM FUEL RESOURCES INTO MORE DESIRABLE FORMS.
- INCREASE THE EFFICIENCY AND RELIABILITY OF THE PROCESSES USED IN THE ENERGY CONVERSION AND DELIVERY SYSTEMS.
- TRANSFORM CONSUMPTION PATTERNS TO IMPROVE ENERGY UTILIZATION.
- INCREASE END-USE EFFICIENCY.
- PROTECT AND ENHANCE THE GENERAL HEALTH, SAFETY, WELFARE AND ENVIRONMENT RELATED TO ENERGY.
- PERFORM BASIC AND SUPPORTING RESEARCH AND TECHNICAL SERVICES RELATED TO ENERGY.

*ERDA-48, A NATIONAL PLAN FOR ENERGY RESEARCH, DEVELOPMENT AND DEMONSTRATION: CREATING CHOICES FOR THE FUTURE, VOLUME 1: THE PLAN, June 1975, p. III-1.

1.2 DBER Objectives

DBER'S MAIN OBJECTIVE IS TO DETERMINE, THROUGH SCIENTIFIC RESEARCH AND ASSESSMENTS, THE HEALTH AND ENVIRONMENTAL EFFECTS OF ENERGY TECHNOLOGY DEVELOPMENT AND APPLICATIONS: TO EXPLORE METHODS OF MITIGATING ADVERSE EFFECTS; AND TO PROVIDE THE BASIS FOR FORMULATING AND IMPLEMENTING POLICIES TO ENSURE THE SAFE AND SOCIALLY ACCEPTABLE DEVELOPMENT OF ENERGY TECHNOLOGIES.

- ENERGY TECHNOLOGY DEVELOPMENT REQUIRES PARALLEL ENVIRONMENTAL RESEARCH AND ASSESSMENTS TO ALLOW COMMERCIALIZATION WITH MINIMAL HEALTH AND ENVIRONMENTAL RISKS.
- RESULTS OF DBER RESEARCH WILL HAVE MAJOR IMPACTS ON POLICIES AND DECISIONS CONCERNING ENERGY OPTIONS.
- THE RESEARCH PROGRAM MUST BE RESPONSIVE TO TECHNOLOGICAL DEVELOPMENTS AND MUST ANTICIPATE EVOLVING ENVIRONMENTAL CONCERNS.

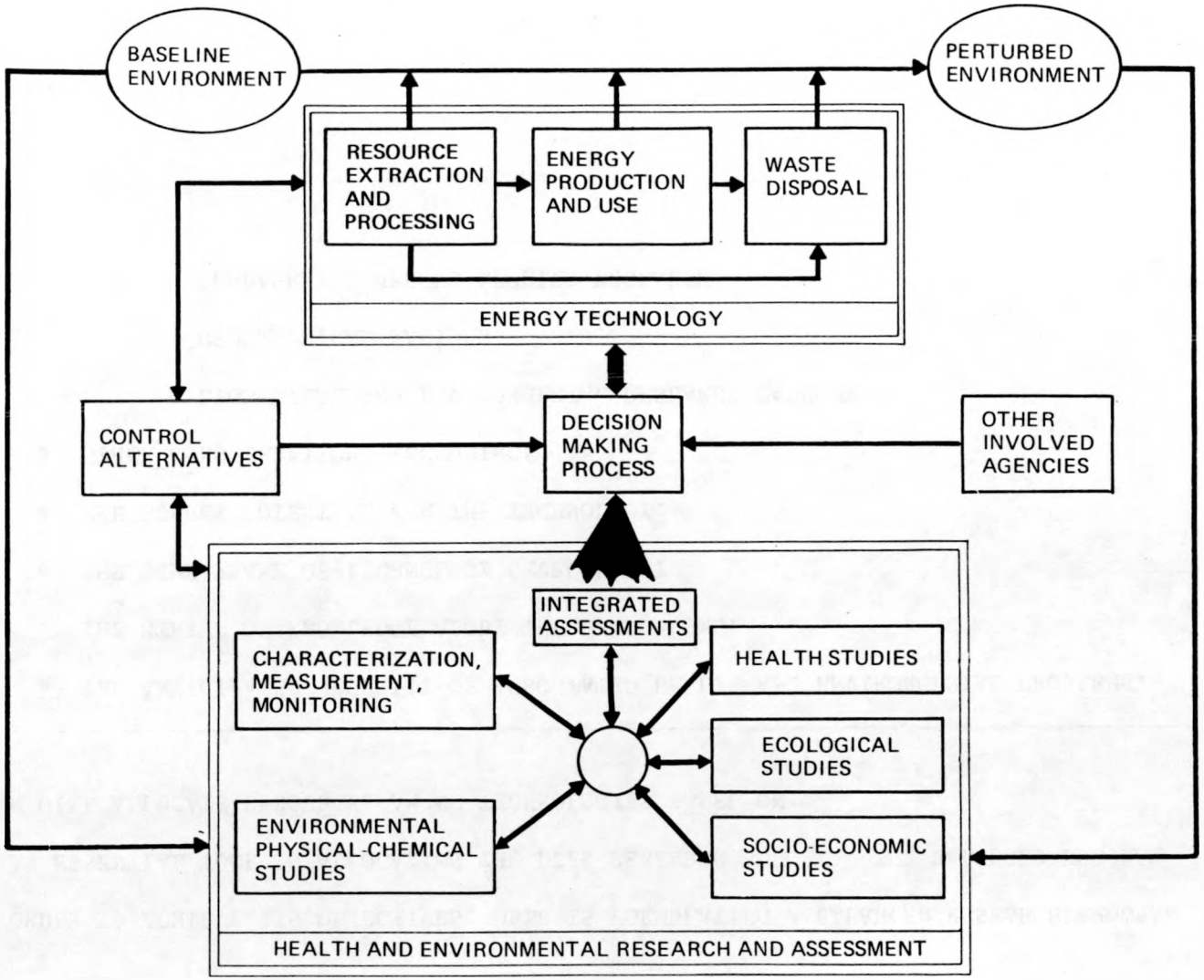


EXHIBIT 5

DIVISION OF BIOMEDICAL AND ENVIRONMENTAL RESEARCH SUPPORT OF ENERGY POLICY AND TECHNOLOGY. The decision-making process on energy technologies is affected by environmental concerns.

1.3 Definition of the Balanced Program Plan

IN ORDER TO ACHIEVE ITS OBJECTIVES, DBER IS FORMULATING A BALANCED RESEARCH PROGRAM AS AN ESSENTIAL TOOL IN ALLOCATING THE DBER RESEARCH BUDGET. THE BALANCED PROGRAM PLAN WILL ALLOCATE RESOURCES AMONG TECHNOLOGIES BASED ON:

- THE ANTICIPATED SEVERITY OF ASSOCIATED HEALTH AND ENVIRONMENTAL PROBLEMS.
- THE STATUS OF KNOWLEDGE ABOUT THESE PROBLEMS.
- THE TIME-FRAME OF TECHNOLOGY DEVELOPMENT.
- THE SUPPLY POTENTIAL FOR THE TECHNOLOGY.
- OTHER CONSIDERATIONS INCLUDING:
  - BIOMEDICAL AND ENVIRONMENTAL RESEARCH CATEGORIES.
  - GEOGRAPHICAL FACTORS.
  - FUNDAMENTAL VERSUS APPLIED RESEARCH.

Biomedical and Environmental Research Categories*	Characterization, Measurement and Monitoring Environmental and Physical Processes and Effects Health Effects Ecological Processes and Effects Integrated Assessment, Social Processes and Effects
Energy Technologies*	Coal Extraction Processing and Combustion (Cx) Coal Conversion (Cc) Oil Shale (Sh) Oil and Gas (Oi) Conservation (Ef)** Solar (So) Geothermal (Ge) Fusion (Fu) Fission (Fi)
Time-Phased Needs	Near Term, before 1985 Mid Term, 1985-2000 Long Term, beyond 2000
Geographical Focus	Site Specific Studies Regional Studies National and Global Studies
Type of Research	Fundamental Applied

*Defined more fully in Sections 1 and 2.

**Notation in parentheses represents nomenclature to facilitate subsequent references to environmental categories and technology options.

EXHIBIT 6

ELEMENTS AFFECTING STRUCTURE OF A BALANCED RESEARCH PROGRAM

1.4 Purpose of BPP Documentation (a)

THE BPP MUST PROVIDE, FOR EACH ENERGY TECHNOLOGY, A PROGRAM OF HEALTH AND ENVIRONMENTAL RESEARCH DIRECTED TOWARD THE IDENTIFICATION AND QUANTIFICATION OF POTENTIAL (OR EXISTING) ENVIRONMENTAL PROBLEMS, AND THE ASSESSMENT OF METHODS FOR MITIGATING EFFECTS.

- EACH DEVELOPING TECHNOLOGY MAY PRODUCE HEALTH, ECOLOGICAL AND/OR SOCIOECONOMIC EFFECTS WHICH REQUIRE ENVIRONMENTAL ASSESSMENT DURING THE RD&D CYCLE FROM PILOT TESTING TO COMMERCIAL DEMONSTRATION.
- TECHNOLOGY DEVELOPMENT TIMELINES REQUIRE DEVELOPMENT AND REVIEW OF ENVIRONMENTAL DATA AT SPECIFIED POINTS IN TIME.
- ENERGY SUPPLY POTENTIAL, TECHNOLOGICAL AND ECONOMIC FEASIBILITY, AS WELL AS PERCEIVED ENVIRONMENTAL AND HEALTH PROBLEMS WILL INFLUENCE THE DEVELOPMENT OF THE VARIOUS ENERGY ALTERNATIVES.

1.4 Purpose of BPP Documentation (b)

THE BPP MUST PROVIDE GUIDELINES TO INVESTIGATORS REGARDING KEY BIOMEDICAL AND ENVIRONMENTAL RESEARCH AREAS, ON A TIME-PLANNED BASIS.

- HEALTH AND ENVIRONMENTAL RESEARCH PLANNING REQUIRES DEFINITION OF THE PROBLEM AND DELINEATION OF THE RESEARCH TASKS.
- ENVIRONMENTAL RESEARCH PROJECTS MUST BE PROPOSED AND FUNDING INITIATED WITHIN SPECIFIED TIME PERIODS TO MEET TECHNOLOGY DEVELOPMENT SCHEDULES.
- RESEARCH CAPABILITIES, STAFF AND EQUIPMENT MUST BE APPLIED TO ADDRESS IMMEDIATE NEEDS AND DEVELOPED CONSISTENT WITH LONGER-RANGE OBJECTIVES.
- INTERRELATIONSHIPS BETWEEN VARIOUS PROJECTS MUST BE IDENTIFIED.

1.4 Purpose of BPP Documentation (c)

THE BPP MUST DEFINE THE DBER RESEARCH PROGRAM TO FACILITATE COORDINATION AND COOPERATION WITH OTHER FEDERAL STATE, LOCAL, AND INDUSTRIAL PROGRAMS IN HEALTH AND ENVIRONMENTAL RESEARCH.

- A UNIFIED PLANNING PROCESS FOR FEDERAL RESEARCH WILL BE FACILITATED.
- DBER PROJECTS WILL COMPLEMENT OTHER RESEARCH.
- ALL USERS OR POTENTIAL USERS WILL BE INFORMED OF PROGRAMS.

1.5 Approach (a)

THE PLANNING PROCESS REQUIRES A SERIES OF STEPS INCLUDING THE DEFINITION OF GOALS AND PROGRAM REQUIREMENTS; DEVELOPMENT OF A METHOD TO ALLOCATE RESOURCES; AND ULTIMATELY IMPLEMENTATION OF THE REQUIRED RESEARCH INTO THE DBER PROGRAM.

- CURRENT ACTIVITIES HAVE RESULTED IN AN EXAMINATION ANALYSIS OF RESEARCH REQUIREMENTS.
- CONTINUING EFFORT WILL BE PLACED ON THE PROGRAM STRUCTURE, RESEARCH RELATIONSHIPS AND RANKING METHODOLOGY.
- FINAL IMPLEMENTATION WILL REQUIRE CONSIDERATION OF ONGOING RESEARCH AND PRESENT RESEARCH COMMITMENTS.
- PLANNING REQUIRES UPDATING AS NEW UNDERSTANDING IS GAINED OR AS TECHNOLOGY TIME LINES CHANGE.

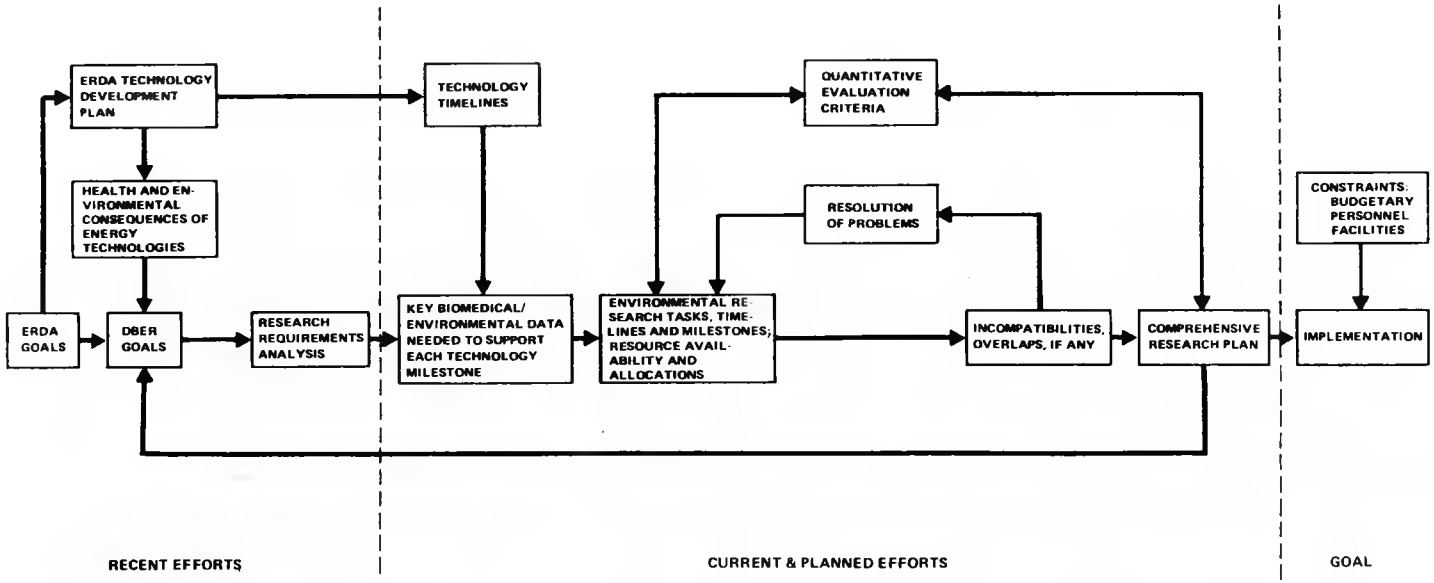


EXHIBIT 7

THE BALANCED PROGRAM PLAN PLANNING PROCESS. Program Planning is a continuing activity requiring a number of studies and analyses.

1.5 Approach (b)

CURRENT PLANNING EFFORTS HAVE FOCUSED UPON DEFINITION AND ANALYSIS OF RESEARCH REQUIREMENTS.

- PLANNING EFFORT INVOLVED BOTH BER HEADQUARTERS AND NATIONAL LABORATORY PERSONNEL.
- EMPHASIS WAS PLACED ON THE COORDINATION OF RESEARCH DISCIPLINES AND TECHNOLOGY RELATED HEALTH AND ENVIRONMENTAL PROBLEMS.
- REQUIREMENTS WERE DEFINED INDEPENDENTLY OF EXISTING PROGRAMS AND COVERED ONLY ENERGY TECHNOLOGY PROBLEM AREAS.
- TIMING OF BPP DEVELOPMENT ALLOWED INITIAL INPUT INTO THE FY77 BUDGETING PROCESS AND PROVIDES A MAJOR FOCUS FOR FUTURE PROGRAM DEFINITION AND BUDGETING.
- BUDGETARY CONSTRAINTS WERE NOT IMPOSED ON THE REQUIREMENTS DEFINITION.

1.5 Approach (c)

CONTINUING BPP ACTIVITIES ARE BEING DIRECTED TOWARD THE CORRELATION OF HEALTH AND ENVIRONMENTAL RESEARCH REQUIREMENTS WITH ENERGY TECHNOLOGY TIMELINES AND MILESTONES AND THE FORMULATION OF AN IMPLEMENTABLE RESEARCH PROGRAM TO SUPPORT THE BUDGET DEVELOPMENT AND MANAGEMENT FUNCTIONS.

- AN INTEGRATED HEALTH AND ENVIRONMENTAL RESEARCH PROGRAM SUPPORTING EACH ENERGY TECHNOLOGY IS BEING DEFINED.
- RELATIVE PRIORITIES ARE BEING DEVELOPED BASED ON THE IMPORTANCE OF THE ENERGY TECHNOLOGY AND THE SEVERITY OF THE HEALTH AND ENVIRONMENTAL PROBLEMS.
- ULTIMATE INTEGRATION OF RESULTS INTO THE ANNUAL DBER PLANNING AND BUDGETING PROCESS IS THE OVERALL BPP OBJECTIVE.
- MECHANISMS ARE UNDER DEVELOPMENT FOR THE CONTINUING REVIEW OF DEVELOPING ENERGY TECHNOLOGIES, AND THE REVISION AND UPDATING OF THE RESEARCH PLAN.

1.5 Approach (d)

INITIAL BPP COORDINATION TOOK PLACE AT A WORKSHOP SESSION INVOLVING HEADQUARTERS AND LABORATORY PERSONNEL AND WAS FURTHER ADDRESSED IN THE DETAILED REVIEW AND REVISION OF THIS DOCUMENT.

- DOCUMENTS GENERATED BY ALL NATIONAL LABS AND HEADQUARTERS STAFF WERE EXCHANGED AND REVIEWED PRIOR TO THE WORKSHOP.
- THE MAJOR HEALTH AND ENVIRONMENTAL PROBLEMS FOR EACH TECHNOLOGY WERE IDENTIFIED, AND RANKED ACCORDING THE THE SEVERITY AND EXTENT OF THE IMPACTS AND THE URGENCY AND NEED FOR THE RESEARCH.
- BUDGET ESTIMATES WERE DEVELOPED FOR THE IDENTIFIED HEALTH AND ENVIRONMENTAL RESEARCH.
- SCHEDULES WERE DEVELOPED FOR CONTINUED PLANNING ACTIVITIES.

2.0 ENERGY TECHNOLOGIES 31

2.1 Aspects of Energy Technology Research 32
2.2 Timelines and Energy Supply Potential 34
2.3 Pollutant and Nonpollutant Effects of Energy Technologies 36
2.4 Technology Descriptions and Key Health and Environmental Problems 40

2.4.1 Coal Extraction, Processing, and Combustion 40
2.4.2 Coal Conversion 44
2.4.3 Oil Shale 50
2.4.4 Oil and Natural Gas 56
2.4.5 Energy Conservation and Efficiency 64
2.4.6 Solar Energy 68
2.4.7 Geothermal Energy 74
2.4.8 Fusion 78
2.4.9 Fission 82

2.1 Aspects of Energy Technology Research

NINE ENERGY TECHNOLOGIES HAVE BEEN IDENTIFIED FOR HEALTH AND ENVIRONMENTAL RESEARCH BY FUEL CYCLE COMPONENT.

- TECHNOLOGIES ARE: COAL EXTRACTION, PROCESSING AND COMBUSTION (Cx); COAL CONVERSION (Cc); OIL SHALE (Sh); OIL AND GAS (Oi); CONSERVATION AND ENERGY EFFICIENCY (Ef); SOLAR (So); GEOTHERMAL (Ge); FUSION (Fu); and FISSION (Fi).

- ENVIRONMENTAL PROBLEMS ASSOCIATED WITH AN ENERGY TECHNOLOGY MAY OCCUR WITHIN ONE OR MORE COMPONENTS OF ITS FUEL CYCLE.

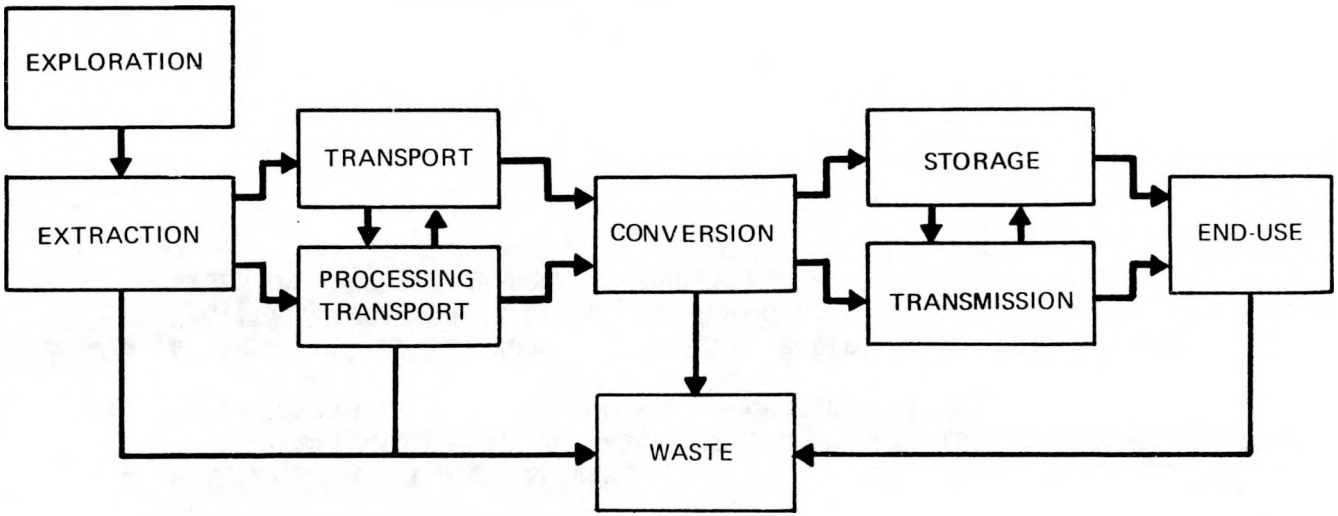


EXHIBIT 8

GENERALIZED ENERGY TECHNOLOGY FUEL CYCLE. A specific technology may include only part of this generalized fuel cycle; health and environmental problems may result from wastes and residuals arising from any of the components.

2.2 Timelines and Energy Supply Potential

DBER'S BPP SHOULD BE RESPONSIVE TO ERDA'S SCHEDULE FOR TECHNOLOGY DEVELOPMENT.

- HEALTH AND ENVIRONMENTAL RESEARCH MUST BE CONDUCTED IN PARALLEL WITH ENERGY TECHNOLOGY DEVELOPMENT TO ENSURE THAT COMMERCIALIZATION CAN BE ATTAINED IN AN ENVIRONMENTALLY SAFE AND SOCIALLY ACCEPTABLE MANNER.

- UNDER A CONSTRAINED BUDGET SITUATION, ENVIRONMENTAL RESEARCH SHOULD MOST HEAVILY SUPPORT THOSE ENERGY TECHNOLOGIES WHICH HAVE GREATEST SUPPLY POTENTIAL BASED ON APPROPRIATE ERDA SCHEDULES AND PROJECTIONS.

TECHNOLOGY	ANTICIPATED INCREASE IN ENERGY SUPPLY (In Quads)		PLANNED DEVELOPMENT					
			COMPLETION BEFORE 1980		COMPLETION 1980-1985		COMPLETION AFTER 1985	
	By 1985	By 2000	Pilot	Demonstration	Pilot	Demonstration	Pilot	Demonstration
Coal (Direct Utilization)	6+	9+	2		4			
Coal Conversion	0-1	9+						
. Gasification			6		2		1	
. Liquefaction			1		4			
Oil Shale	0-2.5	0-4.5				3		
Oil and Gas (Enhanced Recovery)	6+	9+				9		
Conservation								
. Buildings & Consumer Products	2.5-6	4.5-9		1		1		1
. Electric Conversion Efficiency		0-4.5	2	2		4		4
. Electric Power Transmission and Distribution		0-4.5				3	1	3
. Electric Transport		0-4.5						
. Energy Storage			1	4		5		
. Industrial Energy Efficiency	2.5-6	4.5-9		2		3		
. Transportation Efficiency	2.5-6	4.5-9		9		5		
. Waste Materials to Energy	0-2.5	4.5-9						
Solar								
. Fuels from Biomass		0-2			6		3	1
. Solar Electric	0-1	0-4.5			10	6	1	3
. Solar Heating and Cooling	0-1	4.5-9				9		1
Geothermal	0-1	2.5-6			6	2	3	
Fusion	Very major post-2000		(No planned pilots or demonstrations identified at this time)					
Fission								
. Breeder Reactors	Very major post-2000					1		2
. Converter Reactors	6+	9+				1		1
TOTALS			12	18	32	51	9	16

SOURCE: "A National Plan for Energy Research Development and Demonstration: Creating Energy Choices for the Future," Volumes 1 and 2, ERDA-48, Energy Research and Development Administration, June 1975.

EXHIBIT 9

TIMELINES OF ENERGY SUPPLY POTENTIAL. Health and environmental research planning requires consideration of ERDA energy technology development schedules.

2.3 Pollutant and Nonpollutant Effects of Energy Technologies

TECHNOLOGY DEVELOPMENT IMPACTS ON THE ENVIRONMENT THROUGH BOTH POLLUTANT EFFECTS AND A VARIETY OF NONPULLUTANT EFFECTS.

- IDENTIFIED POLLUTANTS INCLUDE ORGANICS, INORGANICS AND RADIOISOTOPES.
- NONPOLLUTANT PROBLEMS INVOLVE CULTURAL AND SOCIAL EFFECTS (e.g., ECONOMICS) AS WELL AS PHYSICAL-CHEMICAL CHANGES (e.g., SEISMICITY, WEATHER MODIFICATION) WHICH MAY IMPACT ON HEALTH AND ECOLOGY.
- THE IDENTIFICATION OF ENVIRONMENTAL PROBLEMS COMMON TO SEVERAL TECHNOLOGIES DEFINES COMMON AREAS OF RESEARCH AND PREVENTS DUPLICATION OF EFFORT.

Technology	POLLUTANTS																					PHYSICAL DISTURBANCES						
	INORGANIC							ORGANIC				RADIOISOTOPES																
	NO_x	Sulfur Compounds	CO_x	Heavy Metals	Trace elements	Particulates	Brine	Aliphatic Satur	Unsaturated	Aromatic	Biohazards	Fission Products	Transuranic Elements	^{3}H	^{14}C	^{222}Rn	Activation Products	^{226}RA	^{85}Kr ^{131}I	Thorium		Surface Disturb.	Subsidence	Noise	Seismicity	Weather Mod.	Electro-Mag.	Waste Heat/ Cooling Systems
CONSERVATION																												
Wastes		X	X	X		X				X	X																	
Agriculture	X	X		X		X				X	X																	
Energy Conservation in Buildings			X			X		X			X																	
Electric Power Transmission and Distribution																						X					X	
GEOTHERMAL																												
Extraction																							X		X			
Ex. & Conversion		X	X	X	X	X	X	X								X		X				X		X		X		X
COAL EXTRACTION																												
Extraction		X				X										X		X				X	X	X	X			
Processing	X	X		X	X	X		X	X	X												X						
Combustion	X	X	X	X	X	X		X	X	X																X		X
COAL CONVERSION																												
Liquifaction/ Gasification- Surface	X	X	X	X	X	X		X	X	X																		
In Situ	X	X	X	X	X	X		X	X	X												X	X		X			

EXHIBIT 10

POLLUTANTS AND PHYSICAL DISTURBANCES OF ENERGY TECHNOLOGIES

This list is an example based on available information and is not inclusive (Socioeconomic impacts are discussed on pages (130-133)

Technology	POLLUTANTS																				PHYSICAL DISTURBANCES						
	INORGANIC							ORGANIC				RADIOISOTOPES															
	NO_x	Sulfur Compounds	CO_x	Heavy Metals	Trace Elements	Particulates	Brine	Aliphatic Satur.	Unsaturated	Aromatic	Biohazards	Fission Products	Transuranic elements	^{3}H	^{14}C	^{222}RN	Activation Products	^{226}RA	^{85}Kr, ^{131}I	Thorium	Surface Disturb.	Subsidence	Noise	Seismicity	Weather Mod.	Electro-Mag.	Waste Heat/Cooling Systems
OIL SHALE																											
Exploration & Extract.					X	X										X					X						
Processing & Transport	X	X				X	X	X	X	X						X											
OIL & GAS																											
Exploration & Extract.	X	X					X	X								X					X	X	X	X			
Refining, Storage	X	X	X		X			X															X		X		
Combustion	X	X	X	X		X		X	X	X											X	X	X				X
SOLAR ENERGY																											
Solar Thermal Conv.					X			X													X				X		X
Heating & Cooling																									X		
Photovoltaic Conv.		X		X	X																X				X		
Wind Energy Conv.																					X		X		X	X	
Ocean Thermal				X	X																				X		
Bioconversion	X			X	X	X		X	X	X	X										X				X		

EXHIBIT 10
POLLUTANTS AND PHYSICAL DISTURBANCES OF ENERGY TECHNOLOGIES

(Continued)

Technology	POLLUTANTS																				PHYSICAL DISTURBANCES						
	INORGANIC							ORGANIC				RADIOISOTOPES															
	NO_x	Sulfur Compounds	CO_x	Heavy Metals	Trace Elements	Particulates	Brine	Aliphatic Satur.	Unsaturated	Aromatic	Biohazards	Fission Products	Transuranic Elements	^{3}H	^{14}C	^{222}RN	Activation Products	^{226}RA	^{85}Kr, ^{131}I	Thorium	Surface Disturb.	Subsidence	Noise	Seismicity	Weather Mod.	Electro-Mag.	Waste Heat/Cooling Systems
FISSION																											
Exploration and Extraction				X	X	X							X			X		X			X						
Processing and Transport	X	X			X	X										X	X	X		X							
Conversion					X							X	X	X	X										X		X
Storage, Transmission and End-Use												X	X	X			X		X								
FUSION																											
Processing and Transport														X			X									X	X
Conversion				X										X	X		X										

EXHIBIT 10
POLLUTANTS AND PHYSICAL DISTURBANCES OF ENERGY TECHNOLOGIES
(Concluded)

2.4 Technology Descriptions and Key Health and Environmental Problems

2.4.1 Technology Description: Coal Extraction, Processing, and Combustion

THE TREMENDOUS DOMESTIC RESERVES OF COAL ACCORD THIS FOSSIL FUEL A MAJOR ROLE IN NEAR-(BEFORE 1985) AND MID-TERM (1985-2000) ENERGY SUPPLY.

- MAJOR COAL FIELDS ARE LOCATED IN THE EAST (APPALACHIA), MIDWEST, THE WEST, AND ALASKA; A MAJOR EXPANSION IN EXTRACTION ACTIVITIES IS FORESEEN WITH SIGNIFICANT, REGIONALLY-DEPENDENT EFFECTS.
- EXPANSION OF MINING MUST OCCUR TO SUPPORT BOTH INCREASED DIRECT UTILIZATION AND ALSO THE NEW TECHNOLOGIES TO CONVERT COAL INTO LIQUID AND GASEOUS FUELS.
- NEW PROCESSING (e.g., SOLVENT REFINING) AND TRANSPORT (e.g. SLURRY PIPELINES) TECHNOLOGIES ARE UNDER INVESTIGATION AND WILL ASSIST EXPLOITATION OF THE RESOURCE.
- NEW TECHNIQUES FOR MORE EFFICIENTLY CONVERTING COAL INTO ELECTRICAL ENERGY ARE UNDER DEVELOPMENT (FLUIDIZED BED, MHD, TOPPING AND BOTTOMING CYCLES).
- MANY OF THE PROCEDURES AND PROCESSES DEVELOPED FOR AND UTILIZED BY THE COAL INDUSTRY MAY BE APPLIED TO OTHER FOSSIL FUEL TECHNIQUES, (MINING TECHNIQUES, TRANSPORTATION SYSTEMS, ETC.).

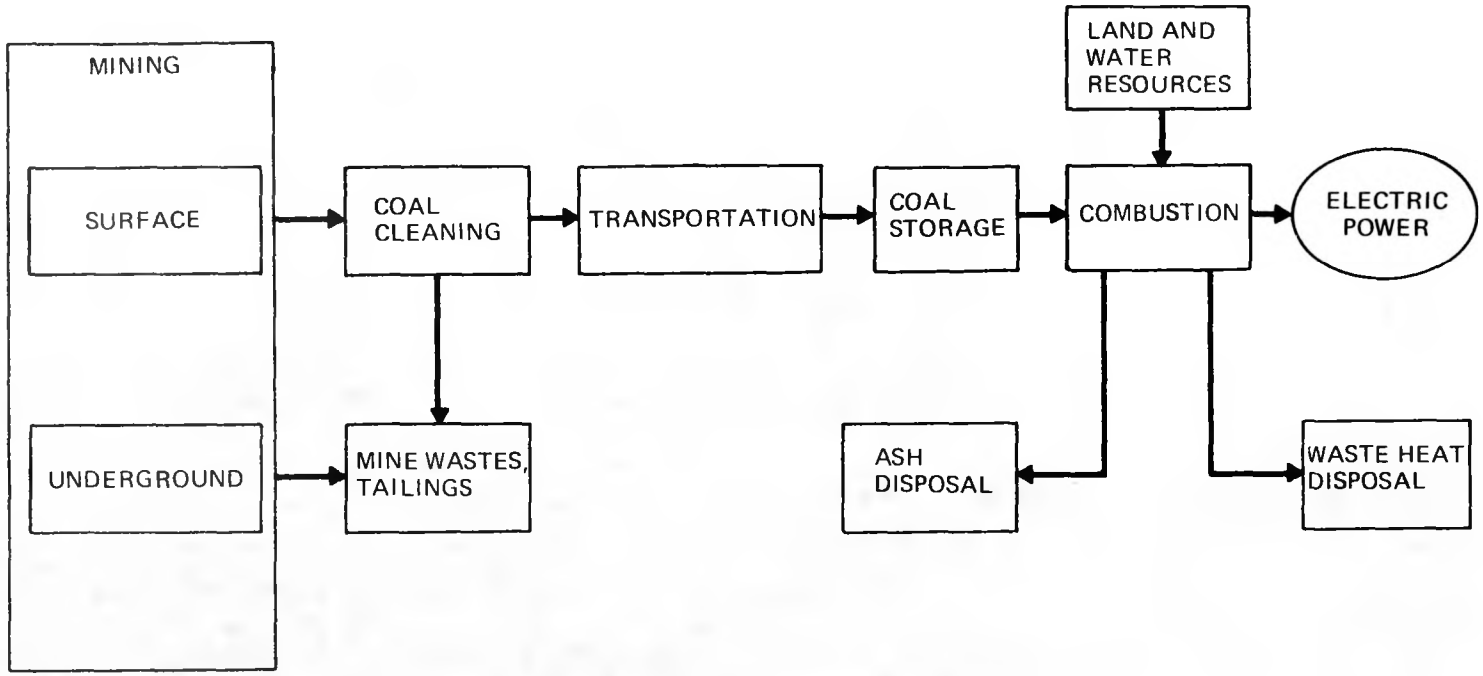


EXHIBIT 11

FUEL CYCLE FOR COAL EXTRACTION, PROCESSING, AND COMBUSTION. Major health and environmental problems are associated with every stage of the fuel cycle.

2.4.1 Environmental Problems: Coal Extraction, Processing, Combustion

ENVIRONMENTAL CONCERNS HAVE BEEN IMPORTANT CONSTRAINTS TO THE USE OF COAL; MAJOR EXPANSION OF THIS ENERGY SOURCE DEPENDS ON THE DEVELOPMENT AND APPLICATION OF ENVIRONMENTALLY ACCEPTABLE PROCESSES AND TECHNIQUES.

- MAJOR ENVIRONMENTAL AND HEALTH PROBLEMS HAVE BEEN IDENTIFIED AND RELATED TO EACH STAGE OF THE COAL FUEL CYCLE.
- INCREASED COAL PRODUCTION WILL COMPOUND EXISTING ENVIRONMENTAL AND HEALTH PROBLEMS.
- ATMOSPHERIC EMISSIONS (PARTICULATES, TRACE ELEMENTS, GASEOUS COMBUSTION PRODUCTS) OCCUR AT ALL STAGES IN THE FUEL CYCLE.
- MAJOR WATER POLLUTION PROBLEMS CAN BE CAUSED BY MINING OPERATIONS, COAL CLEANING, AND THE OPERATION OF COOLING SYSTEMS AT COMBUSTION PLANTS.
- OCCUPATIONAL HEALTH PROBLEMS AND THE SOCIOECONOMIC IMPLICATIONS OF MAJOR FACILITIES ARE CONTINUING CONCERNS AT THE LOCAL, REGIONAL AND NATIONAL LEVELS.

EXHIBIT 12
KEY HEALTH AND ENVIRONMENTAL PROBLEMS FROM
COAL EXTRACTION, PROCESSING AND COMBUSTION

Key Problems	Problem Description
Lack of effective reclamation methods for strip-mined areas.	Significant land disturbance and land use disruption occur during surface mining operations; restoration of natural habitats, biological productivity and esthetic character in mined areas under varying climatological, topographical and soil conditions are essential to the expansion of coal extraction activities.
Impairment by surface mining of water availability and quality in semi-arid regions.	Mining processes and especially restoration techniques require large quantities of water (a scarce resource in many areas); additionally, sediment and leachates from the mining operations can pose significant water quality problems.
Impairment of agricultural productivity and quality due to coal extraction, processing and combustion.	Operations in the coal fuel cycle often occur in the vicinity of agricultural operations; pollutant releases (especially atmospheric) may have deleterious effects on productivity and on the quality of crops and livestock produced.
Socioeconomic effects of the coal production/utilization cycle.	The population shifts, land-use changes and economic implications of a major expansion in coal production and utilization may cause serious consequences in terms of social values and welfare at the local, regional and national levels.
Health implications of coal extraction and combustion.	Occupational health hazards include black lung, silicosis, cancer, explosions, falling rock, etc. Atmospheric pollutants emitted from the coal combustion processes have been implicated as causes or contributory factors in human disease etiologies.

2.4.2 Technology Description: Coal Conversion

COAL CONVERSION IS EXPECTED TO MAKE A MAJOR MID-TERM CONTRIBUTION TO THE NATION'S ENERGY NEEDS.

- IN THIS TECHNOLOGY COAL IS CONVERTED TO GASEOUS, LIQUID OR SOLID HYDROCARBON FUELS.
- A MAJOR ADVANTAGE OF THIS TECHNOLOGY IS ITS USE OF COAL, WHICH IS IN ABUNDANT SUPPLY IN THIS COUNTRY.
- DEVELOPMENT OF THIS TECHNOLOGY WILL OCCUR IN COAL RESOURCE REGIONS OF THE COUNTRY.
- CLEAN HYDROCARBON FUELS ARE PRODUCED BY SEVERAL LIQUEFACTION AND GASIFICATION PROCESSES. THE RESULTANT FUELS ARE RICH IN HYDROGEN COMPARED TO THE ORIGINAL COAL.
- IN GASIFICATION, COAL IS COMBINED WITH STEAM AND AIR OR WITH STEAM AND OXYGEN. DEPENDING ON THE SPECIFIC PROCESS, GASIFICATION RESULTS IN CLEAN GAS OF LOW OR INTERMEDIATE BTU VALUE, OR HIGH BTU SUBSTITUTE NATURAL GAS.
- LIQUEFACTION PROCESSES INCLUDE PYROLYSIS UNDER A RELATIVELY INERT ATMOSPHERE (CARBONIZATION) OR UNDER MODERATELY HIGH HYDROGEN PARTIAL PRESSURE (HYDRO-CARBONIZATION), SOLVATION UNDER MODERATE HYDROGENATION, OR HYDROGENATION IN THE PRESENCE OF A CATALYST.
- PROCESSING CAN BE DONE IN SITU OR ON THE SURFACE, RESULTING IN DIFFERENT ENVIRONMENTAL IMPACTS.

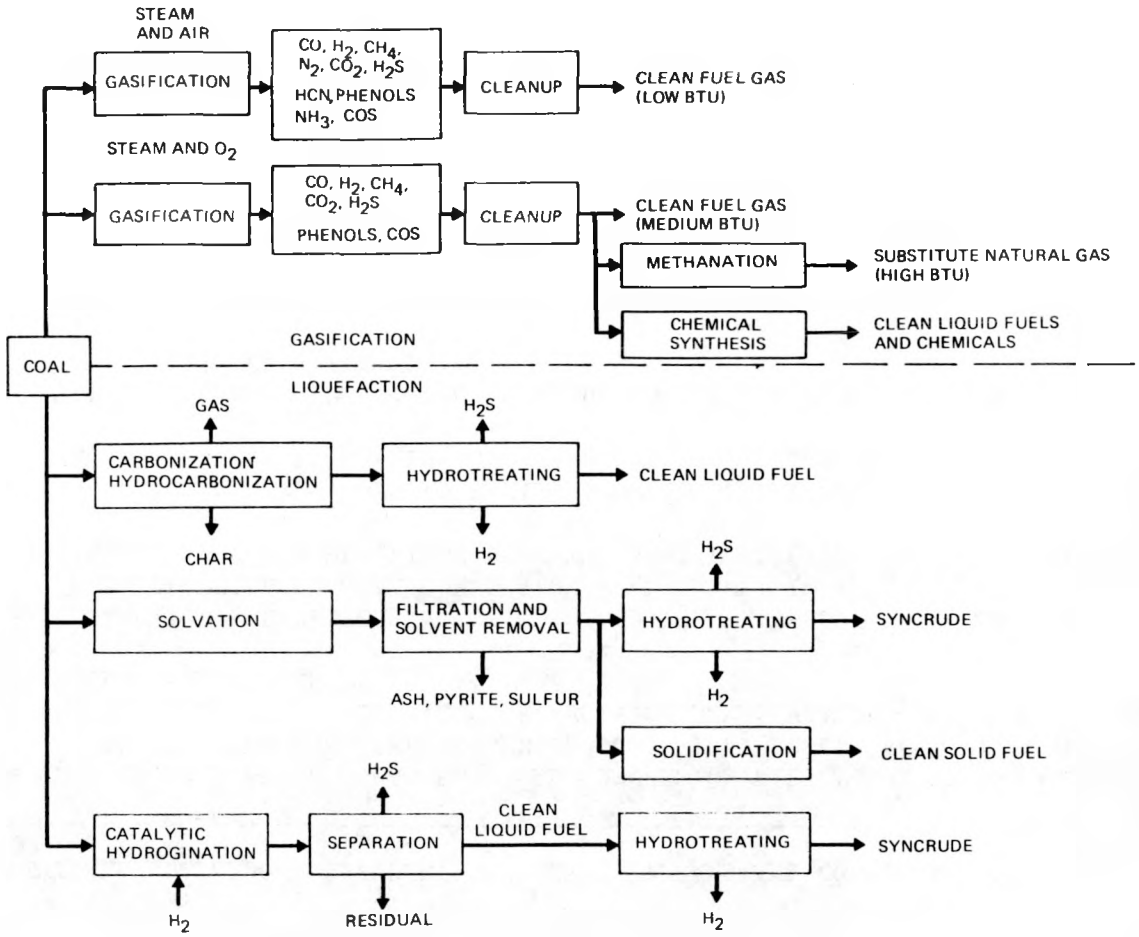


EXHIBIT 13

FUEL CYCLE FOR COAL CONVERSION. Each conversion process may have unique environmental implications.

2.4.2 Health and Environmental Problems: Coal Conversion

THE CONVERSION OF COAL TO LIQUID OR GASEOUS FUELS AND CHEMICAL FEEDSTOCKS WILL RESULT IN POTENTIALLY HAZARDOUS EFFLUENTS, PROCESS STREAMS AND CONVERSION PRODUCTS.

- THE INITIAL BPP PROGRAM FOR COAL CONVERSION WILL FOCUS ON THE CHARACTERIZATION OF EFFLUENTS, PROCESS STREAMS AND PRODUCTS THAT RESULT FROM PILOT OR DEMONSTRATION FACILITIES, AND THEIR DIRECT EFFECTS ON HUMAN HEALTH, NON-HUMAN ORGANISMS, AND ECOLOGICAL PROCESSES.

- EXTRACTION AND PROCESSING OF COAL AND THE TRANSPORT, STORAGE AND USE OF DERIVED FUELS PRODUCED BY COAL CONVERSION WILL RESULT IN ENVIRONMENTAL CONCERNS THAT ARE SIMILAR TO THOSE RESULTING FROM THE SAME FUEL CYCLE STAGES OF EXISTING TECHNOLOGIES.

- ASH AND SOLID RESIDUES RESULTING FROM INCINERATION MAY BE ENVIRONMENTALLY SIGNIFICANT AS LEACHATES AND AIR-BORNE PARTICULATES.

- THE CHEMICAL COMPOSITION OF GASEOUS AND LIQUID FUELS MAY IMPOSE ENVIRONMENTAL CONSTRAINTS ON THEIR USE.

- CHEMICAL COMPOSITION OF EFFLUENT CONSTITUENTS WILL BE DEPENDENT ON COAL COMPOSITION AND PROCESS TECHNOLOGY.

EXHIBIT 14

KEY HEALTH AND ENVIRONMENTAL PROBLEMS FROM COAL CONVERSION

Key Problems	Problem Definition
Insufficient biomedical and environmental data base for coal conversion processes	Pollutant-related and other environmental consequences of coal conversion have not been adequately determined. Available information relating to characteristics and effects of coal conversion processes and products must be synthesized and evaluated as a basis for future research. Significant geological and hydrological parameters must be identified, and effluent emissions, stream process components, and waste materials must be qualititatively and quantitatively characterized at demonstration sites.
Fate of coal conversion effluents	Potentially hazardous elements and compounds will be transported and modified by physical and chemical processes, and transferred, modified and accumulated in biological systems. Abiotic and biological pathways and end products must be delineated.
Ecological effects of pollutants	Because emissions and waste products of coal conversion will be qualitatively and quantitatively unique, their potential effects on non-human organisms must be assessed. Responses of selected organisms to exposure of organic and inorganic compounds, and population and community effects of pollutants in the vicinity of demonstration plants are important indications of ecological impacts.
Health effects of occupational exposures for coal conversion processes.	Chemicals employed in coal conversion processes and resulting effluents and waste materials may contain particles, organic and inorganic compounds, and trace elements that are hazardous to industry and workers. Especially important may be the late effects induced by chronic, low level exposure. Occupation experience can guide the identification, quantification and ultimate mitigation of general population health risks.

(Continued)

EXHIBIT 14

KEY HEALTH AND ENVIRONMENTAL PROBLEMS FROM COAL CONVERSON

(Continued)

Key Problems	Problem Definition
Technological and facility siting decisions	In the next four to ten years the wide range of technology options currently under development will be narrowed to a select group suitable for commercialization. Environmental data will be essential in formulating correct technological decisions. Similarly, coal conversion sites will be selected and should be chosen.

2.4.3 Technology Description: Oil Shale

SHALE OIL IS EXPECTED TO MAKE A MODERATE CONTRIBUTION TO THE NATION'S ENERGY NEEDS IN THE NEAR- AND MID-TERM; LONG-TERM (BEYOND 2000) PROSPECTS DEPEND ON COMPETING (NON-ENERGY) NEEDS AS ALL HYDROCARBON RESERVES BECOME VERY DILUTE AND MORE EXPENSIVE.

- THIS TECHNOLOGY INVOLVES THE RECOVERY OF USABLE PETROLEUM PRODUCTS FROM OIL-BEARING SHALE.
- A MAJOR ADVANTAGE OF THIS TECHNOLOGY IS THAT RESULTANT PETROLEUM PRODUCTS CAN BE READILY UTILIZED.
- THE RICHEST U.S. OIL SHALE DEPOSITS ARE LOCATED IN THE GREEN RIVER FORMATION OF COLORADO, UTAH AND WYOMING.
- SIGNIFICANT FUEL CYCLE ELEMENTS OF THIS TECHNOLOGY ARE EXTRACTION, PROCESSING AND RETORTING.
- BOTH CONVENTIONAL AND IN SITU RECOVERY METHODS HAVE BEEN DEVELOPED OR PROPOSED.
- PRESENT DEVELOPMENT OF THIS TECHNOLOGY IS LIMITED BY HIGH CAPITAL INVESTMENT REQUIREMENTS, POTENTIALLY SERIOUS ENVIRONMENTAL CONSEQUENCES, AND THE SCARCE REGIONAL WATER SUPPLIES.

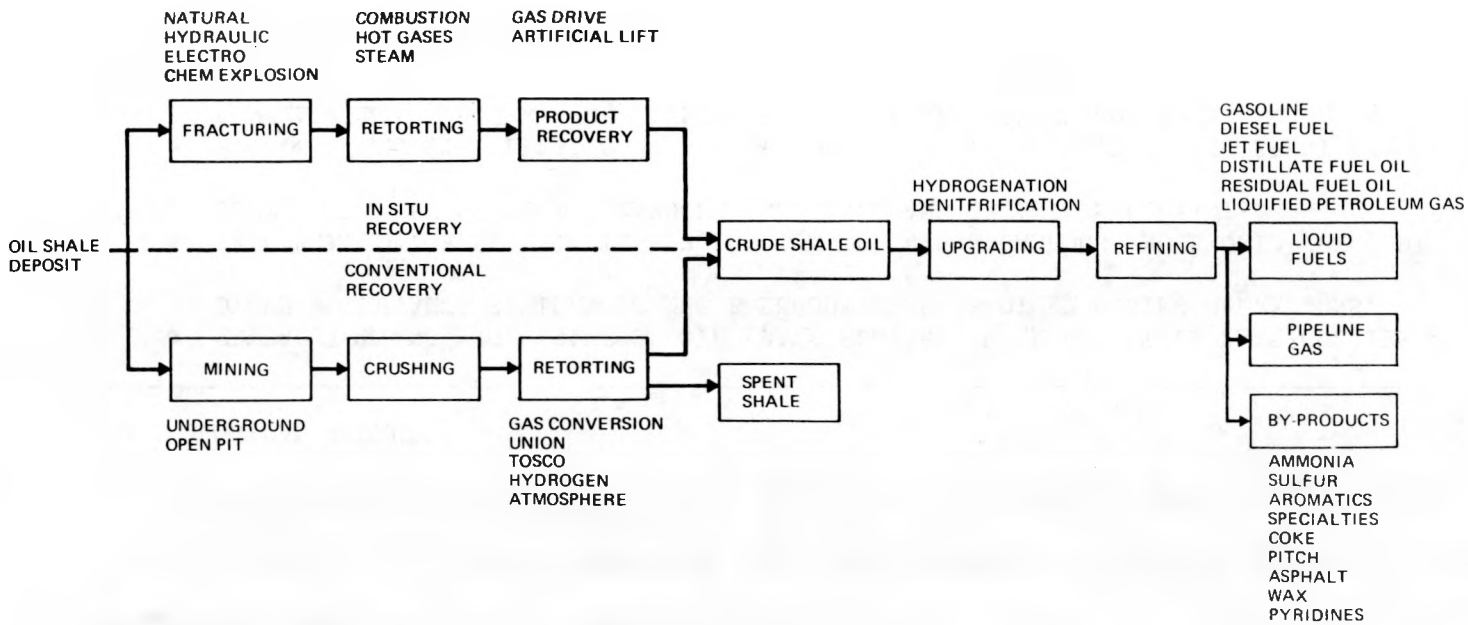


EXHIBIT 15

GENERALIZED FUEL CYCLE FOR OIL SHALE. By-products and effluents may differ in type and quantity depending on type of recovery.

2.4.3 Health and Environmental Problems: Oil Shale

MAJOR HEALTH AND ENVIRONMENTAL PROBLEMS ASSOCIATED WITH CONVENTIONAL RECOVERY RELATE TO THE LARGE AMOUNTS OF WASTE MATERIALS AND EFFLUENTS PRODUCED, AND THE COMPETITION FOR THE LIMITED WATER SUPPLY OF THE REGION. IN SITU RECOVERY MAY PRODUCE LESS STRESSFUL HEALTH AND ECOLOGICAL IMPACTS.

- EXTRACTION AND PROCESSING OF OIL SHALE PROBABLY WILL RESULT IN PARTICULATES AND OTHER POLLUTANTS SIMILAR TO THOSE ENCOUNTERED IN OTHER MINING OPERATIONS.
- RETORTING MAY RESULT IN THE PRODUCTION OF UNIQUE GASEOUS AND LIQUID EFFLUENTS CONTAINING POTENTIALLY HAZARDOUS INORGANIC AND ORGANIC POLLUTANTS.
- DISPOSAL AND STABILIZATION OF LARGE VOLUMES OF POTENTIALLY TOXIC SPENT SHALE FROM CONVENTIONAL RECOVERY ARE SIGNIFICANT WASTE MANAGEMENT CONCERNS.
- UPGRADING OF CRUDE SHALE OIL WILL RESULT IN POLLUTANTS COMMON TO PETROLEUM REFINERY OPERATIONS.
- TECHNOLOGY REQUIREMENTS AND INCREASED HUMAN DEMANDS MAY SEVERELY STRESS THE LIMITED REGIONAL WATER SUPPLY AND ITS QUALITY.
- LARGE SCALE DEVELOPMENT OF OIL SHALE WILL ALTER EXISTING HUMAN POPULATION LEVELS AND LIFE-STYLES IN THE RESOURCE REGION.

EXHIBIT 16

KEY HEALTH AND ENVIRONMENTAL PROBLEMS FROM OIL SHALE

Key Problems	Problem Description
Degradation of limited water resources of the region	The oil shale resource region has restricted water supplies. Management of spent shale requires considerable amounts of water; effluents may significantly degrade the quality of aquifers and surface waters. Existing regional water resources must be defined, and the consequences assessed of diverting additional water from agricultural needs.
Regional socioeconomic impact of oil shale development	The oil shale resource region presently is sparsely populated and rural. Massive implementation of this technology will significantly alter existing demographic patterns and economic and cultural characteristics of the region. Existing demographic and economic conditions must be characterized and the potential socioeconomic and land-use consequences of technology development must be assessed.
Degradation of high quality air of the region	Pollutants resulting from extraction, processing and retorting may alter the present high quality air of the resource region. Existing air quality conditions must be defined; atmospheric emissions from demonstration plants characterized; the transport and fate of sulfates, organic compounds, trace elements, and other contaminants delineated; and the implications of technology development assessed.
Occupational health problems resulting from shale oil extraction and processing	Retorting processes may result in worker exposure to potentially hazardous organic compounds (e.g., polyaromatics) and inorganic and trace elements (e.g., Si, Al, Ca, Pb, Hg, Cd). Existing information will be assessed and research conducted to determine exposure levels and risks of diseases. Mutagenicity of organic compounds associated with industrial operations should be determined.

EXHIBIT 16

KEY HEALTH AND ENVIRONMENTAL PROBLEMS FROM OIL SHALE
(Continued)

Key Problems	Problem Description
Land disruption due to extraction and waste disposal	Surface retorting will result in considerable land disruption and will require the disposal of large amounts of spent shale. The restoration of viable long-lived biological communities on disrupted land and their establishment on spent shale deposits will require significant management research.
Health effects of direct combustion	The combustion of petroleum products recovered from oil shale will expose occupational and general populations to atmospheric pollutants including sulfates, NO_x, organic compounds, oxidants, and trace elements. Health research will be required to identify hazardous agents, develop early indicators of stress and damage, determine the pathways and fate of active agents. An understanding of basic physiological processes and responses, clinical and epidemiological studies, and predictive models of human risks are required.

2.4.4 Technology Description: Oil and Natural Gas

SUPPLIES OF OIL AND NATURAL GAS, THE MAIN SOURCES OF ENERGY IN THE U.S. TODAY, ARE DWINDLING. THEREFORE, NEW TECHNIQUES IN STIMULATION AND RECOVERY NEED TO BE IMPLEMENTED IN THE NEAR FUTURE.

- EXPLORATION, EXTRACTION, REFINING, AND COMBUSTION OF OIL AND NATURAL GAS ARE WELL-ESTABLISHED COMMERCIAL TECHNOLOGIES.

- ENERGY POTENTIAL:
  - OIL AND GAS WILL SUPPLY ABOUT 45 QUADS (60%) OF THE U.S. NEEDS IN 1975.
  - OIL AND GAS PRODUCTION IS NOW PROJECTED TO BEGIN DECREASING. ENHANCED OIL RECOVERY AND STIMULATION OF NATURAL GAS SOURCES WILL DELAY THE REDUCTION IN THESE SUPPLIES.
  - NEAR-TERM (1985) ENHANCEMENT WILL BUY ROUGHLY TEN YEARS TIME (ABOUT 6+QUADS).
  - MID-TERM (2000) ENHANCEMENT WILL PRODUCE AN ADDITIONAL 9+QUADS.
  - ERDA WILL EMPHASIZE NEW STIMULATION AND RECOVERY METHODS IN ITS TECHNOLOGY DEVELOPMENT PROGRAM.

- NEW ENHANCEMENT TECHNIQUES BEING PURSUED IN THE NEAR-TERM BY ERDA AND WHICH WILL BE PASSED ON TO THE INDUSTRY IN THE 1980's:
  - MICELLAR AND POLYMER FLOODING
  - CO_2 INJECTION

(Continued)

2.4.4 Technology Description: Oil and Natural Gas (Continued)

- THERMAL RECOVERY
- SULFUR EXTRACTION AND CYCLIC SOLVENT STIMULANT
- HYDRAULIC FRACTURING
- CHEMICAL EXPLOSIVE FRACTURING

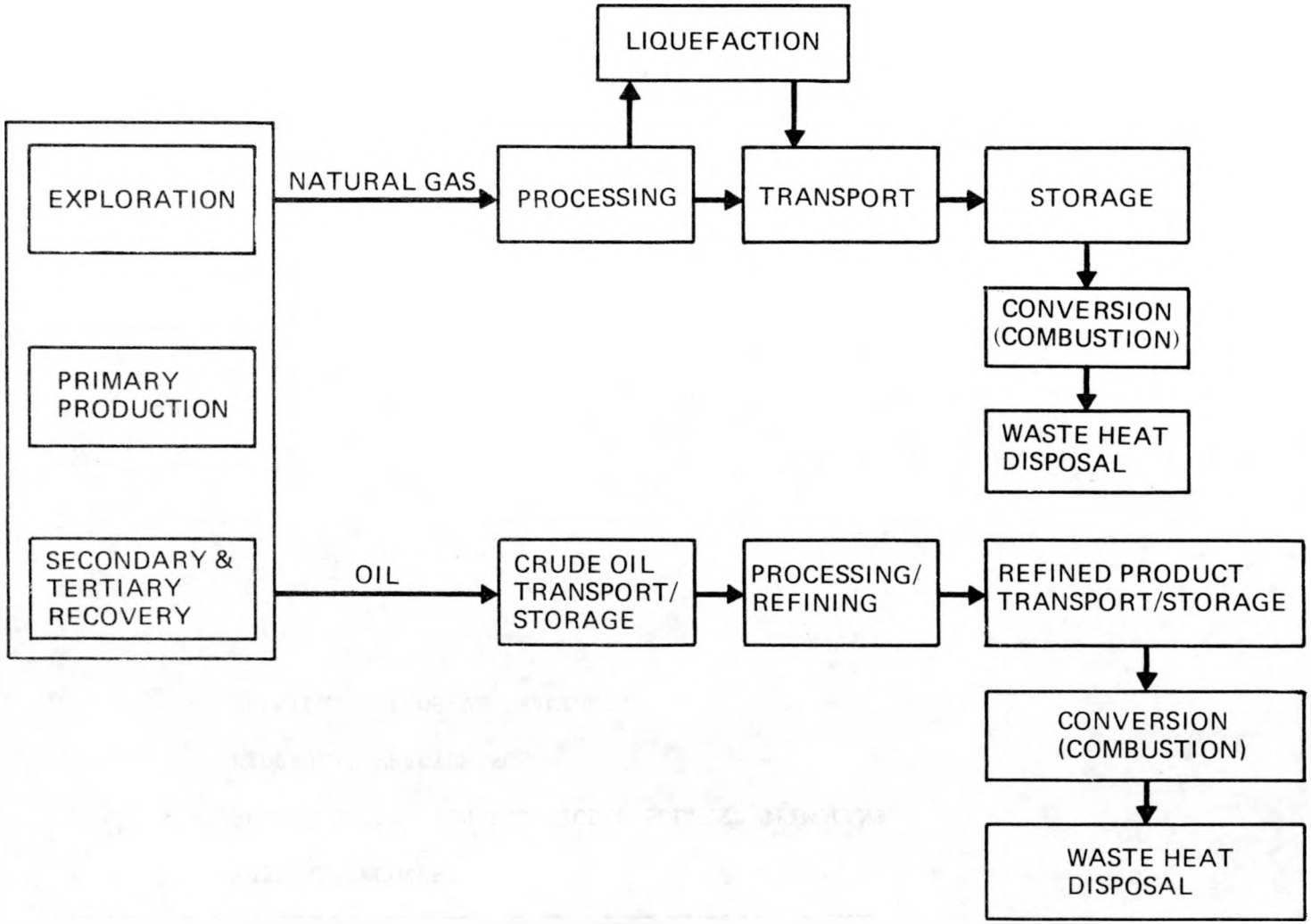


EXHIBIT 17

FUEL CYCLE FOR OIL AND NATURAL GAS. Continued dependence on oil and natural gas will require recovery of geologically locked and viscous reserves.

2.4.4 Health and Environmental Problems: Oil and Natural Gas

RESEARCH EFFORTS WILL BE FOCUSED ON THE MAJOR HEALTH AND ENVIRONMENTAL PROBLEMS ASSOCIATED WITH ENHANCED RECOVERY TECHNIQUES, OIL SPILLS, AND COMBUSTION.

- POSSIBLE GEOLOGICAL AND HYDROLOGICAL HAZARDS OF SECONDARY-TERTIARY RECOVERY TECHNIQUES MAY RESTRICT THE IMPLEMENTATION OF ENHANCEMENT STRATEGIES.
- OIL SPILLS IN THE MARINE ENVIRONMENT WILL NEED MULTI-DISCIPLINARY STUDY.
- HEALTH AND ENVIRONMENTAL EFFECTS OF REFINERY AND FUEL HANDLING FACILITY EMISSIONS AND OIL AND GAS COMBUSTION PRODUCTS REMAIN A MAJOR DBER CONCERN.
- SOCIAL DISRUPTIONS DUE TO VARIOUS SHORT-FALLS OF OIL AND GAS MUST BE ANTICIPATED AND ANALYZED IN RELATIONSHIP TO CONSERVATION (SEE PAGE 66).
- SPECIFIC IDENTIFIED ENVIRONMENTAL CONCERNS ARE:
  - EFFECTS OF HYDROCARBONS AND NO_x FROM REFINERY OPERATIONS AND COMBUSTION ON AMBIENT AIR QUALITY.
  - ACID RAIN FROM COMBUSTION OF OIL OR COAL.
  - ARCTIC LAND DISTURBANCE FROM EXPLORATION, EXTRACTION, AND TRANSPORTATION.
  - EFFECTS OF WASTE HEAT FROM OIL AND GAS UTILIZATION FACILITIES.
  - EFFECTS OF OIL SPILLS ON LAND USE AND BIOTA.
  - WATER POLLUTION FROM DISSOLVED SOLIDS RELEASED IN VARIOUS OIL AND GAS CYCLE STEPS.

(Continued)

2.4.4 Environmental Problems: Oil and Natural Gas (Continued)

- SUSPENDED SOLIDS IN WATER - BIOTIC AND PHYSICAL EFFECTS
- EFFECTS OF BIODEGRADABLE OIL CLEAN-UP MATERIALS
- DETERMINATION OF ALL HEAVY METALS EMITTED AS GASES AND THEIR HEALTH AND BIOTIC EFFECTS.

EXHIBIT 18

KEY HEALTH AND ENVIRONMENTAL PROBLEMS FROM OIL AND NATURAL GAS
(Continued)

Key Problems	Problem Description
Oil spills in the environment	The possibility of oil spills exists in all steps of the energy cycle - well blowouts, processing equipment failures, transport mishaps, user mishandling and disposal practices. All sources enter the terrestrial and marine environments disrupting biotic and abiotic processes. Ecological effects will be greater in northern waters because of the oil solubility/temperature relationship.
Health effects on populations exposed to refinery operations	The health risks of refinery workers, excluding accidents, are poorly defined, but may be presumed significant in view of the carcinogenic potential of certain hydrocarbons. Experience from petroleum refinery may also be directly applicable to the syncrude industry.
Health risks of outer continent shelf exploration	Physiological stresses and their delayed effects experienced by divers below 600 feet are not fully understood, and may delay recovery of offshore oil reserves.
Effects of petroleum short-falls on social structures	Disruptions in the U.S. social structure due to short-falls in petroleum supply must be analyzed so that the total value of the oil and gas enhancement program can be assessed
Geological and hydrological implications of tertiary recovery techniques	Tertiary recovery has a higher potential for environmental damage - aquifer disruption, subsidence and induced seismic activity - by the nature of the size and intensity of these recovery techniques.
Health effects of direct combustion	Since problems are similar to those attending coal combustion those outlined for coal are germane.

EXHIBIT 18

KEY HEALTH AND ENVIRONMENTAL PROBLEMS FROM OIL AND NATURAL GAS

(Continued)

Key Problems	Problem Description
Health risks of Outer Continental Shelf exploration	Physiological stresses and their delayed effects experienced by divers below 600 feet are not fully understood, and may delay recovery of offshore oil reserves.

2.4.5 Technology Description: Energy Conservation and Efficiency

ENERGY CONSERVATION AND EFFICIENCY IMPROVEMENTS HAVE MAJOR ENERGY SUPPLY IMPACTS IN THE NEAR- AND MID-TERMS, SUBSTANTIAL SOCIAL AND LIFE-STYLE CHANGES MAY BE REQUIRED IF ENERGY DELIVERED FROM NUCLEAR AND COAL SOURCES FALLS BEHIND CURRENT TIMETABLES.

- A WIDE VARIETY OF TECHNIQUES, PROCEDURES AND REGULATING STANDARDS ARE BEING CONSIDERED TO EFFECT ENERGY CONSERVATION.
- EFFICIENCY IMPROVEMENTS ARE UNDER DEVELOPMENT IN ELECTRIC POWER GENERATION AND TRANSMISSION, TRANSPORTATION, CONSUMER PRODUCTS, AND INDUSTRIAL OPERATIONS.
- CONSERVATION IS EXPECTED TO REDUCE ENERGY DEMAND FOR HEATING AND COOLING OF BUILDINGS, AND IN AGRICULTURE, URBAN SYSTEMS, AND INDUSTRY.
- TECHNIQUES FOR USE OF WASTE MATERIALS FOR THE PRODUCTION OF ENERGY AND FUELS WILL BE DEVELOPED.

EXHIBIT 19

ENERGY CONSERVATION AND EFFICIENCY PROGRAM ELEMENTS

Program Areas	Program Description
Buildings and Consumer Products	Insulation and ventilation design standards; heating/cooling systems performance; community systems.
Electric Conversion Efficiency	Advanced power cycles; high temperature materials, components.
Electric Power Transmission	Ultrahigh voltage transmission; cryogenic transmission lines.
Electric Transport	Systems and components to allow electricity to substitute for direct fossil fuel use in transportation.
Electric Storage	Techniques and devices to increase energy storage in electric power systems, transportation, buildings and industry.
Industrial Energy Efficiency Transportation Energy Efficiency	Techniques, practices and devices having greater energy efficiency; manufacturing, agriculture and all transportation modes.
Waste Materials to Energy	Conversion of urban and industrial wastes to fuels or energy.

2.4.5 Health and Environmental Problems: Energy Conservation and Efficiency.

MOST CURRENTLY PROPOSED CONSERVATION ACTIONS APPEAR TO PRODUCE FEW ADVERSE ENVIRONMENTAL EFFECTS: REDUCTIONS IN PRIMARY FUEL USE WILL HAVE BENEFICIAL ENVIRONMENTAL EFFECTS WHICH SHOULD BE QUANTIFIED TO SUPPORT THE CONSERVATION ACTIONS.

- CERTAIN ENVIRONMENTAL DAMAGES OR DISRUPTIONS ARE CAUSED BY ENERGY CONSUMPTION; THUS REDUCING FUEL USE WILL BENEFIT OVERALL ENVIRONMENTAL QUALITY.
- SPECIFIC LOCATIONS AND/OR POPULATIONS WHICH MAY BE ADVERSELY AFFECTED BY CONSERVATION AND THE MAGNITUDE OF ITS EFFECTS MUST BE ASCERTAINED AND MITIGATING ACTIONS INSTITUTED BY APPROPRIATE AUTHORITY.
- EFFICIENCY IMPROVEMENTS IN ELECTRIC POWER GENERATION AND TRANSMISSION MAY INTRODUCE NEW ENVIRONMENTAL STRESSES (ELECTROMAGNETIC FIELDS, ETC.) WHOSE EFFECTS MUST BE EVALUATED.
- SOCIOECONOMIC STRESSES AND OTHER CONSEQUENCES RELATED TO CONSERVATION ACTIONS MUST BE EVALUATED.
- NEWLY PROPOSED AND DEVELOPING CONSERVATION MEASURES MUST BE CONTINUALLY REVIEWED IN TERMS OF THEIR ENVIRONMENTAL IMPLICATIONS.
- IMPORTANT EARLY BENEFITS FROM IMPLEMENTING CONSERVATION WILL DIFFER IN DEGREE AND KIND BETWEEN REGIONS, AND CALL FOR REGIONAL ASSESSMENTS.
- INCREASED UTILIZATION OF WASTES MAY INTRODUCE NEW HEALTH AND ENVIRONMENTAL PROBLEMS DUE TO RELEASE OF VIRUSES AND BACTERIA.

EXHIBIT 20

KEY HEALTH AND ENVIRONMENTAL PROBLEMS IN ENERGY CONSERVATION AND EFFICIENCY

Key Problems	Problem Description
Hazards accompanying the production of energy from industrial wastes	Combustion of waste materials to recover energy or to transform them into gaseous, liquid or solid fuels may cause a variety of pollutant emissions whose nature and effects require definition.
Health implications of energy conservation in buildings	Reduced air exchange and ventilation instituted to decrease space conditioning energy requirements may increase the exposure of occupants to toxic agents and communicable diseases.
Possible ecological imbalances due to nutrient management techniques	Changes in agricultural production practices (new or natural fertilizers, new hybrids and cropping techniques, revised livestock raising practices) may place increased stress on occupational populations and on terrestrial and aquatic ecosystems.
Unforeseen consequences of new conservation methods	The identification of potential health or environmental problems associated with the many proposed and developing conservation technologies requires continued review and, in some cases, research programs.

2.4.6 Technology Description: Solar Energy

SOLAR CONVERSION IS EXPECTED TO CONTRIBUTE TO THE NATION'S ENERGY NEEDS BY THE MID-TERM, AND TO BE A MAJOR SOURCE OF ENERGY IN THE LONG TERM.

- SOLAR ENERGY INCLUDES A VARIETY OF TECHNIQUES FOR CONVERTING TO A USABLE FORM A FRACTION OF THE NATURAL ENERGY TRANSFERRED BY THE SUN TO THE BIOSPHERE. THE SOLAR TECHNOLOGIES ACTIVELY SUPPORTED BY ERDA ARE: SOLAR THERMAL, PHOTOVOLTAIC, WIND ENERGY, OCEAN THERMAL, BIOCONVERSION, HEATING AND COOLING OF BUILDINGS, AND AGRICULTURAL AND PROCESS HEAT.

- LARGE-SCALE GENERATION OF ELECTRICITY BY SOLAR THERMAL CONVERSION TYPICALLY INVOLVES THE COLLECTION OF INCIDENT RADIATION, THE TRANSFER OF THERMAL ENERGY TO A FLUID, AND THE CONVEYANCE OF FLUIDS VIA PIPES TO AN ELECTRIC GENERATING FACILITY.

- SMALL-SCALE APPLICATIONS OF SOLAR THERMAL CONVERSION INCLUDE THE USE OF INCIDENT RADIATION FOR HEATING AND COOLING OF BUILDINGS, ANIMAL SHELTERS AND GREENHOUSES, AND FOR DRYING CROPS.

- PHOTOVOLTAIC CONVERSION EMPLOYS ARRAYS OF PHOTOVOLTAIC DEVICES TO CONVERT SOLAR RADIATION DIRECTLY TO ELECTRICITY.

- IN WIND ENERGY CONVERSION, ARRAYS OF TURBINES CONVERT WIND POWER TO ELECTRICITY.

- IN OCEAN THERMAL CONVERSION, ELECTRICITY IS GENERATED BY HEAT ENGINES THAT EXPLOIT VERTICAL THERMAL GRADIENTS IN THE SEAS.

- BIOCONVERSION SYSTEMS UTILIZE THE CHEMICAL ENERGY STORED IN ORGANIC MATERIALS. THE ORGANIC SOURCES MAY BE CROPS GROWN SPECIFICALLY FOR FUELS (BIOPRODUCTION) OR RESIDUAL MATERIALS (BIOCONVERSION).

- PHOTOCHEMICAL CONVERSION, BEING CONSIDERED AS A LONG-TERM TECHNOLOGY, INVOLVES THE ADSORPTION OF SOLAR ENERGY AND THE PRODUCTION OF STABLE CHEMICAL COMPOUNDS SUITABLE AS USE FOR FUELS.

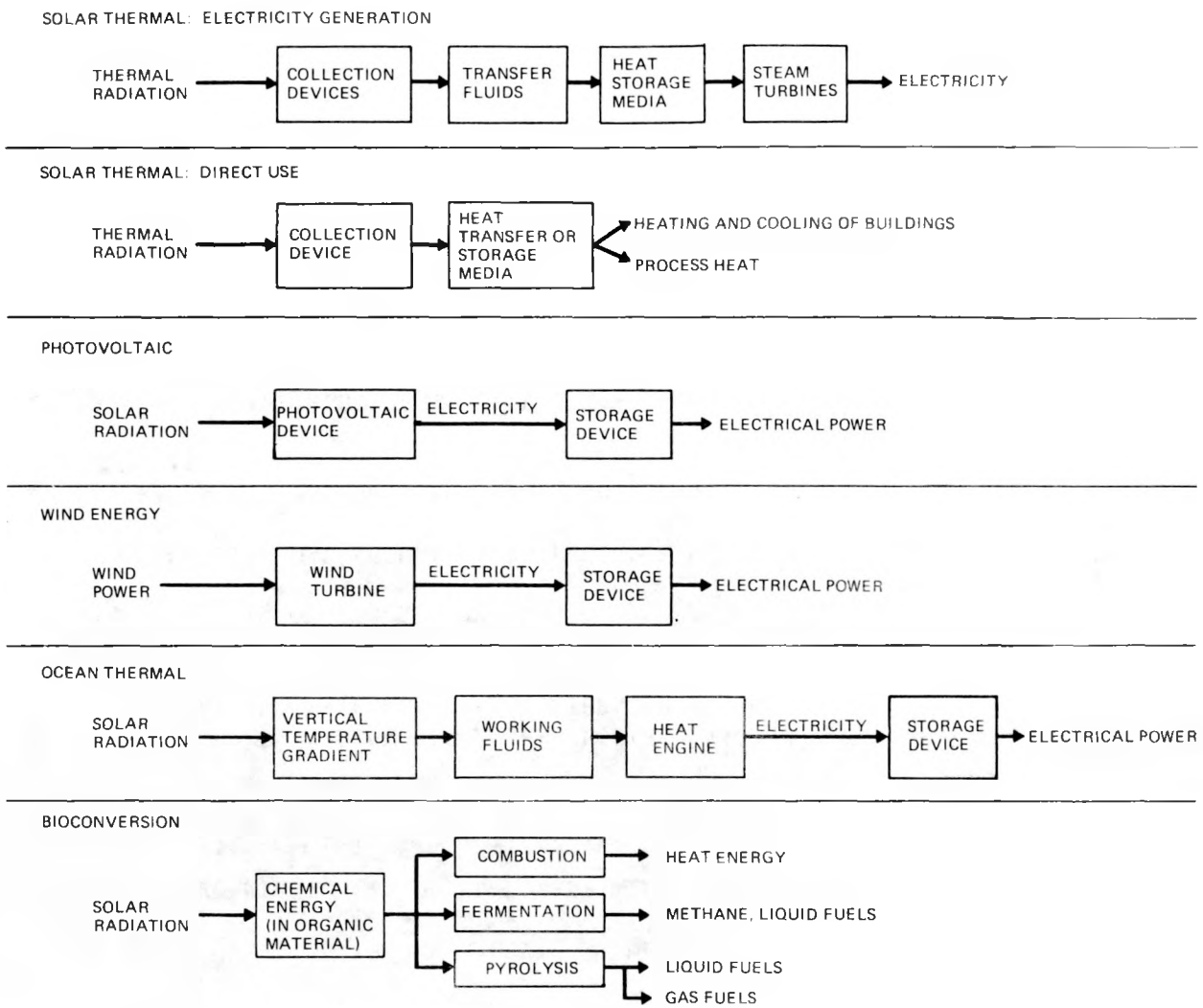


EXHIBIT 21

FUEL CYCLE FOR SOLAR TECHNOLOGIES. Each of the several solar technologies may have unique environmental implications.

2.4.6 Health and Environmental Problems: Solar Energy

ALTHOUGH SOLAR CONVERSION IS GENERALLY CONSIDERED TO BE A RELATIVELY CLEAN TECHNOLOGY, LARGE-SCALE IMPLEMENTATION INVOLVES POTENTIALLY SIGNIFICANT DIRECT AND INDIRECT ENVIRONMENTAL COSTS.

- MOST SOLAR CONVERSION PROCESSES REQUIRE LARGE-SCALE FACILITIES THAT MAY PRODUCE ECOLOGICAL AND METEOROLOGICAL ALTERATIONS.
- SOME PROCESSES MAY EMPLOY TOXIC COMPOUNDS FOR ENERGY CONVERSION OR AS WORKING FLUID IN HEAT TRANSFER OR STORAGE MEDIA.
- BIOCONVERSION MAY RESULT IN POTENTIALLY HAZARDOUS EFFLUENTS AND WASTE PRODUCTS.
- SEVERAL SOLAR TECHNOLOGIES MAY SIGNIFICANTLY ALTER THE PRODUCTIVITY OF BIOLOGICAL COMMUNITIES.
- LAND AND WATER REQUIREMENTS OF SOLAR TECHNOLOGIES MAY RESULT IN LAND-USE CONFLICTS.
- HUMAN POPULATION INFLUXES MAY CREATE SOCIOECONOMIC PROBLEMS IN SOLAR DEVELOPMENT AREAS.

EXHIBIT 22

KEY HEALTH AND ENVIRONMENTAL PROBLEMS FROM SOLAR TECHNOLOGIES

(Continued)

Key Problems	Problem Description
Health and ecological effects of bioconversion processes	Bioconversion production and conversion facilities will result in the emission of potentially hazardous effluents including organic compounds, sulfates, NO_x, trace elements, and pesticides. These emissions must be quantitatively and qualitatively characterized, and their transport, transformation, and fate through abiotic and biological components of ecosystems determined. The ecological and land-use implications of bioconversion effluents must be assessed.
Release to the environment of toxic materials from solar devices	The release of Cd, Si, and other materials or byproducts in photovoltaic devices may be hazardous to biological systems. These active components must be characterized, their toxicity to humans and other organisms determined, and their pathways in the ecosystems delineated.
Climatic and ecological alterations caused by solar energy facilities	Large arrays of collection devices at solar thermal stations and of wind turbines may significantly affect climate on local and larger scales (through alterations of albedo and wind turbulance), and have direct and indirect impacts on local biota. Ocean thermal facilities may alter physical characteristics of marine sites (e.g., through CO_2 absorption by the sea surface) and result in upwelling of nutrients and alterations of the composition and productivity of marine communities. Compounds to prevent biofouling of heat exchanges may be toxic to marine life. Also, massive water intake and throughput in ocean thermal systems is a mechanical danger to marine life.

EXHIBIT 22

KEY HEALTH AND ENVIRONMENTAL PROBLEMS FROM SOLAR TECHNOLOGIES
(Continued)

Key Problems	Problem Description
Economic and social impacts of solar energy use	Large-scale implementation of solar energy will require large national commitments of resources, land and manpower, and may require shifts in population. The short- and long-term implications of regional and national commitments and societal changes must be considered relative to other energy technology alternatives. Also, the use of solar energy for heating and cooling may require housing and community design changes.

2.4.7 Technology Description: Geothermal Energy

IT IS EXPECTED THAT GEOTHERMAL ENERGY CAN MAKE A LIMITED INITIAL ENERGY CONTRIBUTION BY 1985 AND A MODERATE CONTRIBUTION BY 2000.

- GEOTHERMAL ENERGY, SIMPLY DEFINED AS THE HEAT OF THE EARTH, INCLUDES FOUR MAJOR TYPES OF RESOURCES WITH VARYING POTENTIAL FOR ENERGY PRODUCTION: VAPOR DOMINATED SYSTEMS; HYDROTHERMAL SYSTEMS; GEOPRESSURIZED RESERVOIRS; AND HOT DRY ROCK SYSTEMS.

- LAND USE FOR GEOTHERMAL CONVERSION PER UNIT OF ENERGY PRODUCED IS RELATIVELY SMALL, AND ITS FUEL CYCLE IS SHORT COMPARED TO MANY ALTERNATE ENERGY TECHNOLOGIES.

- THE REGIONAL CHARACTERISTICS WHICH MAKE GEOTHERMAL ENERGY ATTRACTIVE TO RESOURCE LOCATIONS ALSO RAISES POSSIBLE LAND-USE CONFLICTS.

- THE STATED GOAL OF THE ERDA GEOTHERMAL ENERGY PROGRAM IS TO STIMULATE THE INDUSTRIAL DEVELOPMENT OF HYDROTHERMAL RESOURCES TO PROVIDE ELECTRIC AND THERMAL POWER DURING THE 1985 TO 1990 PERIOD, AND TO DEVELOP NEW AND IMPROVED TECHNOLOGIES FOR THE LONG-TERM USE OF ALL FORMS OF GEOTHERMAL ENERGY.

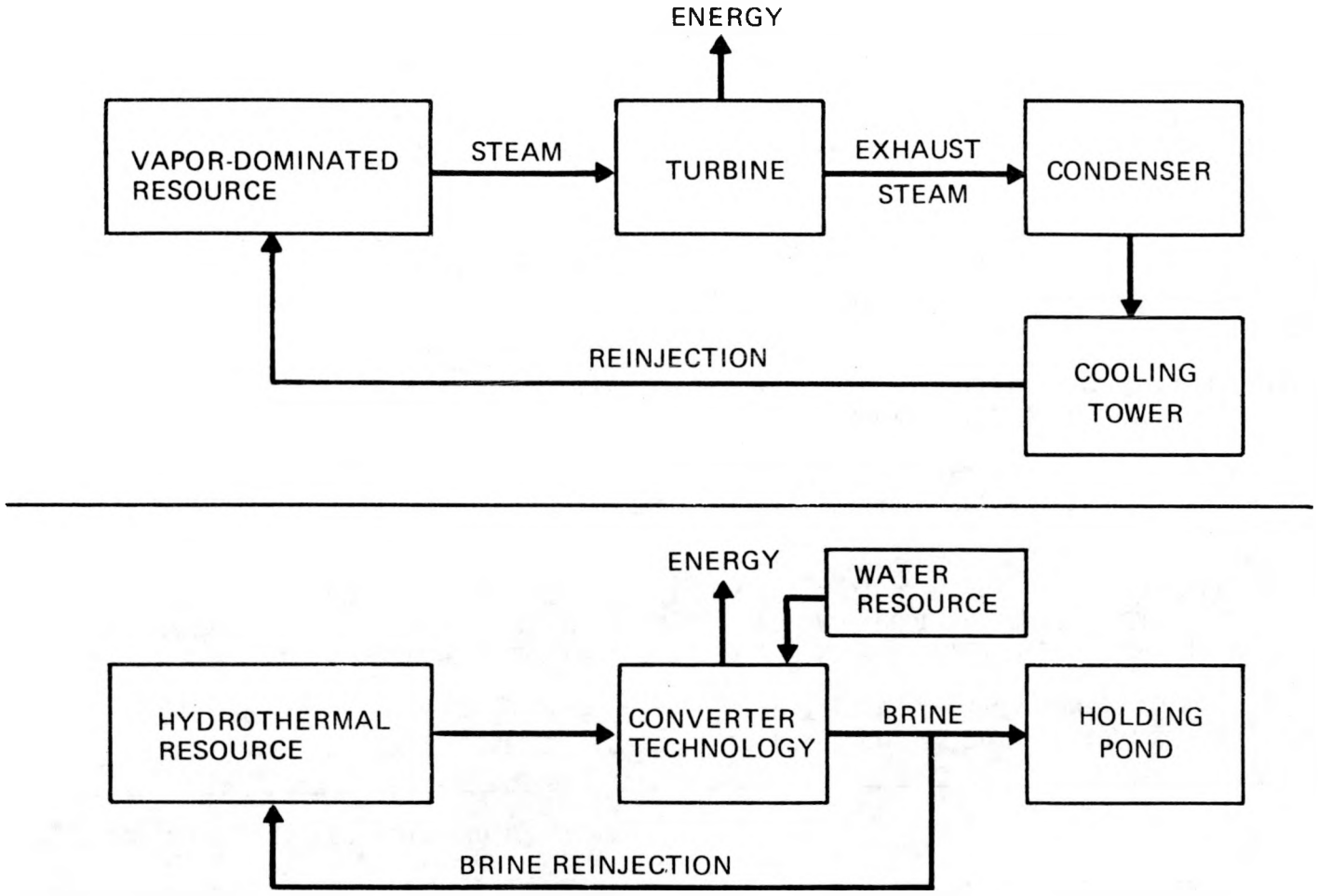


EXHIBIT 23

FUEL CYCLE FOR GEOTHERMAL ENERGY. These geothermal resources are highly localized and therefore environmental issues must be examined on a regional basis; geopressurized and hot dry rock systems are not developed sufficiently to allow depiction of fuel cycles.

2.4.7 Health and Environmental Problems: Geothermal Energy

SEVERAL ENVIRONMENTAL AND HEALTH PROBLEMS ARE ASSOCIATED WITH VAPOR DOMINATED AND HYDROTHERMAL RESOURCE UTILIZATION AND EXTRACTION.

- SEVERAL SUB-TECHNOLOGY ENERGY ALTERNATIVES ARE ACCOMPANIED BY EMISSIONS OF POTENTIALLY HAZARDOUS NONCONDENSABLE GASES INCLUDING H_2S, CO_2, NH_3, and Rn.
- SUBSTANTIAL AMOUNTS OF VOLATILE AND SOLUBLE NONCONDENSABLE GASES AND CHEMICAL ELEMENTS, SUCH AS B, As, AND Hg, ARE EMITTED FROM COOLING TOWERS; ALSO, THE BORON AND SALTS CONTAINED IN COOLING TOWER DRIFT MAY HAVE SIGNIFICANT ADVERSE ECOLOGICAL EFFECTS.
- THE RESIDUAL BRINE PRESENTS A POTENTIAL ENVIRONMENTAL PROBLEM BECAUSE OF ITS SALINITY AS WELL AS ITS CHEMICAL CONTENT INCLUDING B, As, Hg, Pb, AND SILICA.
- THE LARGE-SCALE WITHDRAWAL OF FLUIDS FROM HYDROTHERMAL RESERVOIRS IS FREQUENTLY ACCOMPANIED BY THE PROBLEM OF LAND SUBSIDENCE WHICH MAY AFFECT AGRICULTURE AND IRRIGATION.
- A POTENTIAL SOLUTION FOR BOTH SUBSIDENCE AND BRINE DISPOSAL PROBLEMS IS THE REINJECTION OF BRINE INTO THE WELLS; SATURATION LEVELS OF DISSOLVED SILICA, HOWEVER, MAY LEAD TO CLOGGING OF THE INJECTION WELL AND CONTAMINATION OF GROUND WATER. SEISMIC DISTURBANCE MAY BE INDUCED BY BRINE REINJECTION.
- DISCHARGE OF BRINE INTO A HOLDING POND BEFORE REINJECTION MAY LEAD TO EMISSION OF SALT SPRAY AND RESULT IN A NEED FOR DISPOSAL OF THE PRECIPITATED MATERIALS.
- ADVANCED GEOTHERMAL ENERGY EXTRACTION TECHNIQUES HAVE NOT PROGRESSED TO THE POINT WHERE SPECIFIC HEALTH OR ENVIRONMENTAL PROBLEMS CAN BE IDENTIFIED.

EXHIBIT 24

KEY HEALTH AND ENVIRONMENTAL PROBLEMS FROM GEOTHERMAL ENERGY

Key Problems	Problem Description
Non-condensable gases and trace element emissions	Release on non-condensable gases such as H_2S and Rn, and trace metals such as As, Hg, Cd, and B, have adverse health and ecological effects; noxious odors may also be present.
Liquid effluents, cooling tower drift and waste water disposal	The brine has an appreciable salinity and also contains silica, arsenic, mercury, and lead. Brine disposal problem is presently unresolved, since the reinjection of brine may lead to clogging because of silica polymerization. The holding ponds for silica precipitation lead to the emission of salt spray.
Subsidence and induced seismicity	Withdrawal of fluids from hydrothermal reservoirs has been accompanied by land subsidence. This may have adverse effects on agriculture and irrigation. Reinjection of liquids into the wells may induce seismicity.
Land-water use conflicts	Hydrothermal energy extraction may compete for water with agricultural, recreational and other uses.

2.4.8 Technology Description: Fusion

THE CONTROLLED THERMONUCLEAR REACTOR IS EXPECTED TO BE INTRODUCED COMMERCIALLY SHORTLY AFTER THE YEAR 2000.

- NUCLEAR FUSION IS A PROCESS IN WHICH NUCLEI OF LIGHT ELEMENTS ARE COMBINED WITH A NET RELEASE OF ENERGY, PRIMARILY ASSOCIATED WITH THE MOTION OF PARTICLES FORMED IN THE REACTION.

- A NET ENERGY RELEASE BY FUSION HAS BEEN DEMONSTRATED ONLY IN THE SUN AND STARS AND IN UNCONTROLLED RELEASE, I.E., THERMONUCLEAR BOMBS.

- THE IMMEDIATE PRODUCTS OF NUCLEAR FUSION ARE GAMMA RAYS, ATOMIC NUCLEI, AND NEUTRONS. THE NEUTRONS AND GAMMA RAYS DISSIPATE THEIR ENERGY IN CONTAINMENT MATERIALS, RESULTING IN DAMAGE AND THE GENERATION OF ACTIVATION PRODUCTS.

- TWO BASIC APPROACHES FOR PLASMA CONFINEMENT NECESSARY FOR ENERGY EXTRACTION FROM FUSION PROCESSES ARE: THE USE OF INTENSE MAGNETIC FIELDS AND PULSED LASER OR ELECTRON BEAM CONDENSATION OF FUEL PELLETS.

- FUEL USED IN THE FIRST COMMERCIAL REACTORS IS EXPECTED TO BE A MIXTURE OF DEUTERIUM (^{2}H) AND TRITIUM (^{3}H).

- NATURAL SUPPLIES OF TRITIUM DO NOT EXIST IN ECONOMICALLY RECOVERABLE AMOUNTS; QUANTITIES FOR STARTUP OPERATION CAN BE PRODUCED IN FISSION REACTORS AND CONTINUING SUPPLIES CAN BE PRODUCED AS A PART OF FUSION REACTOR OPERATION.

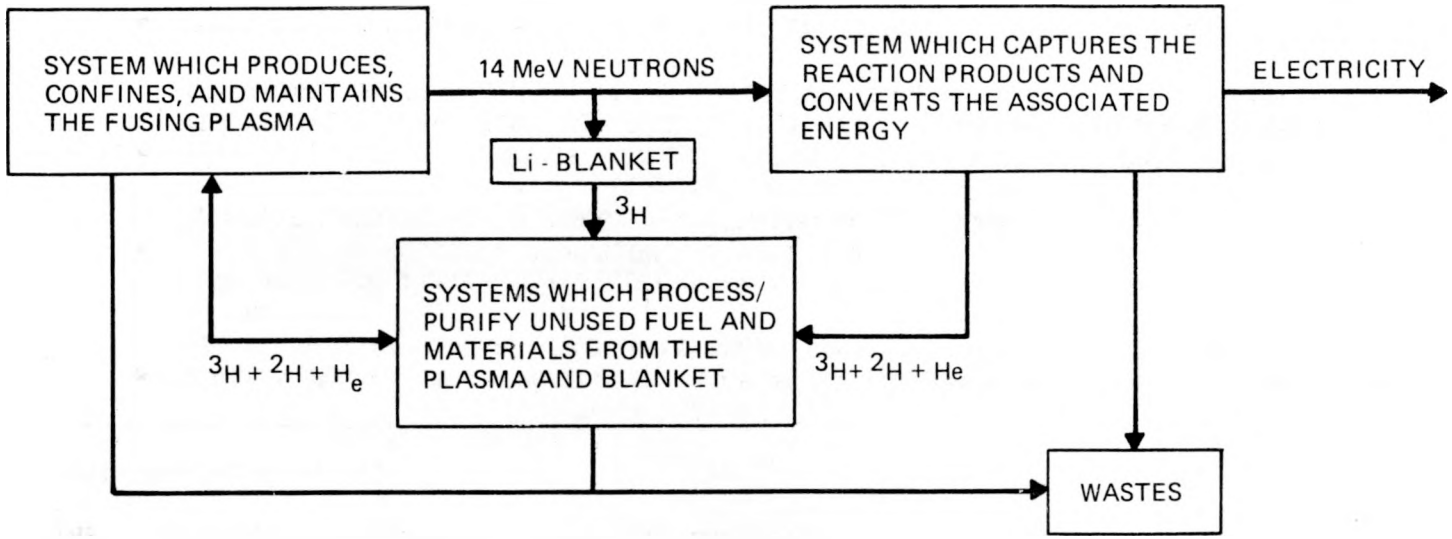


EXHIBIT 25

FUEL CYCLE FOR FUSION. Environmental analyses can assist in the development and selection of the commercial fusion process.

2.4.8 Health and Environmental Problems: Fusion

A SERIES OF POTENTIAL ENVIRONMENTAL AND HEALTH PROBLEMS ARE ASSOCIATED WITH THE FUSION TECHNOLOGY.

- CHRONIC AND POSSIBLE ACCIDENTAL RELEASE OF TRITIUM MAY RESULT IN EXPOSURE OF HUMAN POPULATIONS AND OTHER BIOLOGICAL SYSTEMS.
- HIGH MAGNETIC FIELDS MAY PRODUCE PHYSIOLOGICAL CHANGES IN WORKERS.
- POSSIBLE VIBRATIONS IN THE VICINITY OF INERTIAL CONFINEMENT REACTORS COULD RESULT IN ECOLOGICAL AND AESTHETIC DISTURBANCES.
- RADIOACTIVE WASTE FROM SHIELDING AND INTERNAL COMPONENTS MAY BE RELEASED DURING REPLACEMENT.
- SOME DESIGNS REQUIRE ROUTINE HANDLING OF LARGE QUANTITIES OF LITHIUM WITH THE RESULTING POTENTIAL FOR FIRE AND LARGE RELEASES OF LITHIUM AND TRITIUM.
- BERYLIUM AND ITS FLUORIDE MAY BE RELEASED TO THE ENVIRONMENT FROM REACTOR DESIGNS USING MOLTEN SALTS.
- RADIOACTIVE MATERIALS RESULTING FROM NEUTRON ACTIVATION MAY REACH THE ENVIRONMENT DUE TO RADIATION DAMAGE TO AND CORROSION OF THE CONTAINMENT VESSEL.

EXHIBIT 26

KEY HEALTH AND ENVIRONMENTAL PROBLEMS FROM FUSION

Key Problems	Problem Description
Chronic release of tritium	Typical inventories of tritium for a 2000 MWe generating plant are about 6 Kg. Such a large amount of ^{3}H and its rapid diffusion rate at temperatures above 300°C make the ^{3}H-problem the most significant environmental problem of fusion technology.
Occupational exposure to high magnetic fields	High-intensity magnetic fields, one of the two techniques of plasma confinement, may cause adverse health effects on occupational workers if not properly shielded.
Neutron activation of CTR wall	Damage to the containment material from neutron and alpha radiations may necessitate periodic replacement of the inner walls. Neutron activation of containment materials may lead to potential radiation hazards.
Continuing technology assessment	At this stage of development, maintenance of close contact with CTR technology for identification and assessment of environmental obstacles is important.

2.4.9 Technology Description: Fission

NUCLEAR POWER CURRENTLY PROVIDES ABOUT TWO PERCENT OF THE NATION'S ENERGY SUPPLY; BY 1985 AND THEREAFTER, CONVERTER REACTORS ARE EXPECTED TO MAKE A MAJOR ENERGY CONTRIBUTION, AND AFTER 2000, BREEDER REACTORS ARE EXPECTED TO MAKE A MAJOR CONTRIBUTION.

- AFTER SEVERAL STEPS, SUCH AS MINING, MILLING, AND ISOTOPIC ENRICHMENT, URANIUM-235 IS FISSIONED BY SLOW NEUTRON CAPTURE AND SUPPLIES THE NEUTRONS NEEDED IN THE CHAIN REACTION WHICH WILL LEAD TO ENERGY PRODUCTION.
- MINED URANIUM ORE AVERAGES ABOUT 0.2 PERCENT USABLE URANIUM OXIDE.
- PRESENTLY, 70% OF THE URANIUM ORE IS MINED IN NEW MEXICO AND WYOMING AND 17% IN COLORADO AND UTAH.
- IN THE MILLING OPERATION, URANIUM ORE IS CRUSHED, GROUND, AND THEN LEACHED WITH EITHER SULPHURIC ACID OR SODIUM CARBONATE SOLUTION TO EXTRACT THE URANIUM.
- ISOTOPIC ENRICHMENT OF U-235 IS ACCOMPLISHED BY CONVERSION OF U_3O_8 INTO GASEOUS HEXA-FLUORIDE (UF_6) AND DIFFUSION OF UF_6 GAS THROUGH POROUS MEMBRANES.
- FUEL FABRICATION INVOLVES THE CONVERSION OF UF_6 ENRICHED IN U-235 TO UO_2 POWDER WHICH IS FORMED INTO PELLETS AND FINALLY PROCESSED INTO FUEL ELEMENTS.
- THE FINAL STEPS OF FISSION FUEL CYCLE ARE POWER PRODUCTION, FUEL REPROCESSING, AND WASTE DISPOSAL.

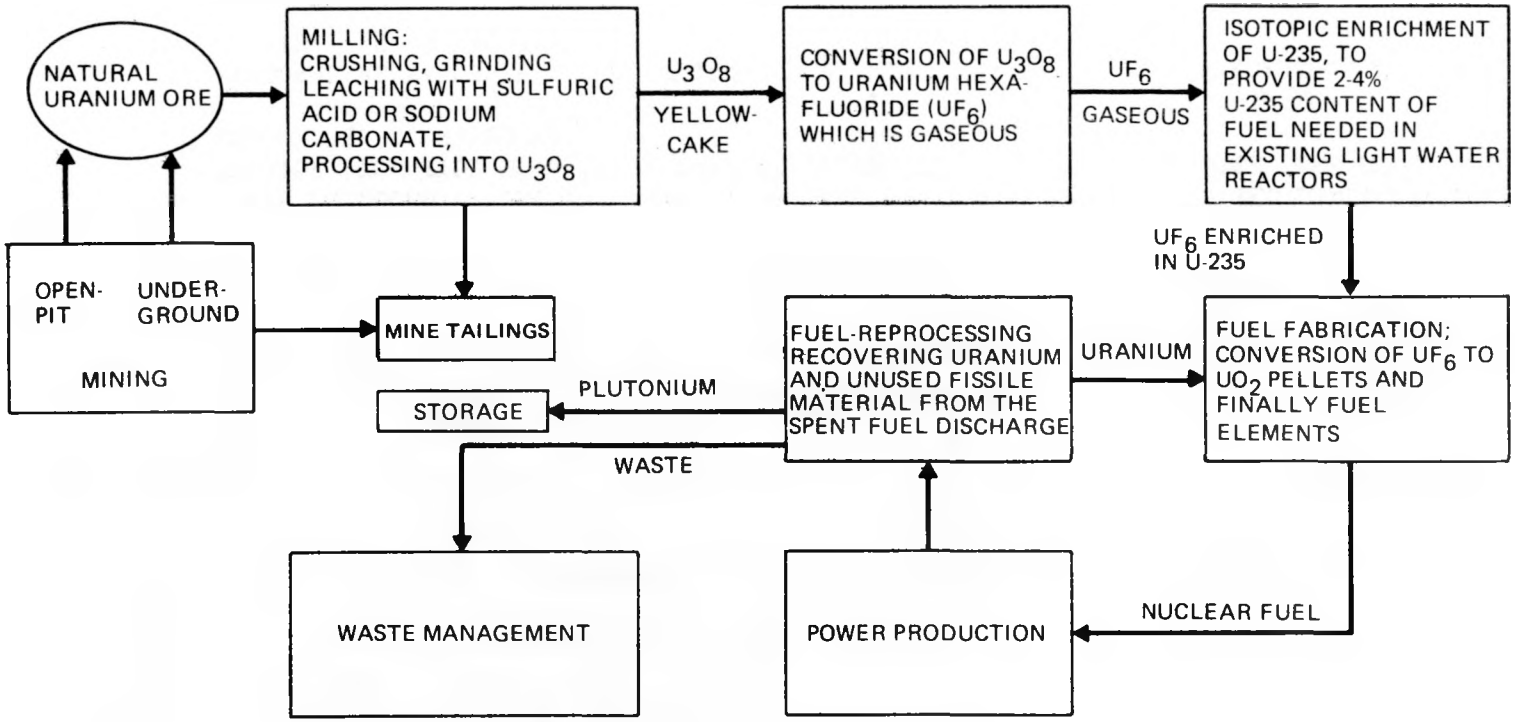


EXHIBIT 27

FUEL CYCLE FOR FISSION. Chronic and/or accidental release of radio-isotopes throughout the fuel cycle represents the major environmental concern.

2.4.9 HEALTH AND ENVIRONMENTAL PROBLEMS: Fission

MAJOR HEALTH AND ENVIRONMENTAL PROBLEMS ARE ASSOCIATED WITH FISSION POWER PRODUCTION AT EACH OF THE NINE STAGES OF THE FISSION FUEL CYCLE.

- AIRBORNE RADIOACTIVE MATERIALS SUCH AS URANIUM-BEARING DUSTS AND RADON GAS AND ITS DAUGHTERS ARE RELEASED TO THE ATMOSPHERE DURING MINING OPERATIONS.
- DISSOLVED AND SUSPENDED URANIUM AND ITS DAUGHTER PRODUCTS OCCUR IN MINE DRAINAGE WATER.
- RADIOACTIVE GASES AND PARTICULATES WHICH RESULT FROM MILLING ACTIVITIES INCLUDE RADIUM, THORIUM, URANIUM OXIDES, RADON, AND RADON DAUGHTERS.
- AT PRESENT, THE EFFECTS ON WATER QUALITY CAUSED BY SEEPAGE FROM TAILINGS PONDS INTO GROUNDWATERS, AQUIFERS, OR SURFACE WATERS ARE NOT WELL DEFINED.
- GASES PRODUCED DURING UF_6 PRODUCTION INCLUDE HYDROGEN, HYDROGEN FLUORIDE, HYDROGEN SULFIDE, VOLATILE METALLIC FLUORIDES OF URANIUM, SILICON, VANADIUM, AND MOLYBDENUM, AND OXIDES OF NITROGEN.
- AIRBORNE RELEASES FROM THE ENRICHMENT PLANTS INCLUDE URANIUM, FLUORIDES, SULFUR DIOXIDE, AND NITROGEN OXIDES.
- LIQUID EFFLUENTS FROM ENRICHMENT AND FUEL FABRICATION PLANTS MAY INCLUDE SULFATES, SODIUM, CALCIUM, CHROMATES, URANIUM, FLUORIDES, NITRATES, CHLORIDES, IRON, AMMONIA, SODIUM, PHOSPHOROUS AND CHLORINE.
- PLUTONIUM MAY BE RELEASED TO THE BIOSPHERE DURING FUEL REPROCESSING ACTIVITIES.
- RADIONUCLIDES SUCH AS ^{3}H, ^{131}I, ^{129}I, ^{85}Kr, ^{135}Xe, $^{103-106}Rn$, AND ^{137}Cs MAY BE RELEASED DURING POWER PRODUCTION.

(Continued)

2.4.9 Health and Environmental Problems: Fission (Continued)

- RADIONUCLIDES MAY BE RELEASED ACCIDENTALLY DURING REPROCESSING, WASTE DISPOSAL, AND FUEL OR WASTE TRANSPORTATION; PLUTONIUM AND SOME OTHER TRANSURANICS ARE OF SPECIAL CONCERN.

- WASTE HEAT DISPOSAL CAN BE A SIGNIFICANT PROBLEM AT NUCLEAR AND OTHER THERMAL POWER STATIONS.

- PUBLIC UNDERSTANDING OF REAL HEALTH RISKS ASSOCIATED WITH NUCLEAR FUEL CYCLE IS OF CONSIDERABLE IMPORTANCE.

EXHIBIT 28

KEY HEALTH AND ENVIRONMENTAL PROBLEMS FROM FISSION

Key Problems	Problem Description
Releases of radioactive isotopes from fuel processing and waste storage	Long-lived radionuclides, such as Pu and other transuranics, ^{14}C, and ^{129}I, are of concern because they may persist in the biosphere and contribute to radiation dose for hundreds of years. Specific problems include: the deposition and resuspension of particles; availability to living organisms through food chains and inhalation; and organ burdens vs. effects.
Resolution of radiation dose-effects relationships at low doses and dose rates	Frequency of cancer and mutation resulting from chronic exposure to low levels of ^{3}H, ^{14}C, and ^{85}Kr; the validity of linear extrapolation of dose-response curves for low-and high-LET radiation; biological effects and dose-response relationships at low-level chronic exposure to Pu and other transuranics, are among the issues which need to be resolved.
Environmental effects of power plant cooling in relation to mode of waste heat disposal	Cooling towers affect atmospheric conditions and terrestrial ecosystems; waste heat plumes, toxic chemicals, and intake and outfalls of cooling water may have adverse effects on aquatic biota.
Public understanding and acceptance of nuclear power	Most issues peculiar to nuclear power are linked to public perception of the associated radiation risks.

3.0 BALANCED BIOMEDICAL AND ENVIRONMENTAL RESEARCH PROGRAM 87

3.1 Division of Research into Biomedical and Environmental Research Categories 88
3.2 Description and Definition of Research Program by BERC 90

3.2.1 Characterization, Measurement and Monitoring 90
3.2.2 Physical and Chemical Processes and Effects 92
3.2.3 Ecological Processes and Effects 94
3.2.4 Health Effects 96
3.2.5 Integrated Assessment and Socioeconomic Processes and Effects 98

3.3 Relationships of Biomedical and Environmental Research Activities 102

3.3.1 Interrelationships and Characteristics of Biomedical and Environmental Research Categories 102
3.3.2 Baseline Characterization and Measurement 104
3.3.3 Physical Disturbances Characterization and Measurement 108
3.3.4 Pollutant Characterization and Measurement 112
3.3.5 Transport and Fate 116
3.3.6 Atmospheric, Hydrological and Geological Modification 120
3.3.7 Ecological Processes and Effects 124
3.3.8 Socioeconomic Effects 130
3.3.9 Health Effects 134
3.3.10 Occupational Health 140
3.3.11 Integrated Assessment 144
3.3.12 User Communities 148

3.4 Balanced Research Allocation 150

3.4.1 Research Effort by Technology 150
3.4.2 Research Effort by Biomedical and Environmental Research Category 152
3.4.3 Budget Allocation by BERC and Energy Technology 154
3.4.4 Relative Allocation of Research by Technology 156
3.4.5 Allocation of Effort by ERDA Feasibility Estimate 162

3.1 Division of Research into Biomedical and Environmental Research Categories

PROJECTS IN THE BPP WERE ARRANGED INTO FIVE BIOMEDICAL AND ENVIRONMENTAL RESEARCH CATEGORIES (BERC'S).

- THESE CATEGORIES ARE:
  - CHARACTERIZATION, MEASUREMENT, AND MONITORING
  - PHYSICAL AND CHEMICAL PROCESSES AND EFFECTS
  - ECOLOGICAL PROCESSES AND EFFECTS
  - HEALTH EFFECTS
  - INTEGRATED ASSESSMENT AND SOCIOECONOMIC PROCESSES AND EFFECTS
- THESE CATEGORIES HAVE RESULTED FROM VARIOUS RESEARCH PLANNING EXERCISES, INCLUDING:
  - "THE NATION'S ENERGY FUTURE", DR. D.L. RAY, WASHINGTON-1281, DECEMBER, 1973.
  - "REPORT OF THE INTERAGENCY WORKING GROUP ON HEALTH AND ENVIRONMENTAL EFFECTS OF ENERGY USE", PREPARED FOR THE OFFICE OF MANAGEMENT AND BUDGET, EXECUTIVE OFFICE OF THE PRESIDENT, AND THE COUNCIL ON ENVIRONMENTAL QUALITY, EXECUTIVE OFFICE OF THE PRESIDENT, NOVEMBER, 1974.

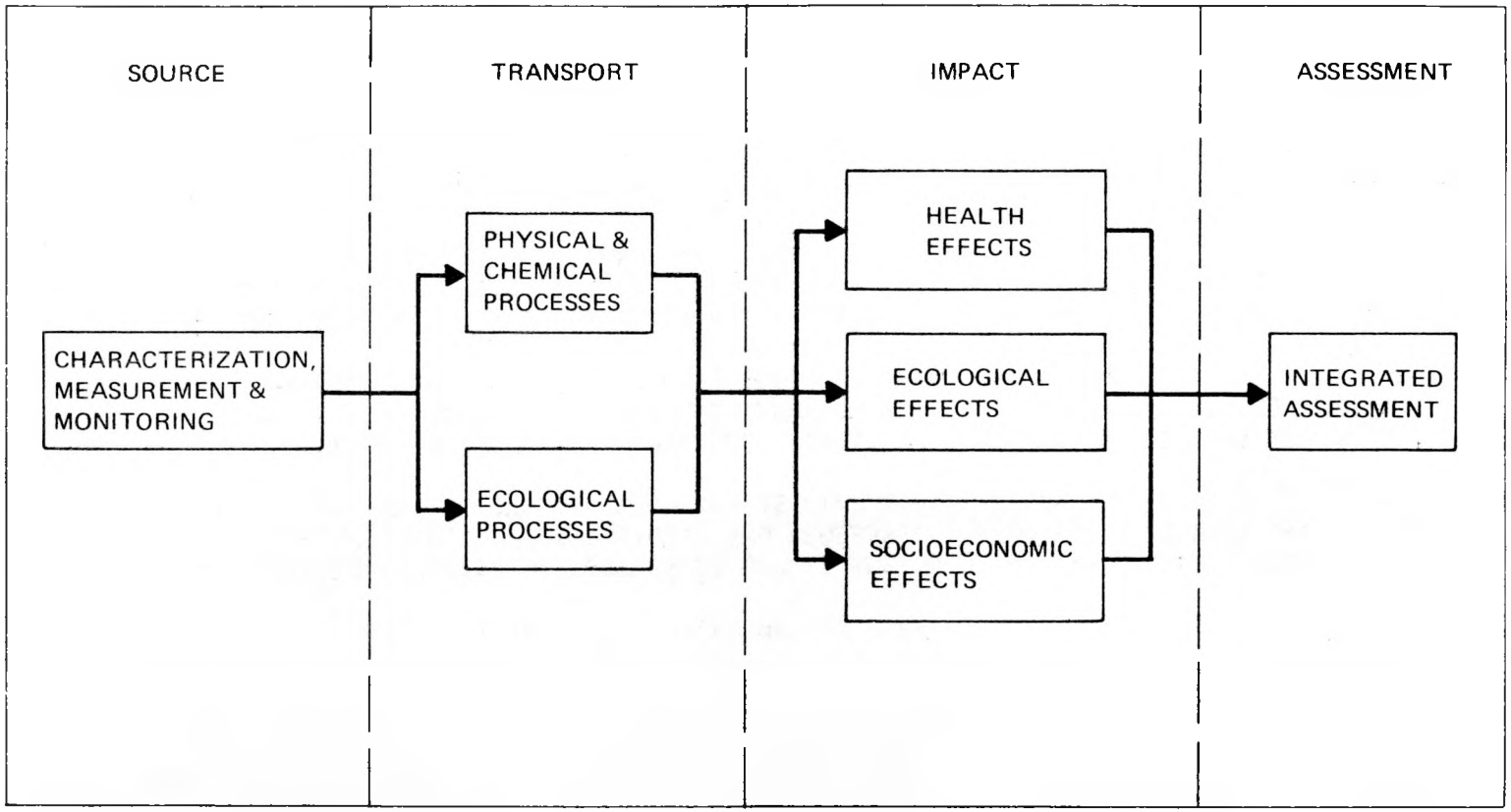


EXHIBIT 29

BIOMEDICAL AND ENVIRONMENTAL RESEARCH CATEGORIES. Integrated categorical research activities are necessary to address health and environmental problems.

3.2 Description and Definition of Research Program by BERC

3.2.1 Characterization, Measurement and Monitoring

THE CM&M PROGRAM IS DESIGNED TO GATHER BASELINE INFORMATION, MONITOR TECHNOLOGY DEVELOPMENT ACTIVITIES, AND ENSURE THE AVAILABILITY OF MEASUREMENT TOOLS AND PROCEDURES FOR RESEARCH AND ASSESSMENT.

- CMM SUPPORTS RESEARCH ACTIVITIES OF OTHER BERC'S.
- THE CHARACTERIZATION PORTION OF CMM IS INTENDED TO FURNISH INFORMATION ON DISTRIBUTIONS, CONCENTRATIONS, AND PROPERTIES OF POTENTIALLY HAZARDOUS AGENTS AT SITES UNDER CONSIDERATION AND AT OPERATIONAL SITES.
- TO DEVELOP THE NECESSARY ADVANCED CAPABILITIES, CMM WILL IDENTIFY AND EVALUATE CURRENTLY AVAILABLE MEASUREMENT TECHNIQUES (e.g., LASER TECHNOLOGY) AND WILL DEVELOP NEW MATERIALS, DEVICES, SUB-UNITS, AND SYSTEM CONCEPTS.
- CMM WILL DEVELOP INSTRUMENTS AND SYSTEMS WHICH ARE NOT COMMERCIALLY OBTAINABLE, BUT ARE REQUIRED IN THE DBER PROGRAMS IN MEDICAL APPLICATIONS, OCCUPATIONAL HEALTH PROTECTION APPLICATIONS, ETC.
- CMM WILL DEVELOP CAPABILITIES FOR QUALITY ASSURANCE STANDARDS FOR COLLECTION AND STORAGE OF SAMPLES AND THEIR SUBSEQUENT CHEMICAL AND PHYSICAL ANALYSIS; STANDARDIZED REFERENCE MATERIALS WILL BE DEVELOPED TO SUPPORT QUALITY ASSURANCE.
- UNDER THE MONITORING PROGRAM CMM WILL DEVELOP ANALYTIC TECHNIQUES AND WILL INITIATE AND CARRY OUT MONITORING OPERATIONS ON DEVELOPING AND EXPANDING ENERGY TECHNOLOGY ACTIVITIES.

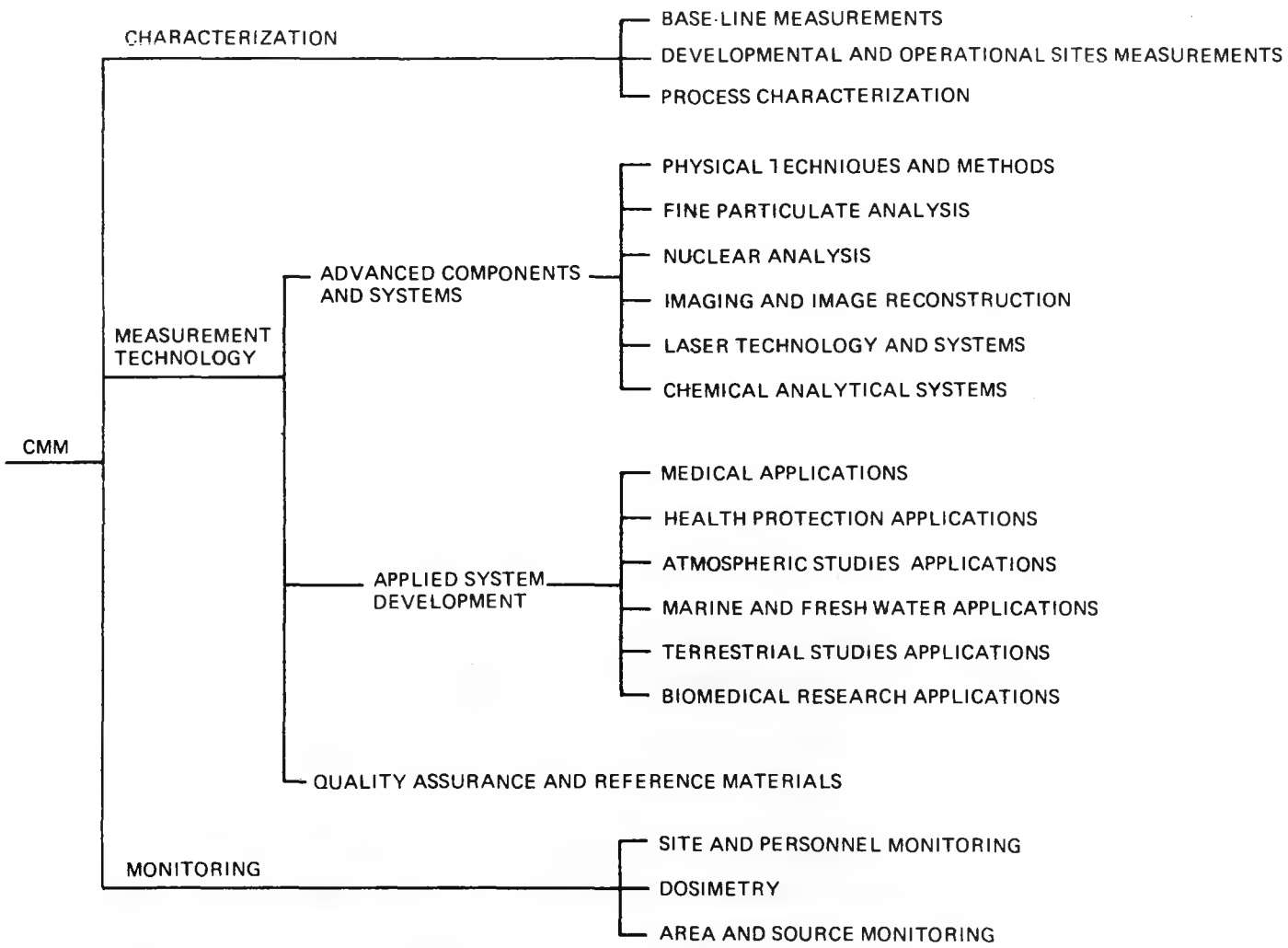


EXHIBIT 30
COMPONENTS OF CHARACTERIZATION, MEASUREMENT, AND MONITORING

3.2.2 Physical and Chemical Processes and Effects

THIS CATEGORY INCLUDES STUDIES OF ABIOTIC PHYSICAL AND CHEMICAL PROCESSES AND EFFECTS.

- PREDICTING ENVIRONMENTAL SOURCE-RECEPTOR RELATIONSHIPS REQUIRES AN UNDERSTANDING OF THE POLLUTANT TRANSPORT AND FATE MECHANISMS IN ALL THREE MEDIA (AIR, WATER, AND LAND).

- TRANSPORT COVERS MOVEMENT OF POLLUTANTS FROM SOURCES THROUGH ENVIRONMENTAL MEDIA TO RECEPTORS: SOILS, SURFACE AND GROUNDWATER, PLANTS AND ANIMALS (INCLUDING MAN).

- PHYSICAL-CHEMICAL PROCESS RESEARCH CHARACTERIZES AND MEASURES PHYSICAL DISTURBANCES AND STUDIES METEOROLOGICAL, HYDROLOGICAL, AND GEOLOGICAL MODIFICATIONS FROM ENERGY TECHNOLOGY DEVELOPMENT.

- FATE COVERS THE PHYSICAL AND CHEMICAL TRANSFORMATION, DEPOSITION, AND RE-EMISSION ASPECTS OF ALL POLLUTANTS; THIS WORK CLEARLY HAS MUTUAL RELATIONS TO VARIOUS BIOLOGICAL AND ECOLOGICAL TRANSPORT PHENOMENA.

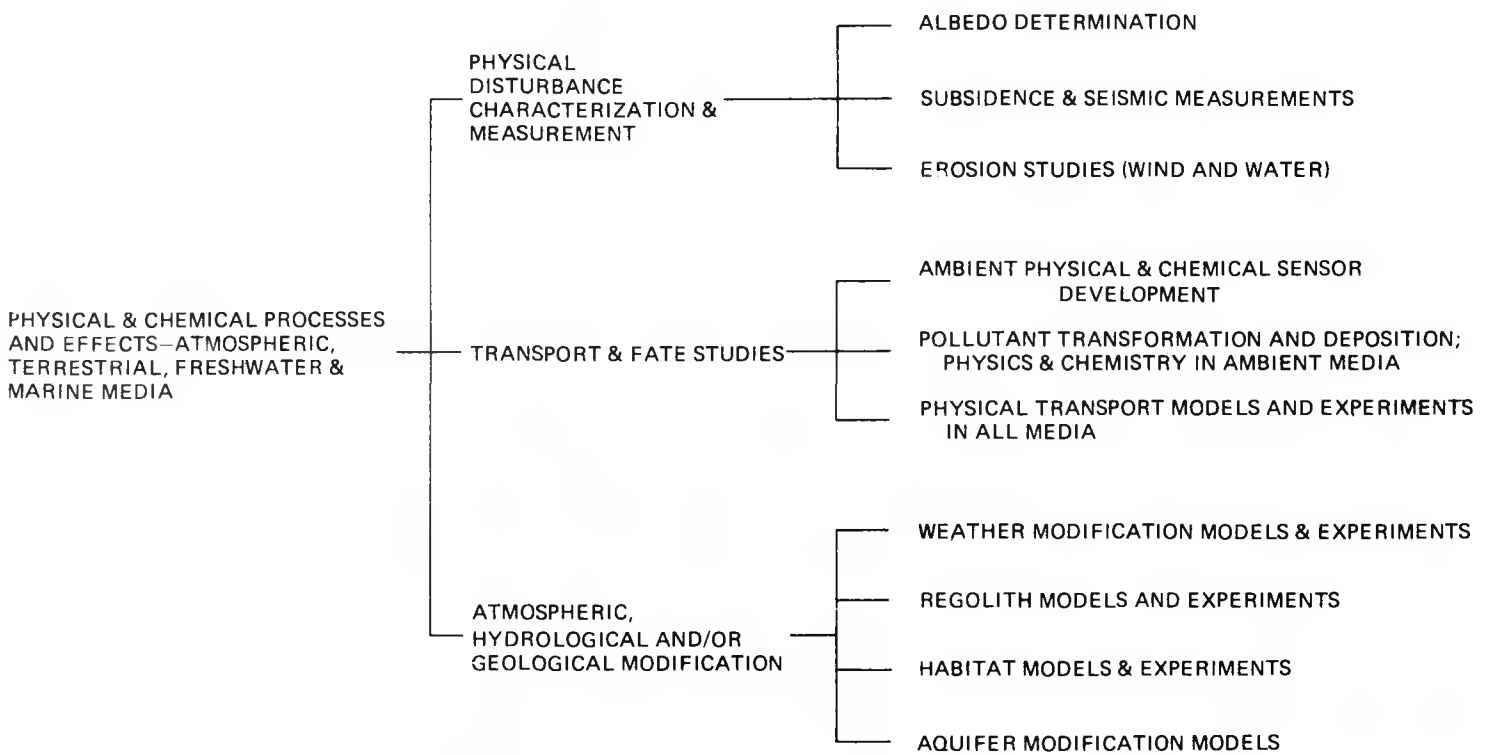


EXHIBIT 31

MAJOR COMPONENTS OF PHYSICAL AND CHEMICAL PROCESSES AND EFFECTS

3.2.3 Ecological Processes and Effects

IN THIS CATEGORY, RESEARCH WILL BE DONE TO EVALUATE THE ECOLOGICAL EFFECTS OF ENERGY TECHNOLOGY ALTERNATIVES AND DEVELOP PROCEDURES FOR MITIGATING ADVERSE ECOLOGICAL IMPACTS.

- TECHNOLOGY DEVELOPMENTS MAY HAVE SEVERAL KINDS OF ADVERSE EFFECTS ON INDIVIDUAL ORGANISMS AND ON BIOLOGICAL POPULATIONS AND COMMUNITIES.
- ECOLOGICAL RESEARCH WILL INVOLVE THE COLLECTION OF BASELINE INFORMATION, THE EVALUATION OF EFFECTS, AND THE DEVELOPMENT OF EFFECTIVE ECOLOGICAL MANAGEMENT PROCEDURES.
- SEVERAL BASIC APPROACHES WILL BE EMPLOYED IN ECOLOGICAL RESEARCH. THESE INCLUDE MEASURES OF BEHAVIORAL AND PHYSIOLOGICAL RESPONSES, DELINEATIONS OF FOOD CHAINS AND OTHER CRITICAL PATHWAYS AND PROCESSES, NUMERICAL AND STRUCTURAL RESPONSES OF POPULATIONS AND COMMUNITIES, MEASURES OF BIOLOGICAL PRODUCTIVITY, AND THE DEVELOPMENT OF ECOSYSTEM MANAGEMENT TECHNIQUES.
- SEVERAL BASIC RESEARCH PROGRAMS WILL PROVIDE IMPORTANT GENERIC SUPPORT TO TECHNOLOGY-ORIENTED ECOLOGICAL RESEARCH.
- ECOLOGICAL RESEARCH WILL HAVE A STRONG SITE AND REGIONAL ORIENTATION.
- DEPENDING ON TECHNOLOGY AND FUEL CYCLE STAGE, RESEARCH IN THIS CATEGORY WILL BE CONDUCTED IN A VARIETY OF HABITATS IN TERRESTRIAL, FRESHWATER, AND MARINE ECOSYSTEMS.

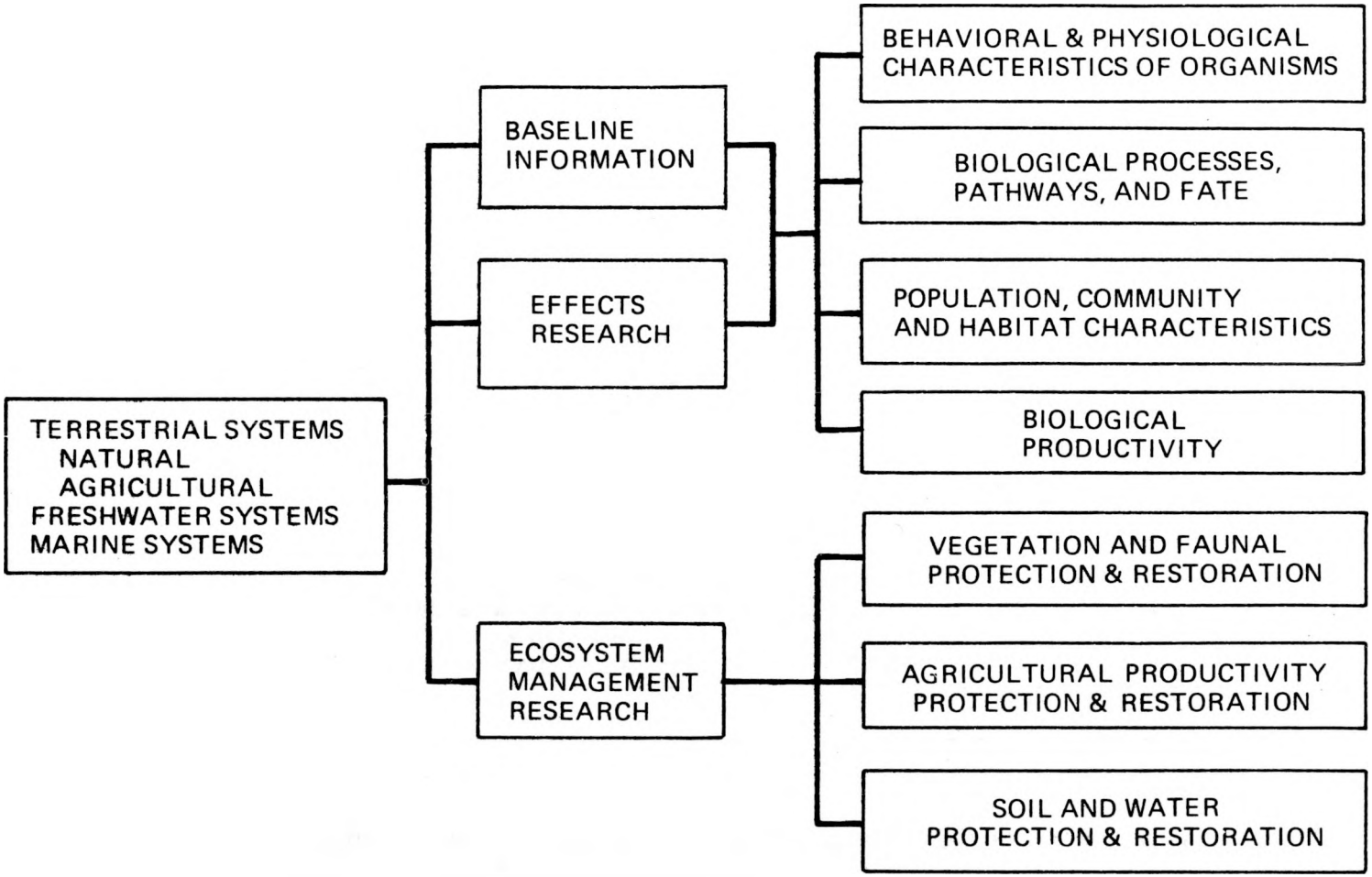


EXHIBIT 32
MAJOR COMPONENTS OF ECOLOGICAL PROCESSES AND EFFECTS

3.2.4 Health Effects

HEALTH EFFECTS STUDIES ATTEMPT TO DEFINE AND QUANTIFY THE IMPACTS OF THE VARIOUS ENERGY TECHNOLOGIES IN TERMS OF THEIR ULTIMATE RISK TO HUMAN HEALTH; THE FOLLOWING PROCEDURES ARE NECESSARY TO OBTAIN HEALTH DATA:

- IDENTIFICATION OF POTENTIALLY HAZARDOUS AGENTS THROUGH RAPID BIOLOGICAL SCREENING TESTS AND/OR PHYSICAL AND CHEMICAL CHARACTERIZATION.
- DEVELOPMENT OF QUANTITATIVE DOSE-RESPONSE RELATIONS OF IDENTIFIED HAZARDOUS AGENTS IN WHOLE ANIMAL AND CELL AND ORGAN CULTURE SYSTEMS TO ALLOW MORE ACCURATE EXTRAPOLATION BEYOND THE RANGE ASSESSABLE BY DIRECT OBSERVATIONS.
- SELECTION AND USE OF REPRESENTATIVE LABORATORY ANIMALS TO MODEL OBSERVED ADVERSE EFFECTS BY A VARIETY OF EXPOSURE ROUTES FOR PREDICTION OF ULTIMATE RISK TO MAN.
- FUNDAMENTAL RESEARCH TO IDENTIFY MODEL BIOLOGICAL SYSTEMS THAT PREDICT EFFECTS, EXAMINE BASIC CELLULAR AND ORGAN FUNCTIONS IN VARIOUS SPECIES, INCLUDING MAN, AND DEVELOP PROPHYLACTIC OR THERAPEUTIC MEASURES THAT COULD BE INSTITUTED TO AMELIORATE EFFECTS.
- EVALUATE AVAILABLE HUMAN HEALTH AND RELATED DATA AND INITIATE NEEDED NEW STUDIES TO ASSESS OCCUPATIONAL AND GENERAL PUBLIC HEALTH RISKS FROM POLLUTANT EXPOSURES, INCLUDING CHRONIC, LOW-LEVEL EXPOSURES IN COMBINATION WITH OTHER STRESSES.

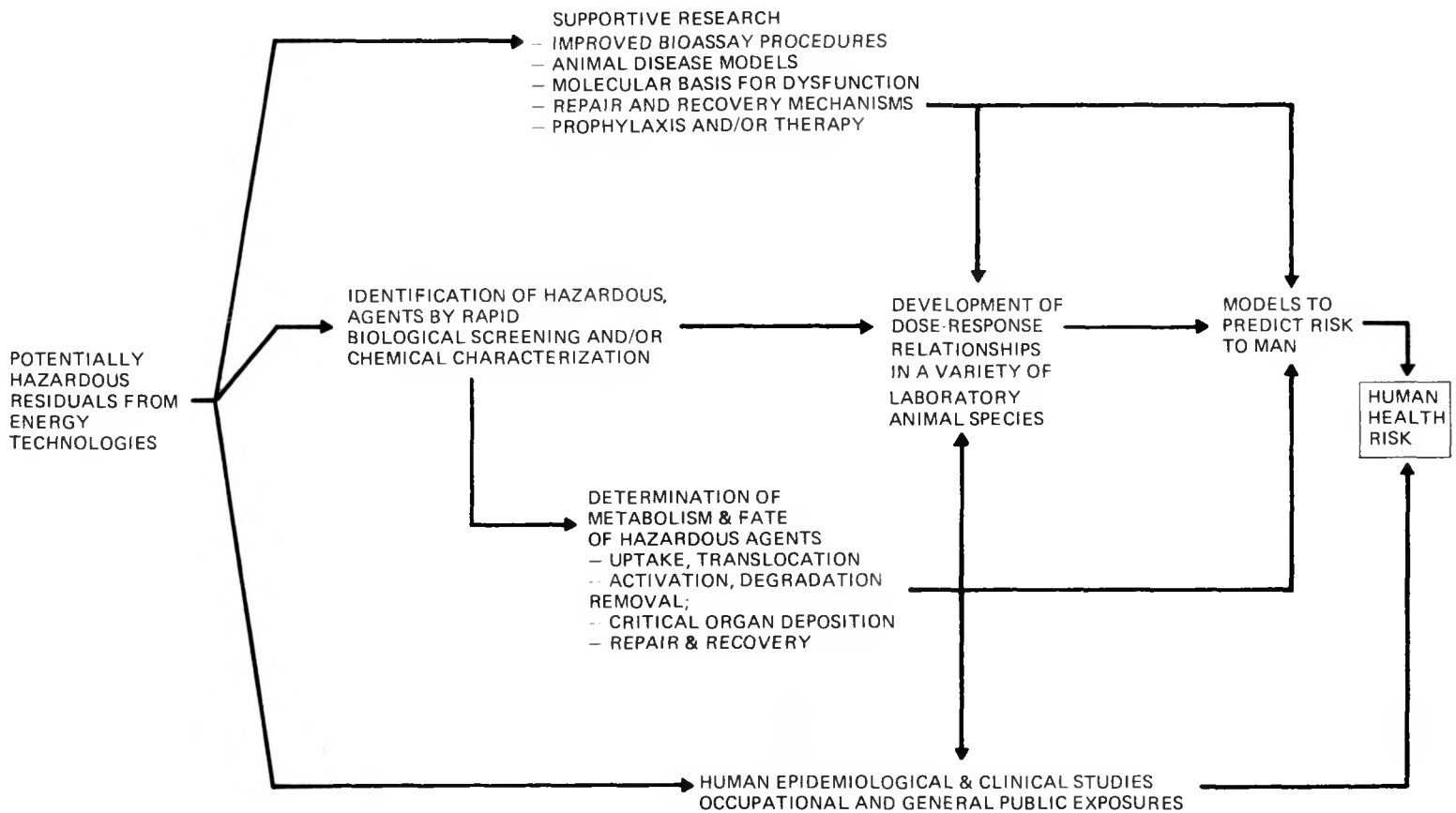


EXHIBIT 33
MAJOR COMPONENTS OF HEALTH EFFECTS

3.2.5 Integrated Assessment and Socioeconomic Processes and Effects (a)

THE SOCIOECONOMIC IMPLICATIONS OF ENERGY TECHNOLOGIES, TOGETHER WITH HEALTH AND ECOLOGICAL EFFECTS, ARE ESSENTIAL CONSIDERATIONS IN DECISION-MAKING FOR ENERGY TECHNOLOGY ALTERNATIVES

- SOCIAL CONSIDERATIONS INCLUDE EDUCATIONAL FACTORS, RECREATIONAL OPPORTUNITIES, AESTHETIC PERCEPTIONS, AND LIFESTYLE AND CULTURAL FACTORS.
- SITING DECISIONS ARE DEPENDENT UPON LOCAL AND REGIONAL SOCIAL CONDITIONS AND STRUCTURES; ANALYSIS TO SUPPORT THESE DECISIONS WILL REQUIRE COORDINATION WITH TECHNOLOGY DEVELOPMENT.
- PUBLIC ATTITUDES AND PERCEPTIONS AFFECT THE COMMERCIALIZATION OF ENERGY TECHNOLOGIES.
- METHODOLOGIES MUST BE DEVELOPED AND APPLIED FOR SOCIOLOGICAL RESEARCH ON ENERGY-RELATED TOPICS.
- ECONOMIC CONSIDERATIONS INCLUDE EMPLOYMENT PATTERNS, COST OF PUBLIC AND PRIVATE SERVICES, AND TAX BASE.

3.2.5 Integrated Assessment and Socioeconomic Processes and Effects (b)

INTEGRATED ASSESSMENT PROVIDES THE MECHANISM FOR ASSURING THAT HEALTH, ECOLOGICAL AND SOCIOECONOMIC ISSUES ARE COMPREHENSIVELY AND CONSISTENTLY CONSIDERED IN DECISIONS TO DEVELOP, DEMONSTRATE AND COMMERCIALIZE NEW ENERGY TECHNOLOGIES.

- INFORMATION MANAGEMENT SYSTEMS MUST BE DEVELOPED TO ALLOW ALL ESSENTIAL DATA TO BE AGGREGATED FOR TIMELY ASSESSMENTS.
- ASSESSMENT REQUIREMENTS WILL PROVIDE CONTINUING DIRECTION TO HEALTH AND ENVIRONMENTAL RESEARCH EFFORTS.
- INSTITUTIONAL FACTORS (JURISDICTIONAL, LEGAL, REGULATORY) WILL BE ADDRESSED WITHIN THE ASSESSMENT FUNCTION.
- ASSESSMENT OF THE RELATIVE ENVIRONMENTAL IMPACTS FOR DIFFERENT ENERGY SUPPLY AND DEMAND OPTIONS WILL BE MADE.
- COST/RISK/BENEFIT STATEMENTS WILL BE PREPARED AND ANALYZED.

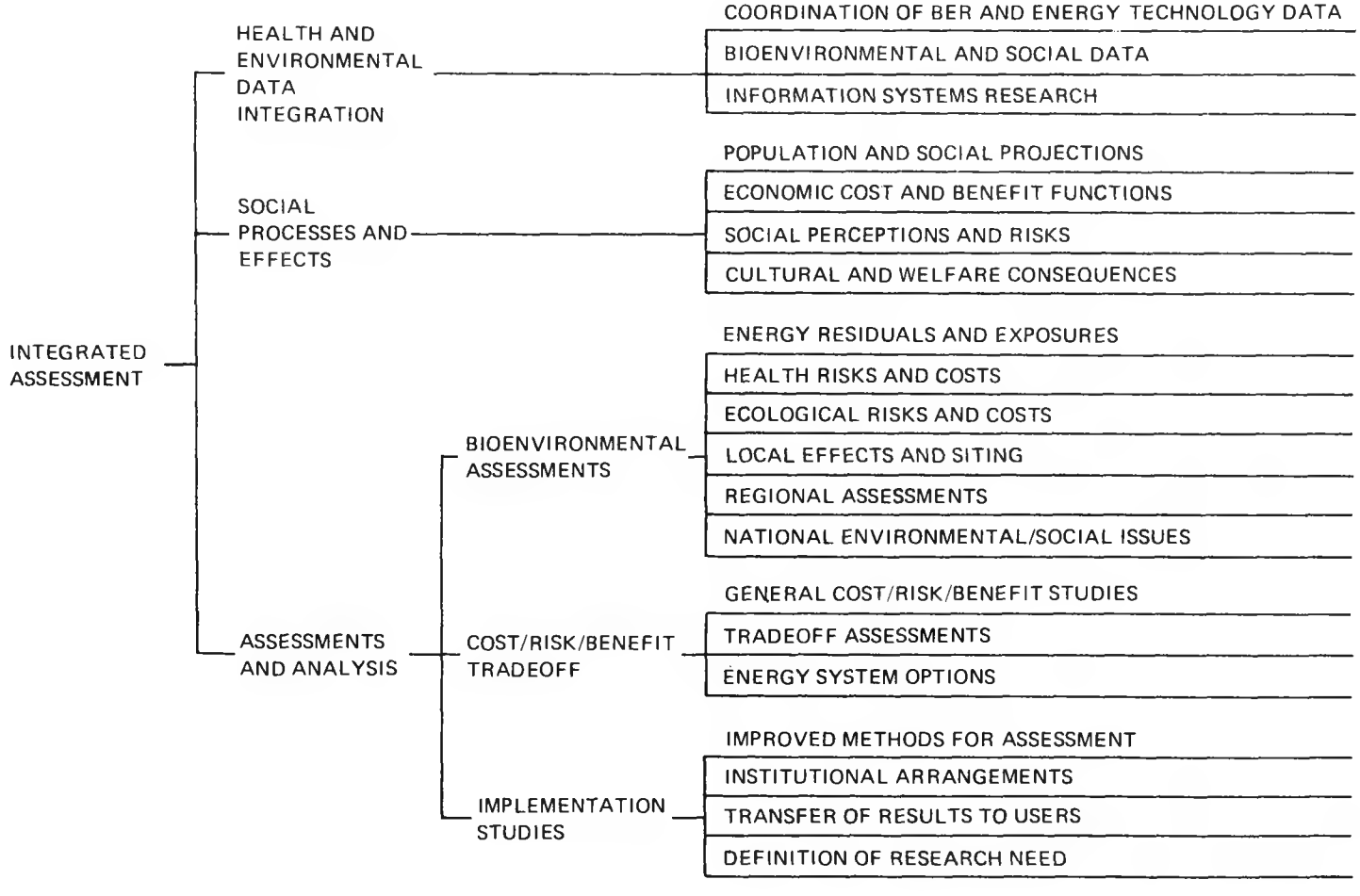


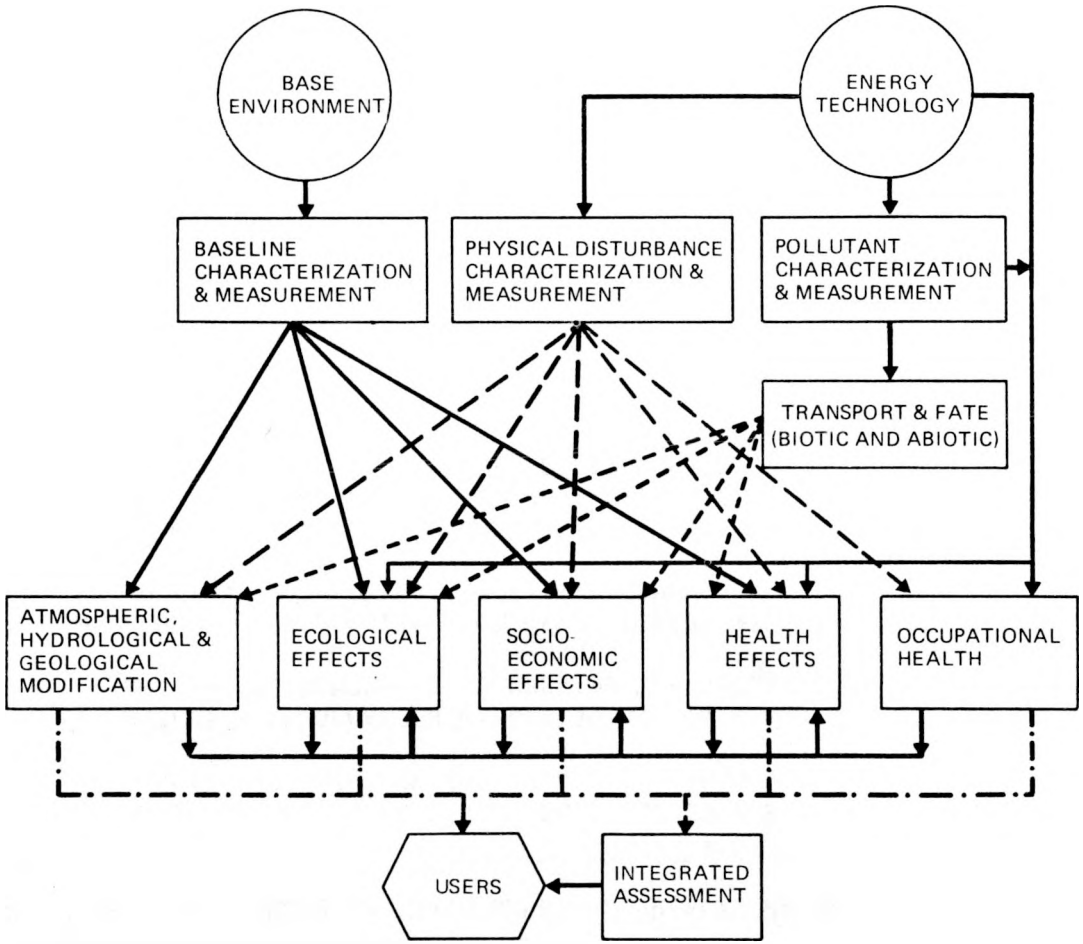
EXHIBIT 34
MAJOR COMPONENTS OF INTEGRATED ASSESSMENTS AND SOCIOECONOMIC PROCESSES AND EFFECTS

3.3 Relationships of Biomedical and Environmental Research Activities

3.3.1 Interrelationships and Characteristics of Biomedical and Environmental Research Categories.

THE PREPARATION OF VALID, COMPREHENSIVE HEALTH AND ENVIRONMENTAL ASSESSMENTS REQUIRES THE PERFORMANCE OF A SERIES OF RELATED RESEARCH ACTIVITIES.

- INDIVIDUAL RESEARCH PROJECTS MUST BE RELATED TO AN OVERALL PLAN SO THAT DATA COLLECTION, COMPILATION AND EVALUATION TASKS CAN BE PERFORMED IN A TIMELY AND EFFECTIVE MANNER.
- THE BASE ENVIRONMENT (NORMALLY INCLUDING MAN) FORMS THE BASIS FOR STUDYING THE ADDITIONAL EFFECTS OF THE SEVERAL ENERGY TECHNOLOGIES.
- EACH ENERGY TECHOLOGY PRESENTS PARTICULAR RISKS TO THE ENVIRONMENT (INCLUDING HUMAN AND ECOLOGICAL SYSTEMS) AND REQUIRES ASSESSMENT BY A SERIES OF RESEARCH PROJECTS.
- THE FOLLOWING SECTIONS DESCRIBE IN MORE DETAIL THE INTERRELATIONSHIPS AND CHARACTERISTICS OF ENVIRONMENTAL RESEARCH CATEGORIES.
- THE FLOW OF RESEARCH DATA IS SHOWN ON THE FACING CHART, DATA NEEDS CAN BE PERCEIVED BY REVERSING THE DIRECTION OF FLOW.
- INFORMATION MANAGEMENT SYSTEMS ARE UTILIZED BY ALL RESEARCH CATEGORIES.



NOTE:
BECAUSE OF THE COMPLEXITY OF THE INTERRELATIONS DEPICTED IN THIS DIAGRAM, DIFFERENT TYPES OF LINES (SOLID, DASHED, DOTTED) ARE USED TO IMPROVE CLARITY IN INDICATING RELATIONSHIPS.

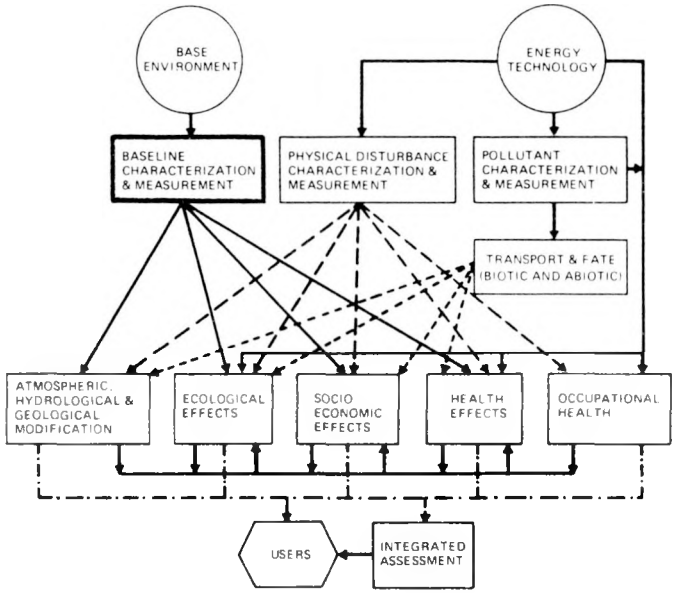
EXHIBIT 35

RELATIONSHIPS OF BIOMEDICAL AND ENVIRONMENTAL RESEARCH ACTIVITIES. Complex interrelationships exist between research activities.

3.3.2 Baseline Characterization and Measurement: Interfaces

ASSESSMENT OF CONSEQUENCES OF OPERATION OF AN ENERGY FACILITY NECESSITATES ACCURATE DEFINITION OF A WIDE RANGE OF ENVIRONMENT AND HEALTH PARAMETERS PRIOR TO IMPLEMENTATION.

- BASELINE INFORMATION WILL BE OBTAINED FOR ATMOSPHERIC, HYDROLOGICAL AND GEOLOGICAL CONDITIONS, AND FOR ECOLOGICAL, SOCIOECONOMIC AND HEALTH CONDITIONS.
- BASELINE INFORMATION WILL ALSO AID IN PLANNING THE RECLAMATION OF THE EXPOSED AREAS AND IN ASSESSMENT OF SUCCESS OF THE RECLAMATION OPERATIONS.
- BASELINE INFORMATION FOR TECHNOLOGIES WITH NEAR TERM POTENTIAL FOR ENERGY PRODUCTION IS OF IMMEDIATE SIGNIFICANCE.
- WITH REGARD TO NEW TECHNOLOGIES, THERE EXIST UNIQUE OPPORTUNITIES TO CARRY OUT BASELINE MEASUREMENTS SINCE THE FUTURE SITES OF MANY ENERGY FACILITIES HAVE ALREADY BEEN SELECTED OR WILL BE SELECTED SHORTLY.



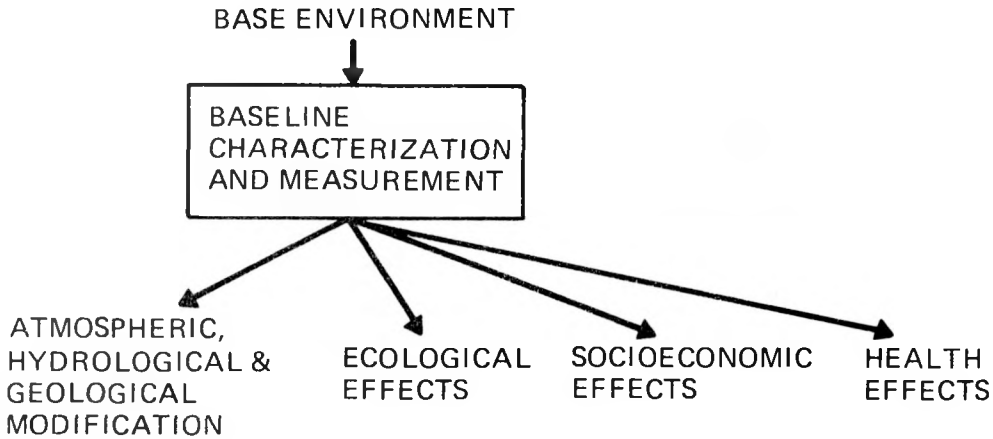


EXHIBIT 36

RELATION OF BASELINE CHARACTERIZATION AND MEASUREMENT ACTIVITIES TO OTHER RESEARCH ACTIVITIES. Determination of environmental impacts requires baseline information.

3.3.2 Baseline Characterization and Measurement: Research

BASELINE INVESTIGATIONS WILL CHARACTERIZE PRE-IMPLEMENTATION PHYSICAL, CHEMICAL, ECOLOGICAL, HEALTH, AND SOCIOECONOMIC PARAMETERS FOR ALL TECHNOLOGIES.

- BASELINE STUDIES ARE SITE-DEPENDENT.
- BASELINE INVESTIGATIONS ON PHYSICAL AND CHEMICAL EFFECTS INCLUDE ATMOSPHERIC, AQUATIC AND TERRESTRIAL MEASUREMENTS.
- BASELINE ECOLOGICAL STUDIES INCLUDE PHYSIOLOGICAL AND BEHAVIORAL CHARACTERISTICS, BIOLOGICAL PROCESSES, POPULATION AND COMMUNITY CHARACTERISTICS, AND PRODUCTIVITY MEASUREMENTS.
- BASELINE SOCIOECONOMIC STUDIES DEAL WITH SOCIAL, ECONOMIC AND DEMOGRAPHIC CHARACTERISTICS.
- BASELINE HEALTH INVESTIGATIONS INCLUDE REVIEW, REFINEMENT AND ANALYSIS OF AVAILABLE HEALTH STATISTICAL DATA.

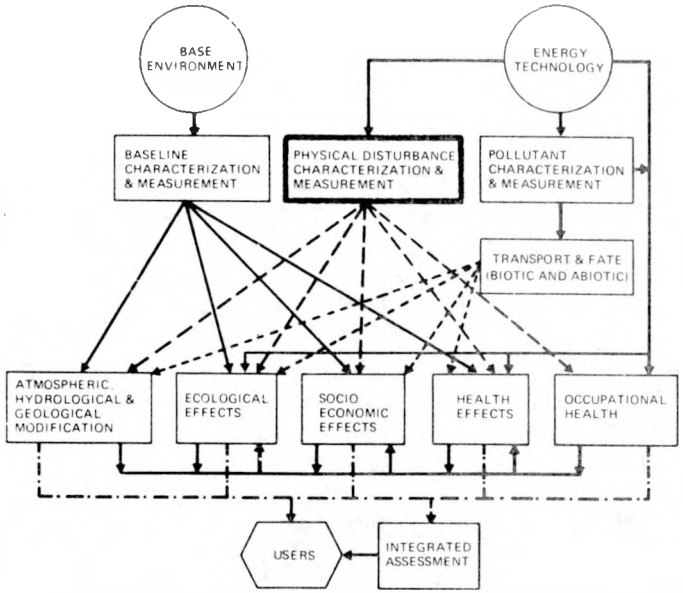
	BASELINE STUDY AREAS	MEASUREMENTS OF:
PHYSICAL/CHEMICAL STUDIES	Atmospheric	Air quality (technologies determine the pollutants of interest), air flow, temperature, humidity, cloud cover, distribution of direct and diffuse solar radiation by intensity and wave length.
	Hydrological	Marine water: temperature, turbidity, sediment load, particale size distribution, current pattern, dissolved solids, nutrients, dissolved oxygen, microorganisms, etc. Surface water and Ground water: physical–temperature, specific conductivity turbidity, color, Ph, suspended solids; chemical–dissolved solids, chloride, nutrients (nitrogen, phosphorus), hardness, radiochemicals, dissolved oxygen, pesticides, carbon, etc.; biological–microorganisms; sedimentation–concentration, particle size distribution
	Geological	Topography; potential for movements of the surface caused by internal crustal processes (such as: tectonic movements, movements resulting from volcanism, isostatic movements); potential for movement of the surface caused by surficial processes such as: mass movements on slopes (landslides, soil creep), collapse and subsidence of the surface; surface reflectivity
ECOLOGICAL STUDIES	Physiological and Behavioral	Reproductive, respiratory, digestive, growth and development, etc. Reproductive, seasonal and daily movements; predatory behavior and other interspecies interactions
	Biological Processes	Nutrient cycles, energy transformations, transport and accumulation of specific compounds
	Population, Community	Abundance, sex and age composition and quantitative dynamics of population; distribution, species composition, structure and interspecies relationship of communities
	Productivity	Photosynthetic rates and biomass measures of primary and secondary productivity
SOCIOECONOMIC STUDIES	Social	Public attitude and perceptions, social and cultural structures
	Economic	Income, and income distribution; occupational characteristics; cost of living indicators and trends
	Demographic	Existing population characteristics such as sex, age, race, education, ethnic composition, and trends; local, regional and national data
HEALTH STUDIES	Health Statistics	Baseline quantities of radionuclides and other pollutants in appropriate populations Epidemiological studies on existing populations, including definition of at-risk populations Demographic evaluation of potential sites

EXHIBIT 37
EXAMPLES OF BASELINE CHARACTERIZATION AND MEASUREMENT RESEARCH

3.3.3 Physical Disturbances Characterization and Measurement: Interfaces

IMPLEMENTATION OF VARIOUS ENERGY TECHNOLOGIES RESULT IN PHYSICAL DISTURBANCES WHICH MAY CAUSE INADVERTENT ATMOSPHERIC, HYDROLOGICAL, AND GEOLOGICAL MODIFICATIONS, AND UNDESIRABLE ECOLOGICAL AND SOCIOECONOMIC EFFECTS.

- PHYSICAL DISTURBANCES INCLUDE NOISE, ELECTROMAGNETIC FIELDS, AND GEOPHYSICAL AND HYDROLOGICAL MODIFICATIONS SUCH AS SUBSIDENCE AND SEISMICITY.
- THE NATURE OF PHYSICAL DISTURBANCES ARE IN GENERAL DETERMINED BY THE RESPECTIVE ENERGY TECHNOLOGIES.
- PHYSICAL DISTURBANCES ASSOCIATED WITH TECHNOLOGIES SUCH AS OIL SHALE AND GEOTHERMAL MAY HAVE SIGNIFICANT SOCIOECONOMIC, ECOLOGICAL, ATMOSPHERIC, HYDROLOGICAL AND GEOLOGICAL CONSEQUENCES.
- EVEN THOUGH THE PHYSICAL DISTURBANCES ARE GENERATED LOCALLY AT THE ENERGY EXTRACTION SITES, THE CONSEQUENCES MAY BE REGIONAL.
- PHYSICAL DISTURBANCES SUCH AS NOISE AND ELECTROMAGNETIC RADIATION MAY AFFECT THE HEALTH OF BOTH GENERAL POPULATIONS AND WORKERS.



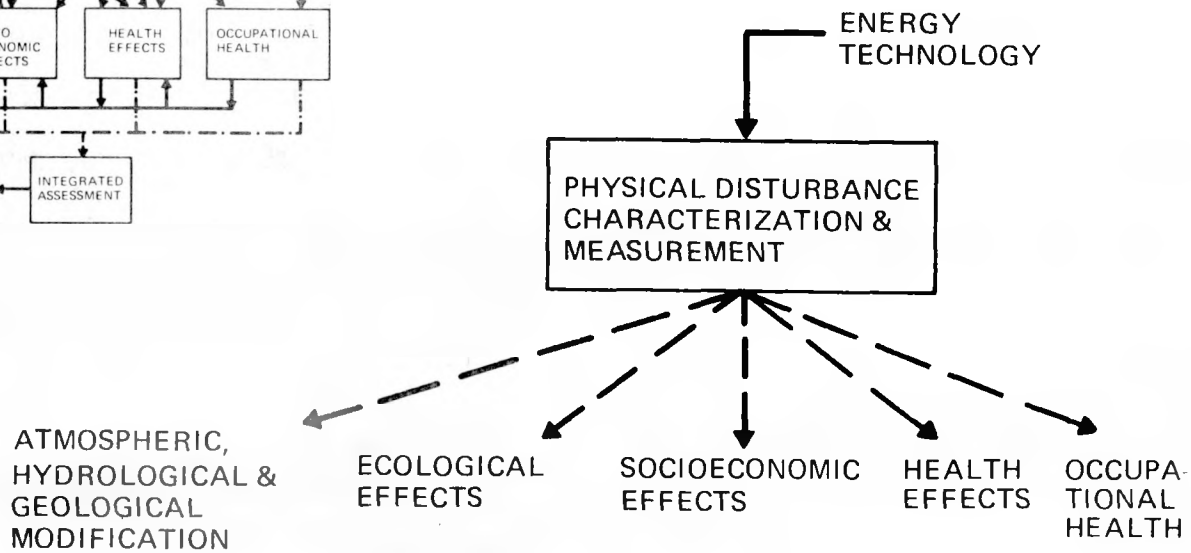


EXHIBIT 38

RELATION OF PHYSICAL DISTURBANCE CHARACTERIZATION AND MEASUREMENT ACTIVITIES TO OTHER RESEARCH ACTIVITIES. Local physical disturbances may have regional consequences.

3.3.3 Physical Disturbances Characterization and Measurement: Research

STUDIES IN CHARACTERIZATION AND MEASUREMENT OF PHYSICAL DISTURBANCES ARE DESIGNED TO GENERATE DATA FOR ASSESSING LOCAL AND REGIONAL IMPACTS AT VARIOUS STAGES OF FUEL CYCLES.

- TWO GENERIC RESEARCH ACTIVITIES UNDER THIS PROGRAM ARE:
  - IDENTIFICATION AND EVALUATION OF CURRENTLY AVAILABLE MEASUREMENT TECHNIQUES WHICH MAY BE USEFUL FOR DEVELOPMENT OF ADVANCED MEASUREMENT CAPABILITIES.
  - DEVELOPMENT OF INSTRUMENTS AND SYSTEMS FOR BIOMEDICAL AND ECOLOGICAL PROGRAMS.
- TECHNOLOGY-ORIENTED ACTIVITIES ARE DESIGNED TO:
  - DETERMINE DISTRIBUTION AND THE INTENSITY OF PHYSICAL DISTURBANCES AT DEVELOPMENTAL AND OPERATIONAL SITES.
  - DETERMINE THE EXTENT OF PHYSICAL DISTURBANCES AS THEY RELATE TO THE SPECIFIC PROCESSES IN EACH ENERGY TECHNOLOGY.
- A DETAILED BREAKDOWN OF PHYSICAL DISTURBANCE RESEARCH ACTIVITIES AS THEY RELATE TO VARIOUS ENERGY TECHNOLOGIES IS SHOWN IN EXHIBIT 39.

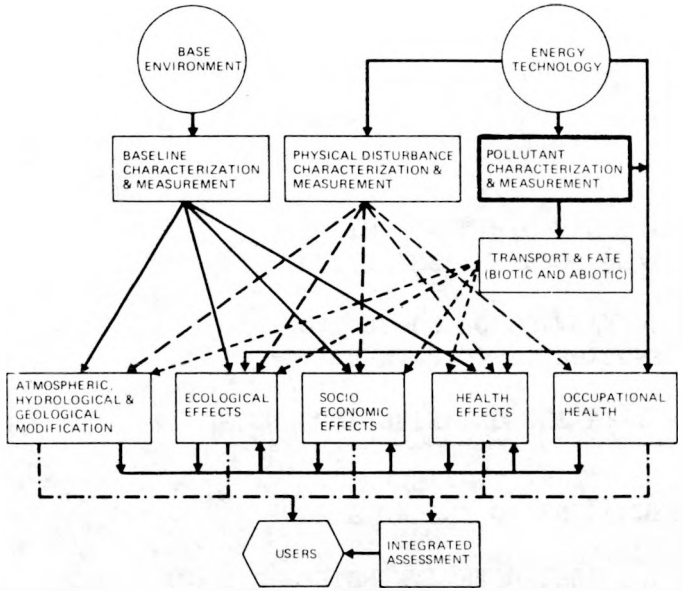
TECHNOLOGIES / PHYSICAL DISTURBANCES CHARACTERIZATION AND MEASUREMENTS	COAL EXTRACTION, PROCESSING, & COMBUSTION	COAL CONVERSION	OIL SHALE	OIL AND GAS	ENERGY CONSERVATION & EFFICIENCY	SOLAR ENERGY	GEOTHERMAL ENERGY	FUSION	FISSION
Measurement Techniques	Identification and evaluation of currently available measurement techniques Development of new materials, devices, sub-units and system concepts related to such measurement techniques Combination of the above two steps generates advanced measurement capabilities for dealing with the growing complexity of energy technology development								
Development of Instruments & Systems	Development of instruments not available but needed in DBFR programs in: - biomedical and health protection - occupational and population exposures - process characterization Development of capabilities in quality assurance for sampling and analysis								
Distribution & Intensity of Physical Disturbances at Developmental and Operational Sites	Waste heat disposal: cooling tower properties related to weather modification and water balance disruption								
	Weather modification: aerosols, CO_2 changes in surface reflectivity Water and land disturbance: aquifer disruption, topographic changes, soil creep and erosion	Disturbances from in situ extraction: subsidence and aquifer disruption	Regional water resource disturbance, ground and surface water degradation by deposition, wastewater releases, erosion, and consumptive water use Degradation of air quality: particulates from shale retorting	Geological & hydrological implications of tertiary recovery: feature driving process, aquifer disruption, subsidence, induced seismicity	Ultra-high voltage lines: electromagnetic field intensity variations & propagation	Ocean thermal modification: surface and subsurface temperature, current & nutrient modifications Weather, climate modification: changes in surface reflectivity & emissivity, wind characteristics, & soil properties	Noise levels & propagation Geological/hydrological disturbances, subsidence, seismicity	Disturbances due to CTR operation, magnetic field intensity and distribution Vibrational & noise	Physical disturbances from processing, conversion & waste disposal: increased ambient radiation level

EXHIBIT 39
EXAMPLES OF PHYSICAL DISTURBANCE CHARACTERIZATION AND MEASUREMENT RESEARCH

3.3.4 Pollutant Characterization and Measurement: Interfaces

OPERATION OF VARIOUS ENERGY TECHNOLOGY FACILITIES RESULTS IN RELEASE OF A VARIETY OF POLLUTANTS TO THE ENVIRONMENT; THE AMBIENT CONCENTRATION OF THESE POLLUTANTS AT RECEPTORS OF INTEREST INVOLVES CONSIDERATION OF THE EFFECTS OF TRANSPORT AND TRANSFORMATION OF THESE CHEMICALS IN AIR, LAND AND WATER.

- POLLUTANTS OF INTEREST ARE CHEMICALS, PARTICULATES, RADIONUCLIDES AND INFECTIOUS ORGANISMS, WHICH HAVE HEALTH AND/OR ECOLOGICAL EFFECTS.
- THE NATURE OF THE POLLUTANTS, SPECIFICALLY THEIR CHEMICAL COMPOSITION AND CONVERSION RATE, DETERMINES THEIR CONCENTRATION AT RECEPTORS OF INTEREST.
- SOME OF THE NEW ENERGY FACILITIES SUCH AS OIL SHALE, COAL CONVERSION AND GEOTHERMAL HAVE STARTED OR WILL START SHORTLY OPERATION OF PILOT AND DEMONSTRATION PLANTS. FOR THESE TECHNOLOGIES, DEVELOPMENTAL SITE MEASUREMENTS ARE URGENTLY NEEDED.
- THERE IS A NEED FOR DEVELOPMENT OF ADVANCED CAPABILITIES WITHIN THE POLLUTANT CHARACTERIZATION AND MEASUREMENT PROGRAM; NEED FOR SUCH CAPABILITIES WILL INCREASE WITH INCREASING COMPLEXITY OF TECHNOLOGIES.
- PRELIMINARY POLLUTANT CHARACTERIZATION PROVIDES DATA FOR STUDIES TO ESTABLISH CAUSAL RELATIONSHIPS IN ECOLOGY AND HEALTH.



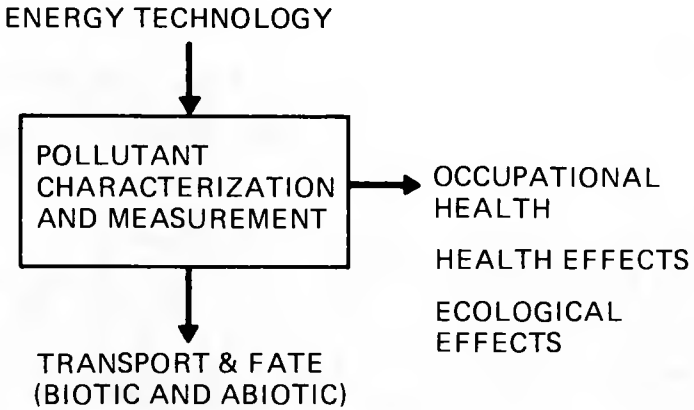


EXHIBIT 40

RELATION OF POLLUTANT CHARACTERIZATION AND MEASUREMENT ACTIVITIES TO OTHER RESEARCH ACTIVITIES. Early and accurate pollutant characterizations are required for environmental assessments.

3.3.4 Pollutant Characterization and Measurement: Research

STUDIES IN CHARACTERIZATION AND MEASUREMENT OF POLLUTANTS PROVIDE DATA FOR ASSESSING LOCAL AND REGIONAL EFFECTS OF POLLUTANTS.

- TWO GENERIC RESEARCH ACTIVITIES UNDER THIS PROGRAM ARE:
  - IDENTIFICATION AND EVALUATION OF CURRENTLY AVAILABLE MEASUREMENT TECHNIQUES WHICH MAY BE USEFUL FOR DEVELOPMENT OF ADVANCED MEASUREMENT CAPABILITIES.
  - DEVELOPMENT OF INSTRUMENTS AND SYSTEMS FOR DBER BIOMEDICAL AND ECOLOGICAL PROGRAMS.
- TECHNOLOGY-ORIENTED ACTIVITIES ARE DESIGNED TO:
  - DETERMINE DISTRIBUTIONS, CONCENTRATIONS AND PROPERTIES OF POTENTIALLY HAZARDOUS POLLUTANTS AT DEVELOPMENTAL AND OPERATIONAL SITES.
  - DETERMINE THE PROPERTIES OF POTENTIALLY HAZARDOUS POLLUTANTS AS THEY RELATE TO THE SPECIFIC PROCESSES IN EACH ENERGY TECHNOLOGY.

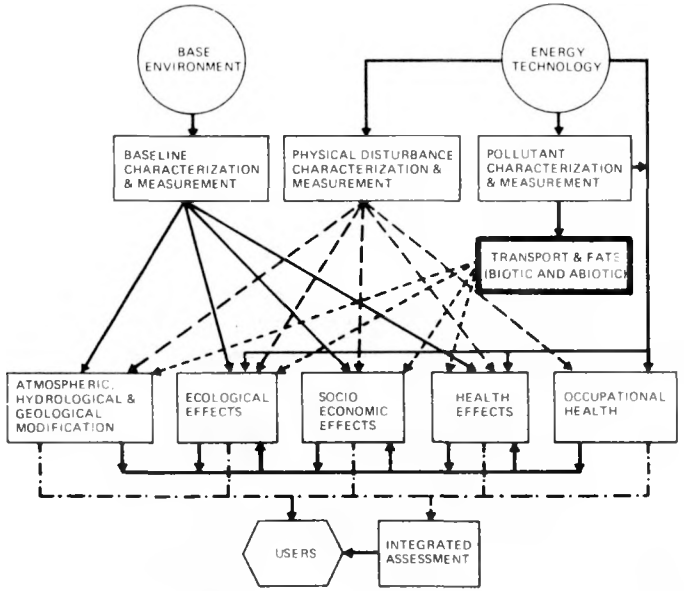
TECHNOLOGIES / POLLUTANT CHARACTERIZATION MEASUREMENT	COAL EXTRACTION PROCESSING & COMBUSTION	COAL CONVERSTION	OIL SHALE	OIL AND GAS	ENERGY CONSERVATION AND EFFICIENCY	SOLAR ENERGY	GEOTHERMAL ENERGY	FUSION	FISSION
Measurement Techniques	Identification and evaluation of currently available measurement techniques Development of new materials, devices, sub-units and system concepts related to such measurement techniques Combination of the above two steps generates advanced measurement capabilities for dealing with the growing complexity of energy technology development								
Development of Instruments & Systems	Development of instruments not available but needed in DBER programs in: – biomedical and health protection – occupational and population exposures – process characterization Development of capabilities in quality assurance for sampling and analysis								
Distribution, Concentration, & Properties of Pollutants at Developmental & Operational Sites	Combustion products: SO_X, sulfate, acids, NO_X, oxidants, aerosols, trace metals, & others (ash, slurry residues) Coal extraction: hydrocarbons, particulates, leachates from mine & tailings	Airborne discharges: gases & fumes released from stacks & process streams Organic pollutants: unburned hydrocarbons, polyaromatic hydrocarbons Aqueous discharges: dissolved & suspended organic & inorganic compounds	Combustion products: SO_X, sulfate, NO_X, oxidants, aerosols, trace metals, others Extraction & processing products: particulates, organic compounds (e.g., polyaromatic hydrocarbons) & minerals (e.g., Si, Al, Ca, Pb, Hg, Cd) Aqueous discharge: particulates & dissolved gases	Oil spills: hydrocarbon classes & their conversion products	Waste utilization products: SO_X, NO_X, HCl, organic chlorides H_2S, NH_3, CO, particulates, heavy metals Air quality inside insulated buildings: aerosols, building materials, pathogens Nutrient management, soil & groundwater pollution from green manure, sewage farming, & slow release fertilizers Liquid waste utilization, potentially toxic & hazardous biological agents released from conventional cooling towers using municipal waste	Effluents from biomass production & conversion: hydrocarbons, trace elements, pesticides Component materials of solar devices: Cd-based compounds & other chemicals used in solar cell production	Noncondensable gases & trace element emissions: CO_2, H_2S, As, Hg, Si, Cd, B, Rn, etc. Liquid effluents, cooling tower drift, waste water disposal: H_2S, CO_2, by-products of brine treatment, emission of salt spray from disposal ponds	Tritium & other radionuclides in & around CTR containment structures	Radio nuclides: transuranics, ^{14}C, ^{129}I, ^{85}Kr, thorium, & plutonium, etc. in air, soils & water at various fuel cycle stages

EXHIBIT 41
EXAMPLES OF POLLUTANT CHARACTERIZATION AND MEASUREMENT RESEARCH

3.3.5 Transport and Fate: Interfaces

DELINEATIONS OF THE ABIOTIC TRANSPORT AND CONVERSION OF POLLUTANTS IN AIR, WATER, AND LAND AND THEIR BIOTIC CONVERSION THROUGH TRANSFER, ACCUMULATION, AND TRANSFORMATION IN FOOD CHAINS AND OTHER BIOLOGICAL SYSTEMS ARE DEPENDENT ON SOURCE TERM CHARACTERISTICS AND PROVIDE DATA ON AMBIENT CONDITIONS FOR ASSESSMENTS OF PHYSICAL, ECOLOGICAL, AND HEALTH EFFECTS.

- CHARACTERIZATION AND MEASUREMENT ACTIVITIES SUPPLY DATA ON POLLUTANTS AND INSTRUMENTATION FOR USE IN TRANSPORT AND FATE RESEARCH.
- ABIOTIC TRANSPORT AND FATE ACTIVITIES DESCRIBE AMBIENT POLLUTANT CHARACTERISTICS AS THEY RELATE TO HEALTH AND ECOLOGICAL ANALYSES.
- BIOTIC TRANSPORT AND FATE ACTIVITIES DESCRIBE THE STEPS INVOLVED IN THE TRANSFER, ACCUMULATION, AND TRANSFORMATION OF MATERIALS THROUGH BIOLOGICAL SYSTEMS.
- THE TRANSFER, ACCUMULATION, AND MODIFICATION OF POLLUTANTS, VIA PATHWAYS IN NONHUMAN ORGANISMS, SIGNIFICANT TO HUMAN HEALTH ARE THE SUBJECT OF BIOTIC TRANSFER AND FATE STUDIES.
- TRANSPORT AND FATE ALSO PROVIDES THE INFORMATION NECESSARY TO DESCRIBE ATMOSPHERIC, HYDROLOGIC, AND GEOLOGIC CONSEQUENCES OF POLLUTION.
- TRANSPORT AND FATE REQUIRES SPECIALIZED INSTRUMENTATION FOR MONITORING POLLUTANTS.



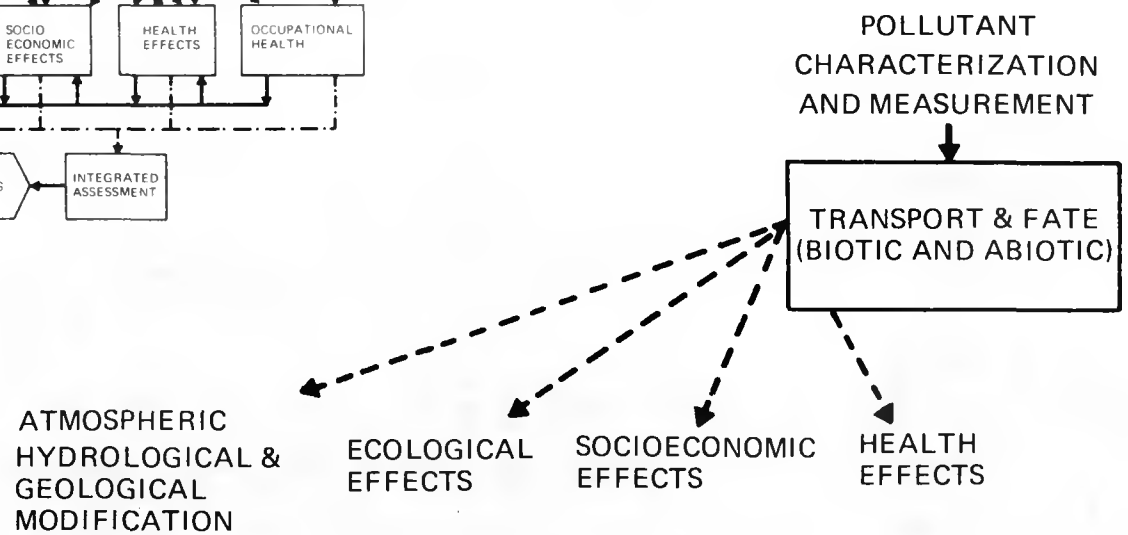


EXHIBIT 42

RELATION OF TRANSPORT AND FATE ACTIVITIES TO OTHER RESEARCH ACTIVITIES. Major activities in this area include sensor development and analysis of transport and conversion processes.

3.3.5 Transport and Fate: Research

SPECIFIC PHYSICAL AND CHEMICAL PROCESSES AND EFFECTS INVESTIGATIONS INCLUDE THE EXAMINATION OF THE TRANSPORT AND FATE OF POLLUTANTS IN ALL MEDIA FROM SOURCE TO RECEPTOR AS WELL AS THE MODIFYING PROCESSES ON THE POLLUTANT.

- GENERIC REMOTE AND CONTACT SENSORS WILL BE DEVELOPED FOR USE IN THE DETERMINATION OF PHYSICAL AND CHEMICAL PROCESSES IN AMBIENT AIR, WATER, AND LAND.
- PHYSICAL AND CHEMICAL MODELS FOR ATMOSPHERIC, HYDROLOGIC, AND GEOLOGIC PROCESSES WILL BE DEVELOPED.
- EXPERIMENTS WILL BE USED TO DEFINE PROCESSES AND PARAMETERS RELATED TO ENVIRONMENTAL MODELS.
- RESEARCH WILL BE PERFORMED TO DESCRIBE THE PATHWAYS, TRANSFORMATION, AND FATE OF POLLUTANTS AND OTHER MATERIALS IN BIOTIC COMMUNITIES.

TECHNOLOGIES / TRANSPORT AND FATE	COAL EXTRACTION PROCESSING, & COMBUSTION	COAL CONVERSION	OIL SHALE	OIL AND GAS	ENERGY CONSERVATION AND EFFICIENCY	SOLAR ENERGY	GEOTHERMAL ENERGY	FUSION	FISSION
Ambient Sensor Development	Develop generic remote and contact sensors (not commercially available) for monitoring physical and chemical properties of air, water and land to determine ambient processes								
	1 Sensors to monitor surface displaced materials with regard to water requirements, leaching processes & erosion potential 2 Sensors to monitor subsurface disturbances to assess geological and hydrological effects of extraction		Same as 1 Same as 2	Same as 2	Sensors for waste utilization products	Sensors to monitor geographical distribution of direct & diffuse solar radiation by intensity, wavelengths Sensors for bioconversion products	Sensors to monitor ambient air & water for geothermal related pollutants Same as 2	Sensors for monitoring HT & HTO in air & water	Same as 1 Same as 2 Sensors to monitor distribution & concentration of transuranics, ^{14}C, ^{129}I, ^{85}Kr, thorium & plutonium in air & water
Physical & Chemical Transport Models & Validation Experiments	Generic atmospheric models for complex terrain such as hills and valleys, urban areas, shorelines, etc								
	Generic aquatic models for freshwater flow (surface and subsurface) and for coastal and marine environment								
	Regional models to predict atmospheric pollution from combustion emissions (such models include transport, dispersion, conversion and scavenging processes with emphasis on SO_X, TSP, TOX, NO_X and trace metals) Atmospheric transport, diffusion and conversion models of organic and acid forming compounds				Transport of leachates from uncommon fertilizers, urban waste & agricultural wastes	Development of models to predict wind power potential, & wind turbine efficiencies Ocean thermal models Model heat & water balance of solar thermal, photovoltaic, & wind energy facilities	Geothermal reservoir models Geothermal air pollution transport, diffusion & conversion models (H_2S & others) Same as 8	Transport & conversion of tritium compounds in air & water	Migration models of long lived nuclides Same as 3 Same as 4 Same as 5 Same as 8
	3 Models of surface displaced materials (natural and man-made) 4 Models to predict subsurface disturbances to assess geological and hydrological effects of extraction 5 Residual disposal models Effects of extraction on soil nutrient processes, in NGP, SW, MW & Ap	8 Models to predict effects of process water on surface & subsurface waterbodies & soils	Same as 3 Same as 4 Same as 8	Same as 4 Same as 5 Same as 8					
		In situ retorting models of effects on geology & hydrology							
		Same as 5	Same as 5						
Biotic Transport & Fate Studies	6 Movement & fate of cooling system effluents in terrestrial, freshwater & marine systems 7 Stack emissions in terrestrial, freshwater & marine systems	Accumulation & fate of organic & inorganic conversion compounds in terrestrial & freshwater systems; in NGP, SW, MW, & Ap	Transport & fate of organic compounds from conversion in terrestrial & freshwater system; in RM	Movement & fate of petroleum products, from extraction & transport in marine systems; in AI & MW Movement & fate of extracted or transported petroleum products in Arctic & subarctic systems, in AI Same as 6 Same as 7	Effects of monoculture in bioproduction on nutrient processes in terrestrial & marine systems		Transport and fate of organics & metals in agricultural & natural systems, in PC	Tritium transport & fate in terrestrial & aquatic systems Transport & fate of process materials & activation products in terrestrial & aquatic systems	Effects of extraction on soil nutrient processes, in SW Transport & fate of transuranics & long-lived fission products in terrestrial & freshwater systems Transport & fate of HTGR products in terrestrial & freshwater systems Same as 6 Same as 7

Regional Key

AI	Alaska	RM	Rocky Mts.	Ap	Appalachia
PC	Pacific Coast	SW	Southwest	SE	Southeast
NGP	Northern Great Plains	MW	Midwest	HA	Hawaii

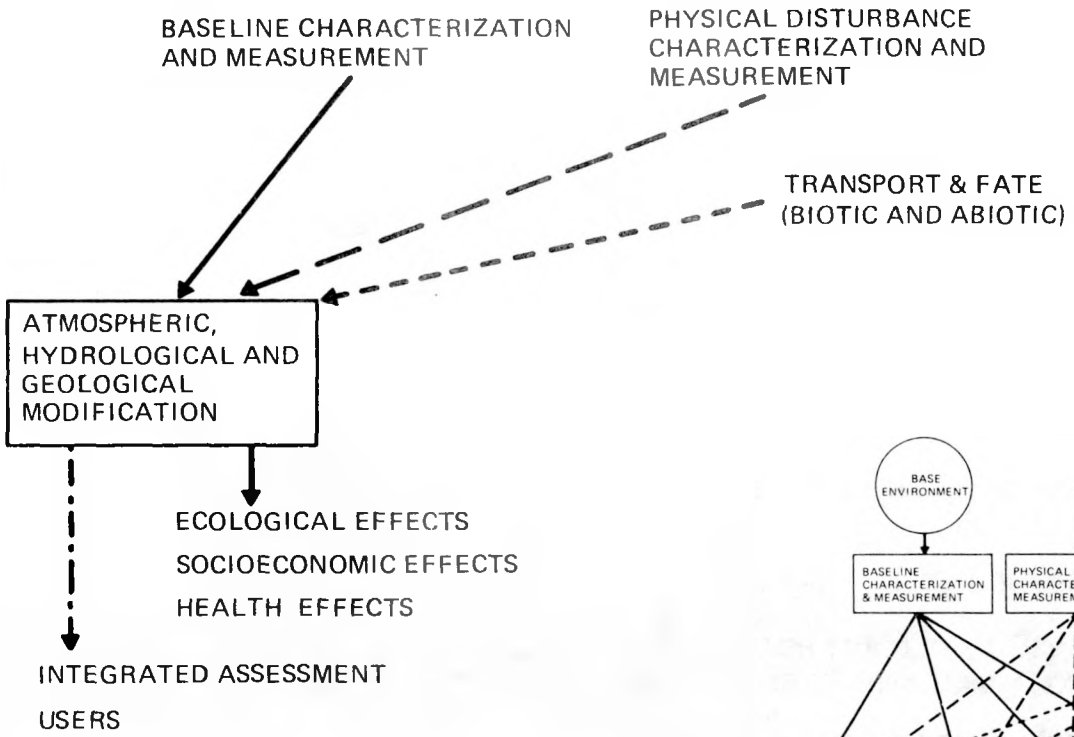
NOTE: Numbers preceding an activity indicate a similar activity will occur for other technologies, as indicated by repetition by the number in the appropriate columns

EXHIBIT 43
EXAMPLES OF TRANSPORT AND FATE RESEARCH

3.3.6 Atmospheric, Hydrological and Geological Modification: Interfaces

ATMOSPHERIC, HYDROLOGICAL AND GEOLOGICAL MODIFICATIONS WILL HAVE ECOLOGICAL AND SOCIO-ECONOMIC CONSEQUENCES, AND ARE AN IMPORTANT ELEMENT IN INCREASING ENVIRONMENTAL COSTS OF ENERGY DEVELOPMENTS; AN EVALUATION OF THESE MODIFICATIONS REQUIRES INFORMATION ON BASELINE CONDITIONS AND ON THE CHARACTER AND EXTENT OF PHYSICAL DISTURBANCES.

- IMPORTANT MODIFICATIONS INCLUDE WEATHER CHANGES, AQUIFER DISRUPTION, SEISMICITY, LANDSLIDES, AND SUBSIDENCE.
- ALL TECHNOLOGIES WILL RESULT IN ATMOSPHERIC, HYDROLOGICAL AND GEOLOGICAL MODIFICATIONS OF VARYING DEGREE AND CHARACTER.
- THESE MODIFICATIONS MAY HAVE DIRECT AND INDIRECT EFFECTS ON BIOTA.
- DEMOGRAPHIC AND OTHER CULTURAL PATTERNS CAN BE EXPECTED TO RESPOND TO MAJOR ATMOSPHERIC, HYDROLOGICAL AND GEOLOGICAL EVENTS.
- THE DEGREE OF IMPACT AND THE COSTS OF REMEDIED ACTIONS WILL BE A COMPONENT OF THE OVERALL ASSESSMENT OF TECHNOLOGY FEASIBILITY.



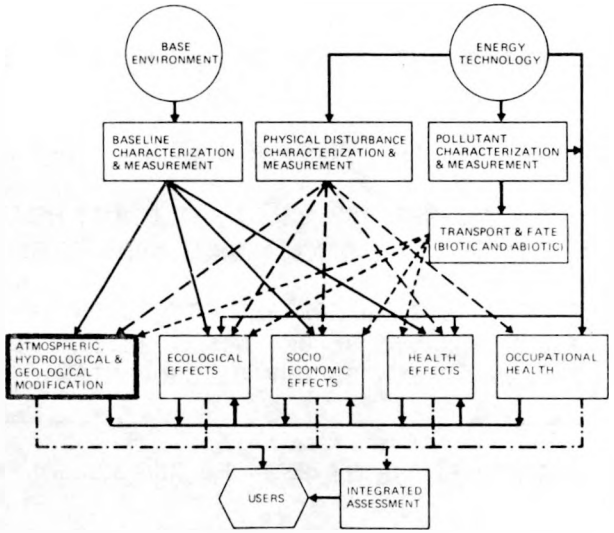


EXHIBIT 44

RELATION OF ATMOSPHERIC, HYDROLOGICAL, AND GEOLOGICAL MODIFICATION ACTIVITIES TO OTHER RESEARCH ACTIVITIES. Important effects include weather modifications, aquifer disruption, seismic events and subsidence.

3.3.6 Atmospheric, Hydrological and Geological Modification: Research

INADVERTENT MODIFICATION OF ATMOSPHERIC, HYDROLOGICAL AND GEOLOGICAL PROCESSES CAN BE EXPECTED TO OCCUR IN VARYING DEGREES FROM ONE OR MORE TECHNOLOGY FUEL CYCLES.

- ATMOSPHERIC MODIFICATION PROCESSES, METEOROLOGIC AND CLIMATIC, NEED TO BE UNDERSTOOD. OF PARTICULAR INTEREST ARE REGIONAL AND GLOBAL SCALE EFFECTS OF CO_2, AEROSOLS, WASTE HEAT, EXCESS MOISTURE, REFLECTIVITY AND EMISSIVITY.
- INADVERTENT GEOLOGICAL MODIFICATIONS (SUBSIDENCE, INDUCED SEISMICITY, ETC.) FROM GEOTHERMAL, COAL, AND OIL EXTRACTION NEED TO BE ADDRESSED.
- INADVERTENT HYDROLOGICAL MODIFICATION SUCH AS OIL SPILLS, ACID MINE DRAINAGE, AQUIFER DISRUPTIONS ARE REAL PROBLEMS.
- ALL OF THESE PROBLEMS REQUIRE EFFORTS IN MODELING AND MODEL VALIDATION EXPERIMENTATION.

TECHNOLOGIES / ATMOSPHERIC, HYDROLOGICAL & GEOLOGICAL MODIFICATION	COAL EXTRACTION PROCESSING & COMBUSTION	COAL CONVERSION	OIL SHALE	OIL AND GAS	ENERGY CONSERVATION AND EFFICIENCY	SOLAR ENERGY	GEOTHERMAL ENERGY	FUSION	FISSION
Inadvertant Atmospheric Modifications	Generic weather and climate models to predict effects of energy activities on regional and global scale Weather implications of cooling towers								
	Climatic effects of fossil fuel combustion products such as CO_2, aerosols, etc.				Weather forecast & warning models for better use of energy	Climatic implications of large scale collector fields	Climatic effects of CO_2 releases		Same as 1
	1 Climatic implications of changes in surface properties due to mining		Same as 1						
Inadvertant Geologic Modifications	2 Subsidence due to mining	Land stability disturbances due to in situ recovery		Effects of tertiary oil recovery			Subsidence & induced seismicity caused by geothermal operations Geothermal blowout analyses		Same as 2
			Same as 2						
Inadvertant Hydrologic Modifications	3 Effects of subsidence on irrigation 4 Influence potential of flooding due to changes in topography 5 Acid mine drainage		Same as 3 Same as 4 Same as 5	Same as 3 Effects of Tertiary oil recovery			Same as 3		Same as 3 Same as 4 Same as 5

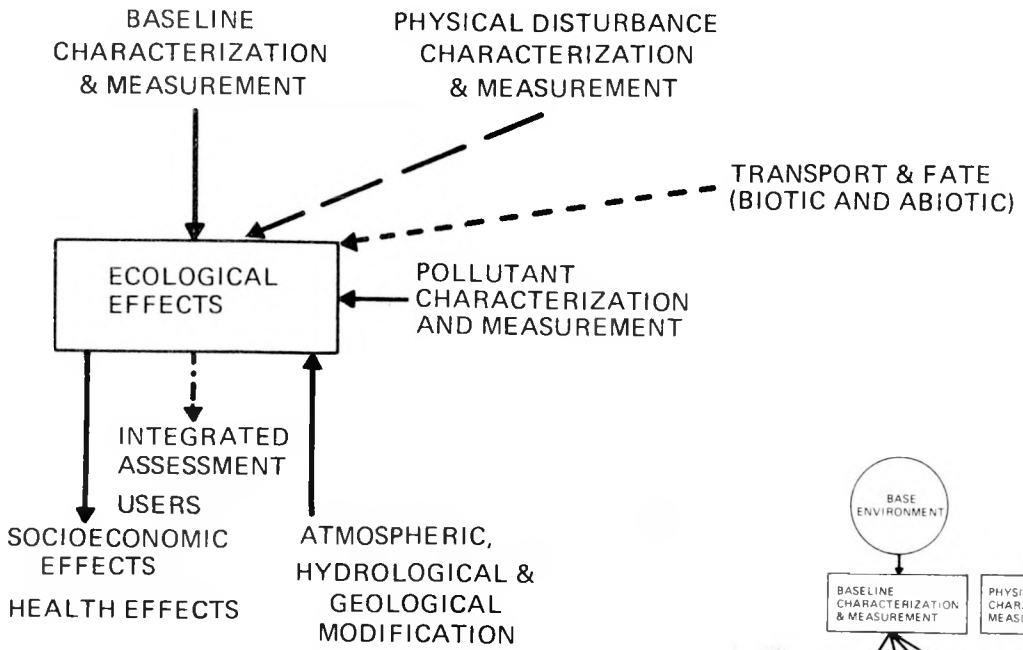
NOTE: Numbers preceding an activity indicate a similar activity will occur for other technologies, as indicated by repetition of the number in the appropriate columns

EXHIBIT 45
EXAMPLES OF ATMOSPHERIC, HYDROLOGICAL, AND GEOLOGICAL RESEARCH

3.3.7 Ecological Processes and Effects: Interfaces

BASELINE ECOLOGICAL INFORMATION AND DATA ON PHYSICAL, CHEMICAL, AND SOCIOECONOMIC PERTURBATIONS MAY HAVE ECOLOGICAL CONSEQUENCES. ECOLOGICAL PERTURBATIONS MAY LEAD TO SOCIOECONOMIC AND HEALTH IMPACTS, AND ARE AN ELEMENT IN ASSESSING OVERALL COSTS OF TECHNOLOGY DEVELOPMENT.

- BASELINE ECOLOGICAL INFORMATION DESCRIBES EXISTING CHARACTERISTICS OF INDIVIDUAL SPECIES, POPULATIONS, COMMUNITIES AND BIOME STRUCTURE AND FUNCTION.
- THE BEHAVIOR OF ORGANISMS AND THE COMPOSITION AND FUNCTION OF ECOSYSTEMS MAY BE ALTERED BY ATMOSPHERIC, HYDROLOGICAL, AND GEOLOGICAL MODIFICATIONS.
- INCREASES IN HUMAN POPULATIONS AND CHANGES IN LIFESTYLE WILL IMPACT BIOTIC RESOURCES.
- ECOLOGICAL CHANGES, SUCH AS MODIFICATIONS IN THE BIOLOGICAL PRODUCTIVITY OF ECOSYSTEMS, MAY HAVE SIGNIFICANT SOCIOECONOMIC EFFECTS.
- ECOLOGICAL COSTS WILL BE AN IMPORTANT ELEMENT IN THE EVALUATION OF ENERGY TECHNOLOGY DEVELOPMENT ALTERNATIVES.



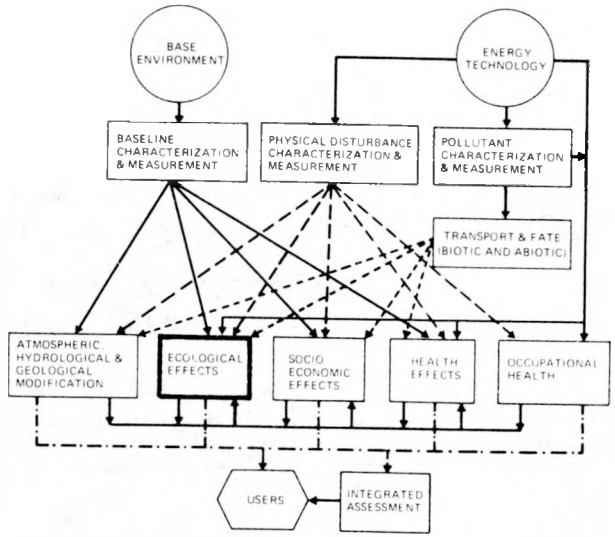


EXHIBIT 46

RELATION OF ECOLOGICAL EFFECTS ACTIVITIES TO OTHER RESEARCH ACTIVITIES. Terrestrial (agricultural and natural), freshwater, and marine environments require ecological analysis.

3.3.7 Ecological Processes and Effects: Research

SPECIFIC ECOLOGICAL INVESTIGATIONS IN THE BPP WILL ADDRESS ENVIRONMENTAL PROBLEMS IN ALL TECHNOLOGIES AND FUEL CYCLE STAGES.

- SPECIFIC RESEARCH PROJECTS ARE IDENTIFIED IN EXHIBIT 43 ACCORDING TO RESEARCH APPROACH, TECHNOLOGY FUEL CYCLE, AND REGION.
- RESEARCH ON BEHAVIORAL RESPONSES OF ORGANISMS, ON BIOLOGICAL PRODUCTIVITY, AND ON ECOSYSTEM MANAGEMENT APPLY ONLY TO A FEW TECHNOLOGIES.
- THE BREADTH OF ECOLOGICAL RESEARCH WILL VARY BY TECHNOLOGY ACCORDING TO ANTICIPATED EFFECTS, EXISTING INFORMATION, IMPLEMENTATION TIMELINES, AND AVAILABILITY OF RESOURCES.
- GENERIC RESEARCH PROGRAMS WILL PROVIDE FUNDAMENTAL BIOLOGICAL INFORMATION IN SUPPORT OF TECHNOLOGY-ORIENTED RESEARCH.

TECHNOLOGIES / ECOLOGICAL EFFECTS RESEARCH	COAL EXTRACTION PROCESSING & COMBUSTION	COAL CONVERSION	OIL SHALE	OIL AND GAS	ENERGY CONSERVATION AND EFFICIENCY	SOLAR ENERGY	GEOTHERMAL ENERGY	FUSION	FISSION
Behavioral Responses					Effects of electromagnetic transmission on terrestrial marine organisms	Effects of large-scale solar thermal conversion facilities on terrestrial fauna in SW Noise and visual effects of wind conversion arrays on terrestrial fauna in NGP	Noise effects at extracted sites on wildlife in PC		
Physiological Responses	1 Toxicity of cooling system materials to terrestrial, freshwater, & marine organisms Toxicity of combustion products to terrestrial, freshwater & marine organisms	Toxicity of organic & inorganic conversion materials to terrestrial & freshwater organisms in NGP, SW, MW, & Ap	Toxicity of organic & inorganic effluents & spent shale to terrestrial & freshwater organisms in RM	Toxicity of petroleum compounds on marine organisms during extraction & transport in Al and MW Toxicity of spilled petroleum products on Arctic & subartic biota during extraction & transport in Al Same as 1	Effects of electromagnetic transmission on terrestrial and marine organisms Toxicity of effluents from waste conversion to terrestrial, freshwater & marine organisms Toxicity of materials from waste heat utilization to terrestrial & aquatic organisms	Toxicity of heat transfer & storage media, during conversion, on terrestrial organisms in SW Toxicity of biocides & other ocean thermal conversion materials on marine organisms in SE Effects of effluents from bioconversion facilities on terrestrial organisms	Effects of extraction effluents & noise on wildlife in PC	Effects of tritium from conversion facilities on terrestrial & aquatic organisms	Same as 1

Regional Key

Al	=	Alaska	RM	=	Rocky Mts.	Ap	= Appalachia
PC	=	Pacific Coast	SW	=	Southwest	SE	= Southeast
NGP	=	Northern Great Plains	MW	=	Midwest	HA	= Hawaii

NOTE: Numbers preceding an activity indicate a similar activity will occur for other technologies, as indicated by repetition of the number in the appropriate columns

EXHIBIT 47
EXAMPLES OF ECOLOGICAL EFFECTS RESEARCH
(Continued)

TECHNOLOGIES / ECO-LOGICAL EFFECTS RESEARCH	COAL EXTRACTION PROCESSING, & COMBUSTION	COAL CONVERSION	OIL SHALE	OIL AND GAS	ENERGY CON-SERVATION AND EFFICIENCY	SOLAR ENERGY	GEOTHERMAL ENERGY	FUSION	FISSION
Population & Community Responses	2 Effects of extraction on terrestrial & aquatic biota; in NGP, SW, MW & Ap 3 Effects of cooling system contaminants on terrestrial, freshwater & marine biota 4 Effects of stack emissions on terrestrial, freshwater & marine biota	Effects of organic & inorganic combustion materials on terrestrial & freshwater biota; in NGP, SW, MW & Ap	Effects of organic combustion materials on terrestrial & freshwater biota; in RM	Effects of petroleum products on coastal biota; in Al & MW Effects of petroleum products on Arctic & subarctic biota; in Al Same as 3 Same as 4	Effects of electromagnetic transmission on terrestrial & marine biota Effects of waste conversion effluents on terrestrial, freshwater & marine biota Effects of materials from waste heat conversion on terrestrial & aquatic biota	Effects of large-scale solar thermal conversion sites on local terrestrial biota; in SW Effects of heat transfer & storage media on terrestrial biota; in SW Noise & visual effects of wind conversion arrays on terrestrial fauna; in NGP Entrainment of marine biota at ocean thermal conversion facilities; in SE Effects of monoculture at bioconversion sites on terrestrial & marine biota	Effects of airborne & aqueous effluents during extraction & conversion on agricultural & terrestrial biota; in PC & PW		Same as 2; in SW Same as 3 Same as 4
Biological Productivity	Revegetation of surface-mineral areas; in NGP, SW, MW, & Ap		Revegetation, reclamation of spent shale disposal areas; in RM	Effects of petroleum products on marine, arctic, & subarctic ecosystems; in Al & MW		Effects of large-scale solar thermal conversion facilities on local terrestrial ecosystems; in SW Effects of ocean thermal conversion facilities on marine ecosystems; in SE Effects of monoculture, at bioproduction sites, on terrestrial & marine ecosystems	Effects of airborne organic & inorganic effluents on agricultural & natural ecosystems; in PC & RM		
Habitat Restoration	5 Reclamation of terrestrial soils, vegetation & aquatic habitats at extraction sites; in NGP, SW, MW, & Ap		Same as 5; in RM	Evaluation of petroleum spill clean-up methods in marine, arctic, & subarctic environments; in Al & MW					Same as 5; in SW
Multi-technology & Supporting Generic Research		Cellular physiology studies Autoecological programs Synecological progrmas Analytical and applied monitoring programs Operational programs							

Regional Key

Al = Alaska
PC = Pacific Coast
NGP = Northern Great Plains
RM = Rocky Mts.
SW = Southwest
MW = Midwest
Ap = Appalachia
SE = Southeast
Ha = Hawaii

NOTE: Numbers preceding an activity indicate a similar activity will occur for other technologies, as indicated by repetition of the number in the appropriate columns

EXHIBIT 47

EXAMPLES OF ECOLOGICAL EFFECTS RESEARCH (Concluded)

3.3.8 Socioeconomic Effects: Interfaces

SOCIAL, CULTURAL, AND WELFARE EFFECTS ON INDIVIDUALS AND COMMUNITIES DUE TO THE INTRODUCTION OF ENERGY TECHNOLOGIES MUST BE IDENTIFIED AND QUANTIFIED TO ALLOW COMPLETE ASSESSMENT OF THEIR ENVIRONMENTAL AND HEALTH IMPLICATIONS.

- NEW ENERGY TECHNOLOGIES HAVE THE POTENTIAL TO INFLUENCE OR CHANGE THE SOCIOECONOMIC FABRIC OF COMMUNITIES (LOCAL, REGIONAL, OR NATIONAL) IN SEVERAL WAYS:
  - CHANGE IN WORK FORCE COMPOSITION AND SIZE
  - CHANGE IN TAX BASE
  - CHANGE IN RECREATIONAL OR EDUCATIONAL OPPORTUNITIES
  - CHANGE IN DELIVERY OF PUBLIC AND PRIVATE SERVICES
  - CHANGE IN LAND (AND WATER) USE PATTERNS
  - CHANGE IN BIOLOGICAL PRODUCTIVITY AND DIVERSITY
  - LOSS OF FUTURE OPTIONS
- RESEARCH ON SOCIOECONOMIC EFFECTS WILL BE BASED ON AN UNDERSTANDING OF EXISTING BASELINE CONDITIONS (DEMOGRAPHIC, ECONOMIC, AND CULTURAL) TOGETHER WITH AN UNDERSTANDING OF EACH TECHNOLOGY IN TERMS OF PERCEIVED AND PROBABLE ENVIRONMENTAL IMPACTS AND ECOLOGICAL AND HEALTH EFFECTS.
- QUANTITATIVE AND QUALITATIVE DESCRIPTIONS OF ANTICIPATED SOCIOECONOMIC EFFECTS WILL FORM THE MAJOR OUPUTS FROM THIS RESEARCH.
- PUBLIC ATTITUDES AND PERCEPTIONS, INCLUDING CONSIDERATIONS OF ESTHETICS, WILL BE AN IMPORTANT AREA OF STUDY AND REPORTING.
- DIRECT USE OF SOCIOECONOMIC DATA AND ANALYSES BY DECISION-MAKERS IS ANTICIPATED; ADDITIONALLY, THIS INFORMATION WILL PROVIDE A KEY ELEMENT IN THE PREPARATION OF INTEGRATED ENVIRONMENTAL ASSESSMENTS.

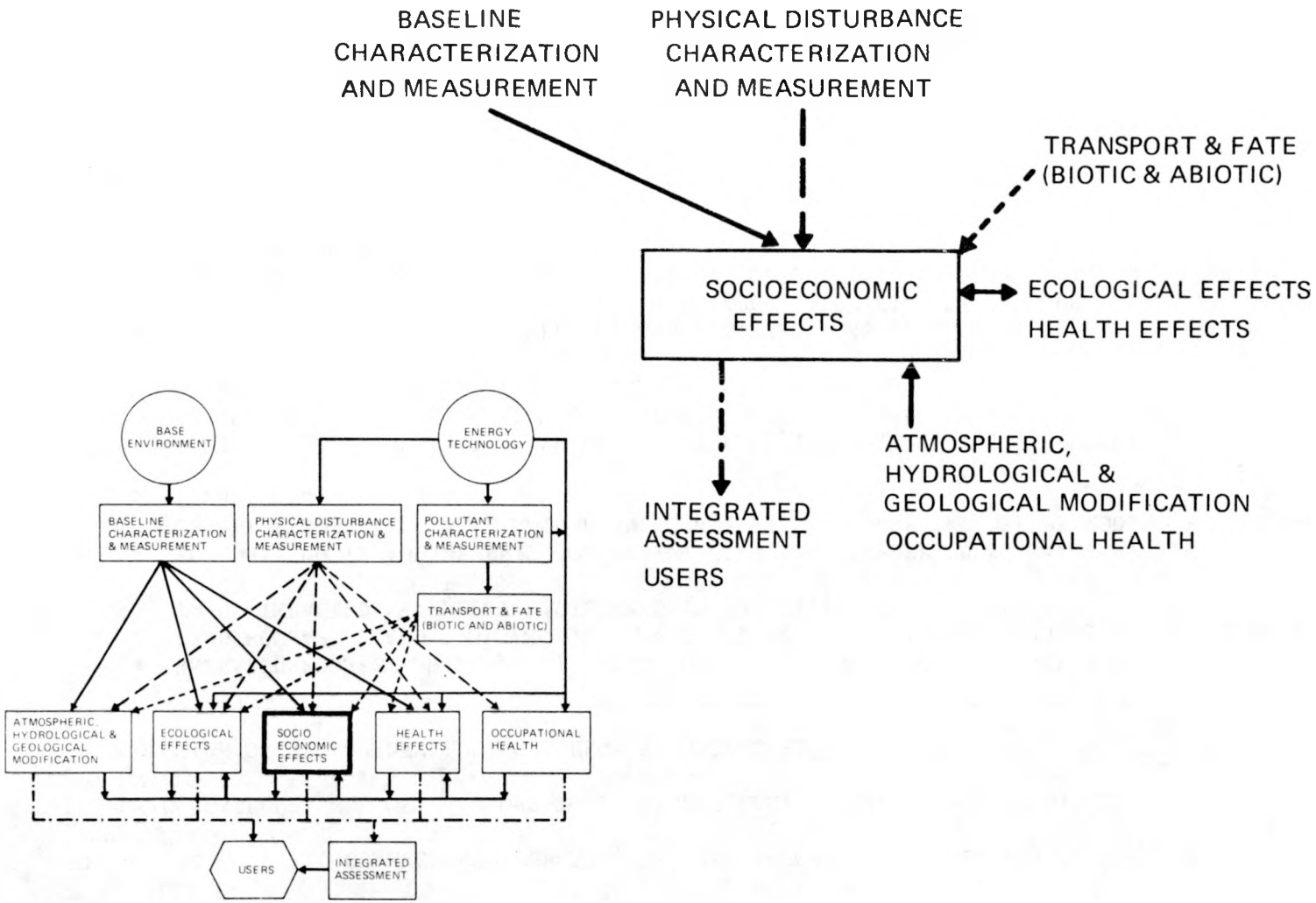


EXHIBIT 48

RELATION OF SOCIOECONOMIC EFFECTS ACTIVITIES TO OTHER RESEARCH ACTIVITIES. Health, ecological, and geophysical effects must be considered in conjunction with baseline data to determine socioeconomic impacts.

3.3.8 Socioeconomic Effects: Research

SOCIAL AND CULTURAL CHANGES AND PERCEPTIONS, AND ACCOMPANYING INDIRECT OR SECONDARY ECONOMIC CONSEQUENCES, OFTEN PROVE TO BE SIGNIFICANT OBSTACLES TO THE WIDESPREAD INTRODUCTION OF NEW OR DEVELOPING ENERGY TECHNOLOGIES.

- RESEARCH PROJECTS WILL BE DIRECTED TOWARD THE COLLECTION, REVIEW, AND DEVELOPMENT OF DEMOGRAPHIC AND SOCIOECONOMIC PROJECTIONS IN THE REGIONS AND LOCALITIES LIKELY TO BE IMPACTED BY ENERGY FACILITY DEVELOPMENT.

- ECONOMIC COSTS AND BENEFITS ON INDIVIDUALS AND DIVERSE PUBLIC AND PRIVATE ORGANIZATIONS WILL BE EXAMINED AND QUANTIFIED THROUGH THE USE OF MODELS AND OTHER TECHNIQUES.

- SOCIAL PERCEPTIONS AND VALUE SCALES WILL BE INVESTIGATED WITH RESPECT TO ALTERNATIVE ENERGY SUPPLY/DEMAND OPTIONS AND ALSO REGARDING BOTH SPECIFIC AND GENERALIZED ENERGY FACILITY SITING DECISIONS.

- STUDIES WILL EXAMINE THE WELFARE AND CULTURAL CONSEQUENCES OF IMPLEMENTATION OF ENERGY SUPPLY ALTERNATIVES; THESE WILL FOCUS SPECIFICALLY ON SUCH ISSUES AS ENERGY EXTRACTION AND THE SOCIAL EFFECTS OF RESOURCE EXHAUSTION AND ON SPECIFIC ENERGY SOURCES.

SOCIOECONOMIC EFFECTS \ TECHNOLOGIES	COAL EXTRACTION PROCESSING & COMBUSTION	COAL CONVERSION	OIL SHALE	OIL AND GAS	ENERGY CONSERVATION AND EFFICIENCY	SOLAR ENERGY	GEOTHERMAL ENERGY	FUSION	FISSION
Population & Socioeconomic Projections	Collection and interpretation of population and economic statistics and trends								
	1 Population growth in sparsely populated areas		Same as 1	Same as 1					
Economic Costs & Benefit Functions	Total fuel cycle costs and resource requirements for fossil fuels				Individual impacts of conservation	Resource requirements & costs	Conflict with agriculture/land use		Nuclear fuel cycle costs
Social Perceptions of Energy Needs & Impacts	Local, regional and national attitudes and values related to energy technology development								
	Dependence upon and tradeoff between fossil energy sources				Conservation ethic-awareness	Perception as "clean" energy		Perception as "clean" energy	Waste disposal Reactor sitings
Welfare & Cultural Consequences	Mined out areas-cultural effects	Economic/cultural impacts on "new" industries		Exhaustion of resource social/cultural disruptions	Lifestyle changes due to reduced consumption	Dispersed energy sources			Safety & waste disposal

NOTE: Numbers preceding an activity indicate a similar activity will occur for other technologies, as indicated by repetition of the number in the appropriate columns

EXHIBIT 49
EXAMPLES OF SOCIOECONOMIC EFFECTS RESEARCH

3.3.9 Health Effects: Interfaces

TO PROPERLY ASSESS THE IMPACTS OF ENERGY TECHNOLOGIES ON HUMAN HEALTH, THEREBY AIDING THE SELECTION OF AVAILABLE ENERGY OPTIONS, REQUIRES INPUT FROM OTHER RESEARCH CATEGORIES.

- HAZARDOUS AGENTS MUST BE CHARACTERIZED AND THEIR VARIOUS ROUTES OF EXPOSURE TO MAN IDENTIFIED.
- THE CONCENTRATION OF HAZARDOUS AGENTS AND THEIR METABOLITES WITHIN FOOD CHAINS THAT ULTIMATELY REACH MAN MUST BE DETERMINED.
- THE EFFECT OF HAZARDOUS AGENTS ON OCCUPATIONALLY EXPOSED INDIVIDUALS PROVIDE DIRECT HUMAN DATA TO ASSESS GENERAL PUBLIC RISK.
- ULTIMATE HUMAN HEALTH RISK PROVIDES INPUTS FOR CONTROL TECHNOLOGY REQUIREMENTS, SITING CONSIDERATIONS, AND SELECTION OF ENERGY ALTERNATIVES.
- SOCIETAL IMPACTS SUCH AS REGIONAL DEVELOPMENT IMPACT OR POPULATIONS-AT-RISK CAN BE DECIDED WITH ADEQUATE COMPARISONS OF ULTIMATE RISK TO MAN.

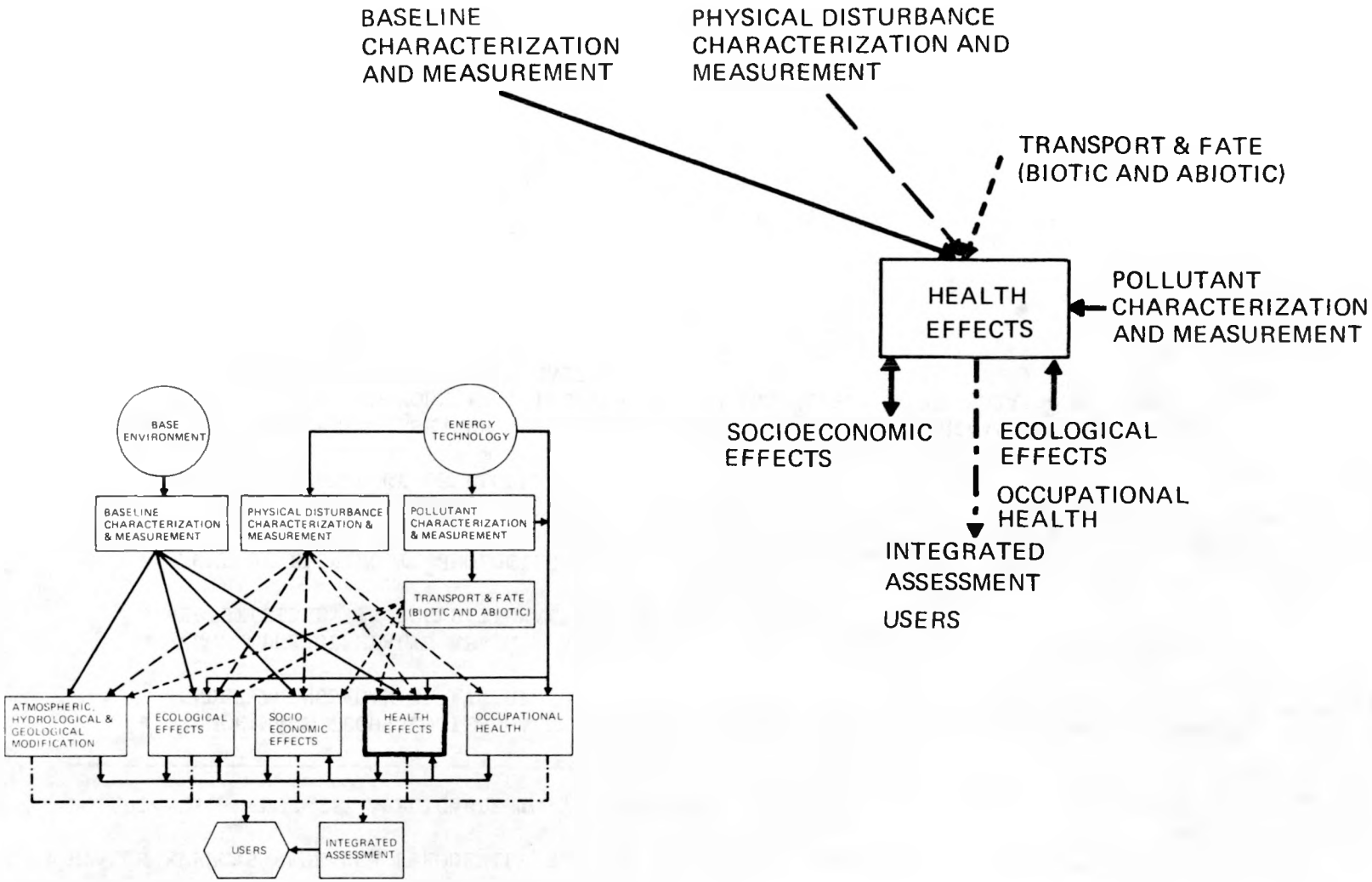


EXHIBIT 50

RELATION OF HEALTH EFFECTS ACTIVITIES TO OTHER RESEARCH ACTIVITIES. Analysis of health effects is the largest environmental research area.

3.3.9 Health Effects: Research

HEALTH EFFECTS RESEARCH FREQUENTLY EMPLOYS METHODOLOGIES COMMON TO MANY TYPES OF SUSPECT POLLUTANTS, HENCE IS APPLICABLE TO THE INVESTIGATION OF VARIOUS ENERGY TECHNOLOGIES.

- SINCE MANY TECHNOLOGIES HAVE AREAS OF COMMON RESEARCH NEEDS, REDUNDANT RESEARCH UNDERTAKINGS CAN BE AVOIDED.
- KNOWLEDGE OF HEALTH EFFECTS ASSOCIATED WITH THE VARIOUS ENERGY TECHNOLOGIES CAN BE UTILIZED IN OCCUPATIONAL HEALTH EVALUATIONS.
- SOME DEVELOPING TECHNOLOGIES (e.g., SOLAR POWER, SHALE OIL, THE BREEDER REACTOR, ETC.) REQUIRE IMMEDIATE INITIATION OF RESEARCH THRUSTS IN ORDER TO DETERMINE ACTUAL HEALTH HAZARDS, SO THAT CONTROL MEASURES CAN BE INITIATED, WHERE NECESSARY, DURING TECHNOLOGY DEVELOPMENT.
- HEALTH EFFECTS RESEARCH INCLUDES EPIDEMIOLOGICAL AND CLINICAL STUDIES, ANIMAL EXPERIMENTS AND MODELING, IDENTIFICATION AND SCREENING OF HAZARDOUS AGENTS, AND FATE AND METABOLIC INVESTIGATIONS.

TECHNOLOGIES / HEALTH EFFECTS	COAL EXTRACTION PROCESSING, & COMBUSTION	COAL CONVERSION	OIL SHALE	OIL AND GAS	ENERGY CONSERVATION AND EFFICIENCY	SOLAR ENERGY	GEOTHERMAL ENERGY	FUSION	FISSION
Epidemiological & Clinical Human Health Studies	Develop and apply epidemiological procedures to clinical and public health data to look for effects Develop and apply appropriate biochemical, cytological, and physiological tests for clinical studies with exposed populations								
	Perform epidemiologic studies of human populations to provide sampling populations representing sensitized individuals in which to evaluate subtle effects from combustion products (e.g., HC, SO_x and NO_x) Effects of unburned hydrocarbons on man				Evaluation of effects resulting from reduced ventilation in buildings (reduction in air quality, increase in biologically active materials) Determine the public health hazards associated with waste utilization (agricultural, industrial, & municipal) Determine indirect public health aspects associated with fertilizer substitutions	Assess the health effects resulting from toxic gases, aromatic hydrocarbons, & biological by-products from fermentation released from waste storage or bioconversion facilities (processing or utilization) Investigate potential hazard from aerosolized pathogens in waste utilization applications	Determination of sensitized populations around geothermal sites Evaluation of subliminal exposures of geothermal releases (H_2S, noise, trace elements, etc.) on predisposed individuals Evaluate effects of Rn and daughters	Examine population exposed to high magnetic fields (including subtle neurophysiological effects and interactions with implanted electronic devices) Determine effects of fuel cycle components on exposed populations (^3H, Li, Be)	Quantitative evaluation of exposure, risk, health effects in man produced by chronic long-term, low-level exposure to radiation & hazardous agents Determine occupational hazards associated with uranium mining
			Retrospective, prospective epidemiological studies & human clinical investigations will be carried out to obtain information on the effects produced under specific situations of exposure to oil shale hazards for occupational & general population groups	Assess the health risks of effluents from oil & petrochemical processing plants including additives					
Animal Modeling Studies to Extrapolate Risk to Man	Identify cells at risk, and cells and organs responsible for activation and detoxification and establish the linkage between proximal causative agent & effect Initiate program to determine dose-effect relationships for known toxic agents in a number of test species Develop animal models in areas of physiological assessment, teratogenesis, carcinogenesis, mutagenesis, & neurological effects Develop quantitative exposure methods which simulate human exposures in rodents, dogs, and subhuman primates							Evaluate effects of chronic low dose neutron exposure Develop chemical, physical methods to remove incorporated radionuclides of long half life or enhanced normal clearance mechanisms Determine kinetics, disposition in animals of radioactive materials and other hazardous agents	
	Evaluate hazards resulting from acute or long-term exposures in experimental biological systems Devise or identify models for interspecies comparisons and extrapolations to effects in man Initiate metabolic studies of toxicants in whole animals and in cell cultures including basic materials, interim and final products and combustion products				Determine effects of reduced air quality (reduced ventilation in buildings) by selective animal exposures (chronic) to anticipated pollutants	Toxicity of heat transfer and storage media (various organic fluids, inorganic salts, & other compounds)	Evaluate hazards resulting from acute or long-term exposures in experimental biological systems		
								Provide information on long-term low dose exposures to high magnetic fields (including teratogenic, mutagenic & carcinogenic potential) Evaluate CTR fuel components for toxic potential (chemical & radioactive)	Identify carcinogenic, mutagenic, teratogenic, other harmful agents (e.g., actinides, tritium, fission products) & determine the pathogenic effect, dose-response relationship on the mammalian system Assess pre-existing disease states & altered metabolism on radionuclide incorporation & effect

EXHIBIT 51
EXAMPLES OF HEALTH EFFECTS RESEARCH
(Continued)

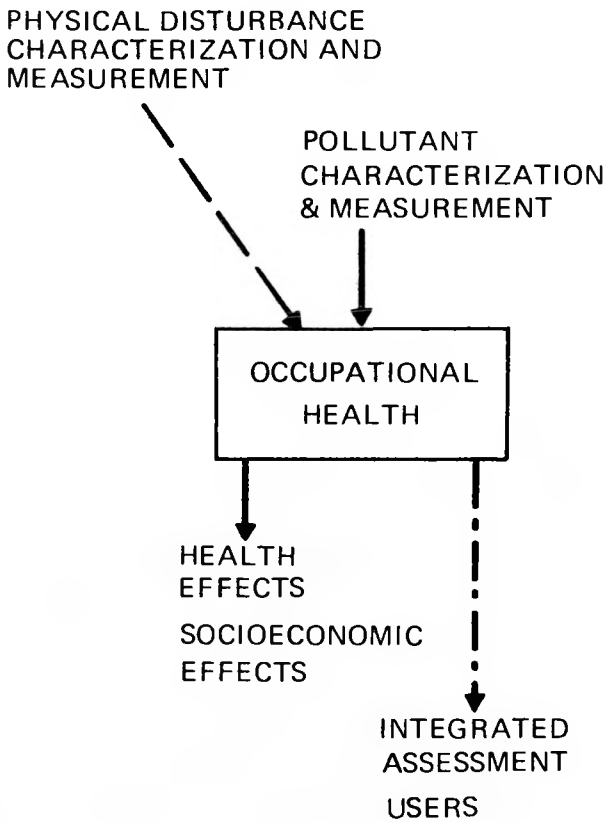
HEALTH EFFECTS \ TECHNOLOGIES	COAL EXTRACTION PROCESSING, & COMBUSTION	COAL CONVERSION	OIL SHALE	OIL AND GAS	ENERGY CONSERVATION AND EFFICIENCY	SOLAR ENERGY	GEOTHERMAL ENERGY	FUSION	FISSION
Identification of Hazardous Agents via Biological Screening	Hazardous agents identified by screening experiments and by prior knowledge will be tested to characterize their entry into the body, how they are changed, distributed, activated, & excreted Quantify in vitro cell systems and develop tests for identifying individuals with enhanced susceptibility Develop in vitro cell systems which maintain their in vivo activation, detoxification functions								
	Develop screening procedures for rapid identification of potentially hazardous pollutants (especially HC, SO_x and NO_x) and synergetsic interactions among pollutants; and provide for oncogenic, mutagenic, and teratogenic behavior Develop, employ in vitro screening methods for determining the carcinogenic, teratogenic, mutagenic, neurologic, and behavioral potential of effluents				Evaluation of hazard, from reduced building ventilation; determining toxic components (toxic fumes, aerosolized pathogens, etc.)	Toxicity of heat transfer and storage media (various organic fluids, organic salts and other compounds)		Screening studies to quantify effects of high magnetic fields on organisms Evaluate effects resulting from CTR technologies (^3H, Li, Be, activation products)	Evaluate existing data & develop, apply biologic screening systems to determine the toxic potential of radioactive, non-radioactive material associated with fission fuel cycles
Fate & Metabolic Studies (e.g., activation, critical organ deposition, recovery & repair)	Develop knowledge of how biological systems recover from or repair potentially deleterious effects and utilize this knowledge to develop remedial and protective procedures Utilize knowledge of the action of deleterious agents and of repair and recovery processes to improve extrapolation from laboratory tests to humans Develop and apply biochemical, cytological and physiological indicators of subclinical effects from exposure Evaluate utility of appropriate methods for detection of disease resulting from exposure Develop chemical and biochemical methods to determine the metabolism, fate and dose for potentially toxic materials								
	Study metabolism of hazardous agents and identify mechanisms of damage and repair (entry into body, routes of translocation, degredation, excretion, and biological activation) Determine organs at risk after pollutant exposures and cellular basis of damage Identify target organs, tissues at risk and dose-effect relationships for single and combinations of effluents in three animal species including stressed populations					Metabolism & fate of exotic organic waxes, salts, & other heat transfer fluids in animal systems Evaluate effects of Cd from photovoltaic conversion	Determine pathways of pollutants associated with geothermal activities (H_2S, volatile metals, etc.)	Elucidate primary reactions by which radiation transfers energy to biologic media and the subsequent transport, radiochemical processes leading to observable lesions Investigate processes by which repair, recovery of radiation induced lesions are achieved.	
								Determine metabolic pathways of internally deposited nuclides associated with CTR technology such as V, Ni, & Cr.	Determine various routes of exposure to determine uptake, deposition distribution, translocation, modification excretion of radioactive materials & other hazardous agents. Identify tissues, cells at risk
Multi-technology & General Science (e.g., improved assy procedures, animal disease models, molecular basis for dysfunction, risk estimation)	Develop instrumentation and methodologies for biochemical studies Develop physiological measuring and monitoring equipment adapted to laboratory use with animals and humans Develop maximum credible accident concepts to given situations Evaluate the reasons for inter-species differences in dose-effect relationships in terms of experimentally quantifiable parameters (e.g.—differences in transport, metabolism, repair) Elucidate structural and functional properties of critical organic systems								
	Identification of cellular and organ systems at risk, pathophysiological responses, and life-shortening characteristics after exposure to fossil fuel effluents				Provide information as to the positive aspects on health from reduced pollution via Energy conservation	Characterize leachates from solar cells, & determine their ultimate path to man	Determine tolerance limits and reasons for segments of populations exposed to geothermal releases (e.g., noise, H_2S, brines, etc.)	Develop instrumentation and methods to quantify dose and dose distribution Establish criteria, develop methodology for detecting and quantifying damage due to key radionuclides and other hazardous materials	
	Develop & maintain models for environmental pathways analysis	Analyze samples from coal conversion processes and provide defined samples for biological tests		Determine neurologic & behavioral effects of selected effluents from oil and gas technologies				Develop sensitive monitoring devices applicable to assess low-level neutron exposures to organism tissues	Determine the validity of linear extrapolation of dose-response curves to the case of very low dose rates and long-term exposures

EXHIBIT 51
EXAMPLES OF HEALTH EFFECTS RESEARCH (Concluded)

3.3.10 Occupational Health: Interfaces

RECOGNITION OF THE HEALTH HAZARDS ASSOCIATED WITH OCCUPATIONALLY EXPOSED INDIVIDUALS IN VARIOUS ENERGY ACTIVITIES (FOR THE TOTAL FUEL CYCLE) IS NECESSARY IN THE SELECTION OF VIABLE ENERGY OPTIONS AND IN PROVIDING DIRECT EVIDENCE TO ASSESS HEALTH RISK TO THE GENERAL PUBLIC.

- HAZARDOUS AGENTS PRESENT IN THE WORK PLACE MUST BE CHARACTERIZED AND, IF NECESSARY, CONTROLLED.
- EFFECTS OF OCCUPATIONAL EXPOSURES TO HAZARDOUS AGENTS PROVIDE A BASIS TO ASSESS THE HEALTH RISK TO THE GENERAL PUBLIC.
- THE COST/RISK/BENEFIT ANALYSES ASSOCIATED WITH THE IMPLEMENTATION OF ENERGY TECHNOLOGIES MUST ASSESS THE TOTAL OCCUPATIONAL HAZARD OF THESE TECHNOLOGIES.



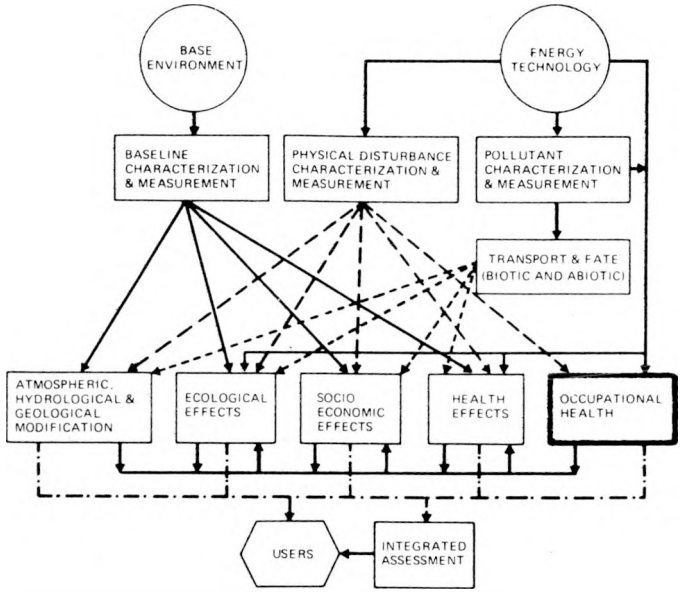


EXHIBIT 52

RELATION OF OCCUPATIONAL HEALTH ACTIVITIES TO OTHER RESEARCH ACTIVITIES. Occupational health data, important in the commercialization of technologies, can provide insights into general population health effects.

3.3.10 Occupational Health: Research

BECAUSE THE MOST IMMEDIATE DATA ON EFFECTS OF POLLUTANTS ASSOCIATED WITH THE VARIOUS ENERGY TECHNOLOGIES ON HUMANS WILL PROBABLY RESULT FROM OCCUPATIONAL EXPOSURES, A STRONG INTERFACE BETWEEN OCCUPATIONAL HEALTH AND GENERAL PUBLIC HEALTH IS NECESSARY.

- INFORMATION GAINED FROM OCCUPATIONAL EXPOSURES SHOULD BE DIRECTLY APPLIED TO ASSESSING ANTICIPATED EFFECTS OF GENERAL PUBLIC EXPOSURES.
- MUCH OF THE BIOLOGICAL RESEARCH (e.g., ANIMAL STUDIES, METABOLIC INTERACTIONS, RAPID BIOASSAYS, ETC.) HAS BEEN IDENTIFIED WITHIN THE HEALTH EFFECTS CATEGORY AND CAN BE DIRECTLY APPLIED TO OCCUPATIONAL EXPOSURE NEEDS.
- SOME DEVELOPING TECHNOLOGIES (e.g., OIL SHALE, COAL CONVERSION) CAN USE HEALTH DATA FROM IN-PLACE ENERGY ACTIVITIES (i.e., EPIDEMIOLOGICAL STUDIES OF OIL REFINERY PERSONNEL) TO AID IN EVALUATING THEIR OWN OCCUPATIONAL HEALTH HAZARDS.

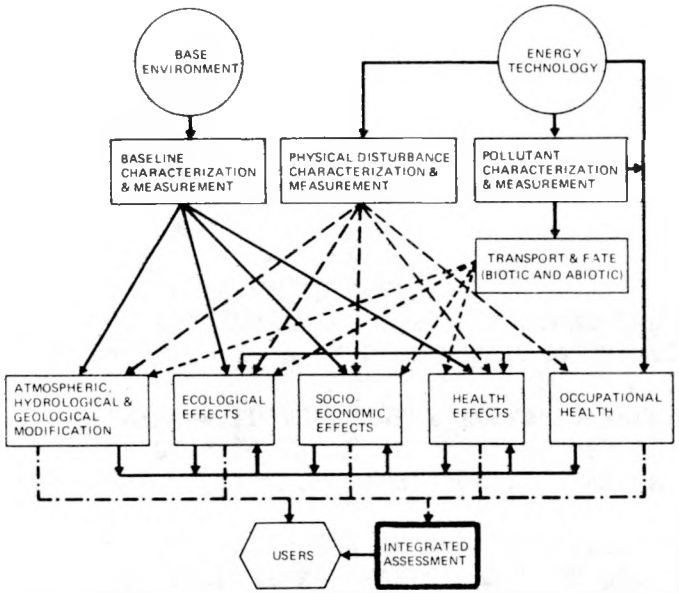
TECHNOLOGIES / OCCUPATIONAL HEALTH	COAL EXTRACTION PROCESSING & COMBUSTION	COAL CONVERSION	OIL SHALE	OIL AND GAS	ENERGY CONSERVATION AND EFFICIENCY	SOLAR ENERGY	GEOTHERMAL ENERGY	FUSION	FISSION
	Determine what clinical parameters or pre-existing diseases and what environmental factors may cause hypersensitivity in personnel								
	Determine pre-existing morbidity conditions with work-force personnel				Effects of high voltage transmission facilities on human health Effects resulting from reduced ventilation in the workplace as a result of energy conservation Review of occupational hazards associated with waste utilization, fertilizer substitution, & irrigation methods	Determine the effects on workers from solar systems fabrication activities (Cu, Si, Se, Al, Cd, organics, etc.) Study energy farm workers – for effects from fly ash recycling, exotic fertilizers, & waste utilization including pathogen aerosolization For waste storage & bioconversion facilities, assess occupational exposures to biological by-products from fermentation, toxic gases, & aromatic hydrocarbons & pathogen aerosolization	Determine hazard associated with geothermal activities (noise, H_2S trace metals, Rn and daughters etc.) Assess potential for interaction of combined subliminal exposures of several pollutants associated with geothermal units (including behavioral & neurophysiological changes) Determine basis for individual threshold perception of noxious compounds, as they relate to acceptable occupational exposures	Determine effects of chronic low-level neutron exposures Determine effects of exposure to high magnetic fields (including subtle neurophysiological effects, & effects on implanted electronic medical devices Determine risk associated with CTR fuel components (^3H, ^6Li, ^4Be) including tritiated compounds in the workplace Evaluate hazard associated with nuclide exposures from CTR maintenance & decommissioning	Conduct epidemiological, clinical studies in selected occupational & general population groups Quantitatively evaluate exposure risk, health effects in man produced by chronic long-term low level exposure to radiation & hazardous agents Determine occupational hazards associated with uranium mining Perform biologic testing of radioactive materials, other fission fuel cycle agents suspected of being hazardous to humans during routine operations
	Assess the health of the exposed worker by epidemiological and clinical studies of extraction and utilization facilities								
		Utilize prospective epidemiological & clinical studies in plant personnel (retrospective studies using oil industry data)	Determine health effects involved in oil shale extraction & shale oil recovery (including in situ & surface recovery activities)	Epidemiological survey of refinery & fuel handling facility personnel (unburned hydrocarbons)					

EXHIBIT 53
EXAMPLES OF OCCUPATIONAL HEALTH RESEARCH

3.3.11 Integrated Assessment: Interfaces

AN EXTENSIVE, MULTIFACETED, RESEARCH PROGRAM IN INTEGRATED ASSESSMENT WILL BE MAINTAINED TO ENSURE THAT THE DBER PROGRAM ADDRESSES ALL SIGNIFICANT ENVIRONMENTAL PROBLEMS ASSOCIATED WITH DEVELOPING ENERGY TECHNOLOGIES AND THAT DATA ON HEALTH AND ENVIRONMENTAL EFFECTS ARE EFFECTIVELY TRANSMITTED TO ALL USERS.

- AN ESSENTIAL AND INTEGRAL PART OF HEALTH AND ENVIRONMENTAL RESEARCH IS THE DEVELOPMENT AND OPERATION OF COMPREHENSIVE INFORMATION MANAGEMENT SYSTEMS; THIS FUNCTION IS CARRIED OUT IN INTEGRATED ASSESSMENT.
- SUMMARIES AND ANALYSIS OF HEALTH AND ENVIRONMENTAL RESEARCH WILL BE PREPARED FOR VARIOUS USER GROUPS ACCORDING TO THE TECHNOLOGY DEVELOPMENT SCHEDULE AND NEEDS.
- COST/RISK/BENEFIT STUDIES AND TRADEOFF ANALYSES WILL BE PERFORMED FOR SIGNIFICANT OPTIONS WITHIN EACH ENERGY TECHNOLOGY AND BETWEEN ALTERNATIVE ENERGY TECHNOLOGIES.
- RESEARCH PROJECTS WILL BE DIRECTED AT THE IDENTIFICATION, DESCRIPTION, AND MITIGATION OF OBSTACLES TO THE IMPLEMENTATION OF ENERGY SUPPLY AND CONSERVATION TECHNOLOGIES.
- ASSESSMENT ACTIVITIES WILL HELP TO IDENTIFY AND DEFINE THE OVERALL RESEARCH PROGRAM AND WILL THUS ASSIST IN THE ORGANIZATION AND MANAGEMENT OF THE DBER PROGRAM.



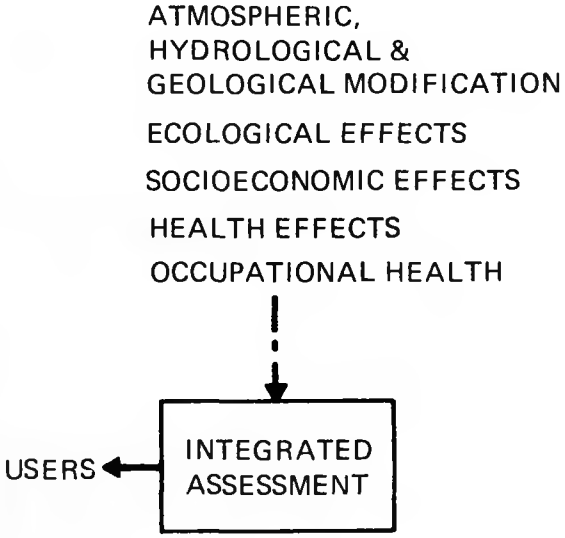


EXHIBIT 54

RELATION OF INTEGRATED ASSESSMENT ACTIVITIES TO OTHER RESEARCH ACTIVITIES. Integrated assessment activities provide the major mechanism by which health and environmental research results are communicated to user communities.

3.3.11 Integrated Assessment: Research

INTEGRATED ASSESSMENT RESEARCH WILL DRAW TOGETHER THE PHYSICAL, ECOLOGICAL, AND HUMAN HEALTH EFFECTS DATA AND WILL PREPARE EVALUATED OPTIONS REGARDING THE ENVIRONMENTAL IMPLICATIONS OF EACH ENERGY TECHNOLOGY.

- ALL ENVIRONMENTAL EFFECTS RESEARCH SUPPLIES DATA TO THE INTEGRATED ASSESSMENT FUNCTION, AND CONVERSELY IT CAN DEFINE AND HELP STRUCTURE THE RESEARCH PROGRAM.
- BECAUSE OF THE COMPREHENSIVE CHARACTER OF THE INTEGRATED ASSESSMENT TASKS, THE SPECIFICATION, DEVELOPMENT, AND OPERATION OF INFORMATION SYSTEMS SUPPORTING THE ENTIRE BPP OCCUR IN THIS RESEARCH CATEGORY.
- ENERGY TECHNOLOGIES REQUIRE ENVIRONMENTAL ASSESSMENTS, CONTAINING VARYING LEVELS OF DETAIL, AT THE SEVERAL STAGES OF THE DEVELOPMENT CYCLE: IT IS THE FUNCTION OF INTEGRATED ASSESSMENT TASKS TO FULFILL THIS NEED.
- PUBLIC ACCEPTANCE OF A TECHNOLOGICAL ALTERNATIVE IS OFTEN CRITICALLY AFFECTED BY ENVIRONMENTAL CONSIDERATIONS AND BY THE QUALITY OF ENVIRONMENTAL DATA AND ANALYSIS AVAILABLE.

TECHNOLOGIES / INTEGRATED ASSESSMENT	COAL EXTRACTION PROCESSING, & COMBUSTION	COAL CONVERSION	OIL SHALE	OIL AND GAS	ENERGY CONSERVATION AND EFFICIENCY	SOLAR ENERGY	GEOTHERMAL ENERGY	FUSION	FISSION
Information Systems & Management	Data systems supporting all technologies in the areas of 1) Environmental Research Management Information; 2) Bioenvironmental Information (Research Data) Management; 3) Social Systems Information Management; 4) Information Systems Research including reporting and display formats, analysis of requirements, hardware and software systems.								
Bioenvironmental Consequences of Energy Technologies	Human health effects of combustion products (i.e., SO_x, NO_x, particulates, etc.) in combination with their atmospheric reaction products				Survey & assessment of new conservation proposals	Resource requirements for solar technologies	Integrated health & ecological implications	Integrated health & environmental impacts of exotic materials (Li, Be)	Total fuel cycle implications
	Safety & health considerations in mining	Exotic fuels implications in transportation, storage & use						Radiological health implications: –Tritium –Activation products	–Fission products –Transuranics
Tradeoff Analysis of Energy/Environmental Issues; Cost/Risk/Benefit Studies	Overall tradeoff analysis of health and environmental factors between energy technologies; Energy supply potential versus environmental consequences at the local (facility siting), regional and national level								
	1 Land/water use conflicts	Introduction of synthetic fuels–cost/risk/benefit analysis	Same as 1 Integrated regional impacts in Western Colo., Utah, Wyo.	Implications of resource exhaustion Oil producing regions trade-off analysis		Same as 1	Same as 1	Nuclear energy park–integrated impacts Tradeoff between conventional & advanced technologies	
						Regional studies of technology impact based on resource: –Southeast –Pacific Northwest	–Imperial Valley –Others		
Implementation of Energy Technologies	Political, legal and institutional obstacles and constraints to the demonstration and commercialization of each technology.								
	2 Resource leasing & regulation		Same as 2	Same as 2 (offshore)		Acceptability of dispersed energy sources in existing energy supply institutions	Same as 2		Analysis of NRC policy regarding technological options

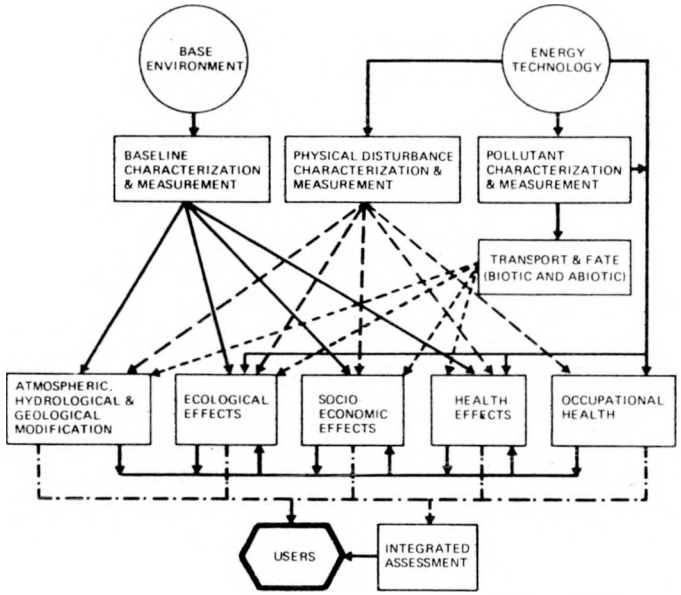
NOTE: Numbers preceding an activity indicate a similar activity will occur for other technologies, as indicated by repetition of the number in the appropriate columns

EXHIBIT 55
EXAMPLES OF INTEGRATED ASSESSMENT RESEARCH

3.3.12 User Communities

THE OVERALL RESEARCH PROGRAM IS STRUCTURED TO PROVIDE EACH OF SEVERAL USER GROUPS WITH VALID, TIMELY INFORMATION REGARDING THE HEALTH AND ENVIRONMENTAL IMPLICATIONS OF EACH DEVELOPING ENERGY TECHNOLOGY.

- USER COMMUNITIES WILL BE IDENTIFIED AND THEIR REQUIREMENTS FOR ENVIRONMENTAL DATA AND ANALYSIS WILL BE USED IN THE STRUCTURING AND CONDUCT OF RESEARCH ACTIVITIES.
- EXAMPLES OF USER GROUPS ARE:
  - DBER
  - TECHNOLOGY DEVELOPERS (ERDA AND INDUSTRY)
  - CONTROL TECHNOLOGY
  - REGULATORY AGENCIES
  - STATE AND LOCAL AGENCIES
  - THE PUBLIC AND ITS REPRESENTATIVES
  - THE SCIENTIFIC/PROFESSIONAL COMMUNITY
  - THE INTERNATIONAL COMMUNITY
- EFFECTS DATA AND INTEGRATED ASSESSMENT WILL BE THE PRINCIPAL OUTPUT INFORMATION PROVIDED TO USERS.
- ANALYTIC TOOLS AND METHODOLOGIES, AS WELL AS RESEARCH RESULTS, MAY BE USEFUL TO CERTAIN MEMBERS OF THE USER COMMUNITY.



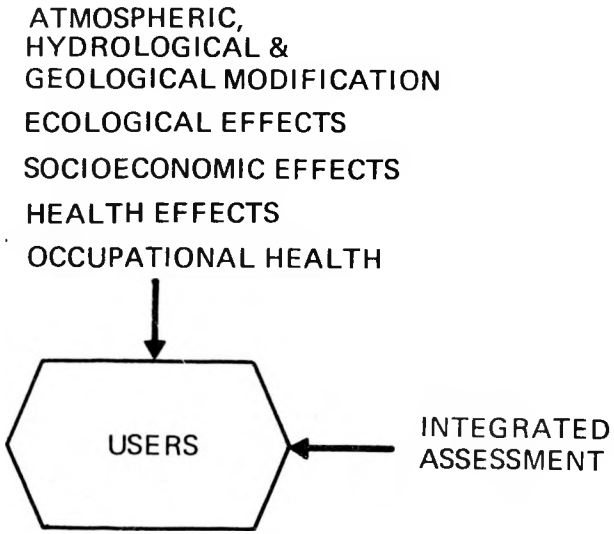


EXHIBIT 56

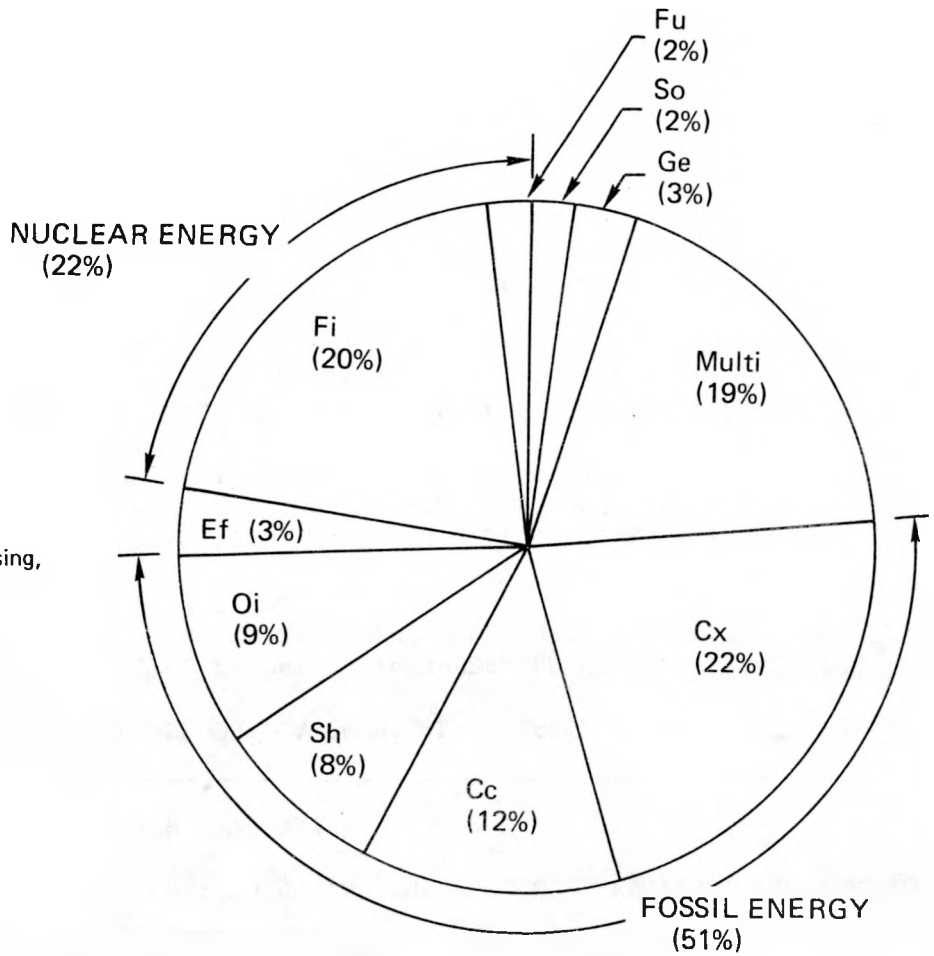
RELATION OF USERS ACTIVITIES TO OTHER RESEARCH ACTIVITIES. Early identification of and continuing contact with user groups will help to assure both the relevance and usefulness of the research program.

3.4 Balanced Research Allocation

3.4.1 Research Effort by Technology

EACH ENERGY TECHNOLOGY WAS ANALYZED BY NATIONAL LABORATORY PERSONNEL WITH REGARD TO ITS HEALTH AND ENVIRONMENTAL IMPLICATIONS; AND INITIAL ASSESSMENT OF RESEARCH EFFORT, BY TECHNOLOGY, WAS PREPARED BASED ON THESE INPUTS AND THE WORKSHOP SESSIONS.

- BRIEF TECHNOLOGY DESCRIPTIONS AND A DISCUSSION OF HEALTH AND ENVIRONMENTAL PROBLEMS WERE PREPARED PRIOR TO THE WORKSHOP.
- PROPOSED RESEARCH ACTIVITIES RELATED TO THE INVESTIGATION OF THESE PROBLEMS WERE DEVELOPED.
- FOR EACH RESEARCH PROJECT UNIT, A SET OF PRIORITIES WERE DEFINED BASED ON A QUALITATIVE ASSESSMENT OF THE FOLLOWING FACTORS:
  - SEVERITY OF THE PROBLEM;
  - EXTENT OF THE PROBLEM;
  - ADEQUACY OF EXISTING INFORMATION; AND
  - URGENCY OR TIMELINES OF THE RESEARCH.
- SCHEDULES AND RESOURCE REQUIREMENTS WERE PREPARED.
- THESE INPUTS, AS MODIFIED DURING THE WORKSHOP AND SUBSEQUENTLY, PROVIDED THE BASES FOR THE ALLOCATION OF RESEARCH EFFORTS DISPLAYED IN EXHIBIT 57.
- MAJOR RESEARCH EMPHASIS WAS ON FOSSIL ENERGY TECHNOLOGIES AND NUCLEAR FISSION.



KEY

Cx	Coal Extraction, Processing, & Combustion
Cc	Coal Conversion
Sh	Oil Shale
Oi	Oil & Gas
Ef	Energy Conservation & Efficiency
Fi	Fission
Fu	Fusion
So	Solar
Ge	Geothermal
Multi	Multi-technology

EXHIBIT 57

TOTAL ENVIRONMENTAL RESEARCH EFFORT BY ENERGY TECHNOLOGY. The majority of the environmental research effort is directed toward fossil energy technologies.

3.4.2 Research Effort by Biomedical and Environmental Research Category

A SET OF PROJECT UNITS DESIGNED TO SUPPORT THE DEVELOPMENT AND COMMERCIALIZATION OF THE ENERGY TECHNOLOGIES WAS PREPARED FOR EACH BIOMEDICAL AND ENVIRONMENTAL RESEARCH CATEGORY (BERC); THESE PROJECT UNITS, AS MODIFIED DURING THE WORKSHOP SESSIONS, PROVIDED THE BASIS FOR DISTRIBUTING EFFORT BY RESEARCH CATEGORY.

- DBER STAFF MEMBERS DEVELOPED THE CATEGORICAL RESEARCH PROJECT DESCRIPTIONS.
- THE SAME CRITERIA (SEVERITY, EXTENT, DATA NEEDS, AND URGENCY) THAT WERE APPLIED TO TECHNOLOGY-BASED RESEARCH PROGRAMS WERE APPLIED TO FORMULATION AND SELECTION OF PROJECT UNITS WITHIN EACH BERC.
- THE PRIMARY EFFORT WAS IDENTIFIED IN HEALTH EFFECTS (35%) WITH SUBSTANTIAL AND ROUGHLY EQUAL EFFORT IN PHYSICAL AND CHEMICAL PROCESSES AND EFFECTS (20%), ECOLOGICAL EFFECTS (21%), AND INTEGRATED ASSESSMENT (17%).
- ALTHOUGH CMM WAS ONLY ASSIGNED 7% OF THE RESEARCH EFFORT, THERE MAY BE PROJECTS OR PORTIONS OF PROJECTS WITHIN OTHER ENVIRONMENTAL CATEGORIES WHICH SHOULD BE INCLUDED IN THIS CATEGORY.
- THE DISTRIBUTION SHOWN IS BASED UPON CURRENT TECHNOLOGICAL EXPECTATIONS AND EXISTING ENVIRONMENTAL ASSESSMENT. AS TECHNOLOGIES ARE DEVELOPED AND AS FURTHER ENVIRONMENTAL INSIGHTS ARE GAINED, THE DISTRIBUTION OF RESEARCH EFFORT WILL BE MODIFIED.

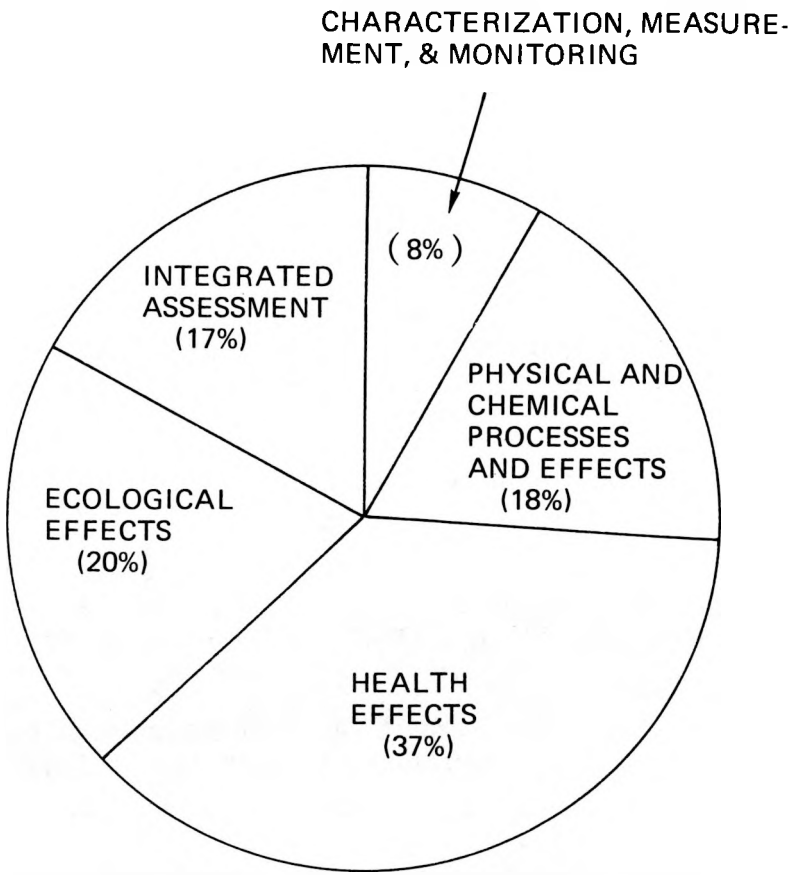


EXHIBIT 58

DISTRIBUTION OF RESEARCH ACTIVITIES BY BIOMEDICAL AND ENVIRONMENTAL CATEGORY. The research effort distribution shown represents a somewhat arbitrary assignment of projects.

3.4.3 Budget Allocation by BERC and Energy Technology

PRELIMINARY REQUIREMENTS ANALYSIS, SHOWING RELATIVE RESEARCH EFFORT ALLOCATED BY BIOMEDICAL AND ENVIRONMENTAL RESEARCH CATEGORIES (BERCs) AND ENERGY TECHNOLOGIES, HAS RESULTED AN INITIAL ANNUAL BUDGET OF APPROXIMATELY $270 MILLION.

- RESEARCH EMPHASIS BY TECHNOLOGY IS PRIMARILY IN THE FOSSIL FUELS, PARTICULARLY COAL EXTRACTION, PROCESSING, AND COMBUSTION. FISSION RANKS SECOND IN TECHNOLOGY FUNDING.
- RESEARCH EMPHASIS BY BERC IS PRIMARILY IN HEALTH EFFECTS WITH SUBSTANTIAL AND ROUGHLY EQUAL EFFORT IN PHYSICAL AND CHEMICAL PROCESSES AND EFFECTS, ECOLOGICAL EFFECTS AND INTEGRATED ASSESSMENT.
- THIS ALLOCATION DOES NOT INCLUDE RESEARCH CURRENTLY BEING CONDUCTED BY DBER WHICH DOES NOT FALL WITHIN THE SCOPE OF A BPP SUPPORTING ENERGY TECHNOLOGY DEVELOPMENT (e.g., NUCLEAR MEDICINE, FALLOUT STUDIES, WEAPONS RESEARCH, ETC.).
- THE DOLLAR ESTIMATES SHOWN EVOLVED FROM DEFINITION OF PROBLEM AREAS AND INFORMED JUDGMENTS CONCERNING THE COST OF REQUIRED RESEARCH ACTIVITIES. NO A PRIORI COST LIMITATIONS WERE PLACED ON THE ACTIVITY.
- THESE ESTIMATES SERVE AS INDICATORS OF THE RELATIVE LEVELS OF EFFORT REQUIRED BUT ARE NOT DEFINITIVE BUDGETARY PROJECTIONS.
- AN IMPLEMENTATION SCHEDULE WAS NOT DEVELOPED, AND NO SPECIFIC YEAR IDENTIFIED FOR INITIATION OF THE RESEARCH RECOMMENDATIONS.

ENERGY TECHNOLOGIES / BIOMEDICAL AND ENVIRONMENTAL RESEARCH CATEGORIES		FOSSIL ENERGY				CONSERVATION	SOLAR, GEOTHERMAL AND ADVANCED ENERGY SYSTEMS			NUCLEAR ENERGY		
		COAL EXTRACTION PROCESSING AND COMBUSTION	COAL CONVERSION	OIL SHALE	OIL AND GAS	ENERGY CONSERVATION AND EFFICIENCY	SOLAR	GEO-THERMAL	FUSION	FISSION	MULTI-TECHNOLOGY	TOTAL
	Page Ref.	40-43	44-48	50-54	56-63	64-67	68-72	74-77	78-81	82-86		
Characterization Measurement and Monitoring	90-1 104-15	4.9*	4.9	1.7	1.1	2.6	0.3	2.9	0.3	2.7	0	21.4
Physical, Chemical Processes and Effects	92-3 116-23	15.9	2.3	3.6	11.8	0.5	1.3	1.8	4.1	4.1	2.7	48.1
Ecological Processes and Effects	94-5 116-19 124-8	14.5	2.9	2.6	6.1	0.4	1.5	2.0	0	10.4	15.0	55.4
Health Effects	96-7 139-8 140-3	18.7	20.3	11.2	1.6	0.5	0.3	0.7	1.2	30.6	16.3	101.4
Integrated Assessment and Socioeconomic Process and Effects	98-100 130-3 144-7	6.2	3.4	1.4	2.6	4.1	3.0	1.4	0.4	6.9	17.2	46.6
TOTAL		60.2	33.8	20.5	23.2	8.1	6.4	8.8	6.0	54.7	51.2	272.9

*Table entries are millions of dollars

EXHIBIT 59

PRELIMINARY REQUIREMENTS ANALYSIS FOR AN INITIAL ANNUAL BUDGET OF $272.9M. Health and Environmental implications of each energy technology are described in Section 2 while research efforts, related to these problems are presented in Section 3.

3.4.4 Relative Allocation of Research by Technology

RESEARCH TASKS REQUIRE VARYING ALLOCATIONS OF BIOMEDICAL AND ENVIRONMENTAL RESEARCH EFFORT BY ENERGY TECHNOLOGY.

- CHARACTERIZATION, MEASUREMENT, AND MONITORING REQUIRES A MAJOR RESEARCH EFFORT IN BASELINE MEASUREMENTS AND DEVELOPMENTAL AND OPERATING SITE MEASUREMENTS, AND IN THE COAL EXTRACTION, PROCESSING AND COMBUSTION, COAL CONVERSION, CONSERVATION, GEOTHERMAL AND FISSION TECHNOLOGIES.

- PHYSICAL AND CHEMICAL PROCESSES AND EFFECTS REQUIRES A CONCENTRATION OF RESEARCH EFFORT IN THE ATMOSPHERIC AND FRESHWATER AND TERRESTRIAL SCIENCES, AND IN THE COAL EXTRACTION, OIL AND GAS, AND FISSION TECHNOLOGIES.

- HEALTH EFFECTS RESEARCH SHOULD BE CONCENTRATED IN EPIDEMIOLOGICAL, ANIMAL MODELING, SCREENING, AND METABOLIC STUDIES, AND IN THE COAL EXTRACTION, PROCESSING AND COMBUSTION, COAL CONVERSION, AND FISSION TECHNOLOGIES.

- ECOLOGICAL PROCESSES AND EFFECTS REQUIRES RESEARCH PRIMARILY IN TERRESTRIAL AND FRESHWATER SYSTEMS, AND IN THE COAL EXTRACTION, PROCESSING AND COMBUSTION, AND FISSION TECHNOLOGIES.

- INTEGRATED ASSESSMENT REQUIRES RESEARCH PRIMARILY IN SOCIAL PROCESSES AND EFFECTS AND BIOENVIRONMENTAL CONSEQUENCES, AND IN THE CONSERVATION, COAL EXTRACTION, COAL CONVERSION, OIL AND GAS, AND FISSION TECHNOLOGIES.

EXHIBIT 60
RELATIVE ALLOCATION OF EFFORT BY TECHNOLOGY FOR CHARACTERIZATION, MEASUREMENT AND MONITORING RESEARCH

RESEARCH AREA \ ENERGY TECHNOLOGY	COAL EXTRACTION PROCESSING AND PROCESSING	COAL CONVERSION	OIL SHALE	OIL AND GAS	ENERGY CONSERVATION AND EFFICIENCY	SOLAR	GEOTHERMAL	FUSION	FISSION
1. CHARACTERIZATION Baseline Measurements Development and Operational Site Measurements.	●	●	○	○	●	○	●	○	◒
2. MEASUREMENT TECHNOLOGY Advanced Components and System Technology; Applied Systems Development	●	●	○	◒	○	○	◒	○	●
3. MONITORING	●	◒	◒	○	◒		◒	○	◒
4. QUALITY ASSURANCE AND STANDARD REFERENCE MATERIALS	○	○	○						

LEGEND: ● - Major effort; ◒ - Moderate effort; ○ - Minor effort; Blank - No effort

EXHIBIT 61
RELATIVE ALLOCATION OF EFFORT BY TECHNOLOGY FOR PHYSICAL AND CHEMICAL PROCESSES AND EFFECTS RESEARCH

RESEARCH AREA \ ENERGY TECHNOLOGY	COAL EXTRACTION PROCESSING AND PROCESSING	COAL CONVERSION	OIL SHALE	OIL AND GAS	ENERGY CONSERVATION AND EFFICIENCY	SOLAR	GEOTHERMAL	FUSION	FISSION
1. ATMOSPHERIC SCIENCES	●	◒	◒	◒	○	◒	○	◒	◒
2. HYDROLOGICAL & GEOLOGICAL	●	◒	◒	◒		○	◒	○	◒
3. MARINE SCIENCES	○			●		○	○	○	◒

LEGEND: ● - Major effort; ◒ - Moderate effort; ○ - Minor effort; Blank - No effort

EXHIBIT 62
RELATIVE ALLOCATION OF EFFORT BY TECHNOLOGY FOR HEALTH EFFECTS RESEARCH

RESEARCH AREA \ ENERGY TECHNOLOGY	COAL EXTRACTION PROCESSING AND PROCESSING	COAL CONVERSION	OIL SHALE	OIL AND GAS	ENERGY CONSERVATION AND EFFICIENCY	SOLAR	GEOTHERMAL	FUSION	FISSION
1. Epidemiological and clinical human health studies	●	◒	◒	◒	◒	○	○	○	●
2. Animal modeling studies to extrapolate risk to man	●	●	◒	◒	○	○	○	◒	●
3. Identification of hazardous agents via biological screening (including low-dose long-term effects)	◒	◒	◒	○		○	○	◒	○
4. Fate and metabolism studies (e.g., activation, degradation, critical organ deposition, recovery and repair)	●	◒	◒	○		○		○	●
5. Supportive research (e.g., improved assay procedures, animal disease models for dysfunction, risk estimation.	●	◒	◒					○	●

LEGEND: ● - Major effort; ◒ - Moderate effort; ○ - Minor effort; Blank - No effort

EXHIBIT 63
RELATIVE ALLOCATION OF EFFORT BY TECHNOLOGY FOR ECOLOGICAL PROCESSES AND EFFECTS RESEARCH

RESEARCH AREA \ ENERGY TECHNOLOGY	COAL EXTRACTION PROCESSING AND PROCESSING	COAL CONVERSION	OIL SHALE	OIL AND GAS	ENERGY CONSERVATION AND EFFICIENCY	SOLAR	GEOTHERMAL	FUSION	FISSION
1. TERRESTRIAL SYSTEMS	●	◒	◒	◒	○	○	◒	○	●
2. FRESHWATER SYSTEMS	●	◒	◒	◒	○	○	○	○	◒
3. MARINE SYSTEMS	◒			◒		◒		○	●

LEGEND: ● - Major effort; ◒ - Moderate effort; ○ - Minor effort; Blank - No effort

EXHIBIT 64
RELATIVE ALLOCATION OF EFFORT BY TECHNOLOGY FOR INTEGRATED ASSESSMENT RESEARCH

RESEARCH AREA \ ENERGY TECHNOLOGY	COAL EXTRACTION PROCESSING AND PROCESSING	COAL CONVERSION	OIL SHALE	OIL AND GAS	ENERGY CONSERVA-TION AND EFFICIENCY	SOLAR	GEOTHERMAL	FUSION	FISSION
1. Information Systems and Management	◒	◒	○	◒	◒	○	○	○	◒
2. Social Processes and Effects	◒	◒	◒	◒	◒	○	○		●
3. Bioenvironmental Consequences	●	◒	◒	●	●	○	◒	○	●
4. Cost/Risk/Benefit Analyses	◒	◒	○	○	◒	○	○	○	◒
5. Implementaion Alternatives	◒	○	○	◒	◒	○	○		◒

LEGEND: ● - Major effort; ◒ - Moderate effort; ○ - Minor effort; Blank - No effort

3.4.5 Allocation of Effort by ERDA Feasibility Estimate

RESEARCH IN THE BPP CAN BE ALLOCATED BY ENERGY TECHNOLOGY WITH RESPECT TO ERDA'S ESTIMATE OF WHEN EACH TECHNOLOGY WILL BECOME A FEASIBLE ENERGY SUPPLY OPTION.

- IN THE NEAR-TERM (BEFORE 1985), COAL EXTRACTION, PROCESSING AND COMBUSTION, FISSION (CONVERTER REACTORS), OIL AND GAS, AND CONSERVATION AND EFFICIENCY ARE EXPECTED TO BE IMPLEMENTED, ACCOUNTING FOR 59% OF THE BPP.
- IN THE MID-TERM (1985-2000) COAL CONVERSION, OIL SHALE, AND GEOTHERMAL TECHNOLOGIES ARE EXPECTED TO BE IMPLEMENTED, ACCOUNTING FOR 23% OF THE BPP.
- IN THE LONG-TERM (AFTER 2000), SOLAR, FUSION, AND FISSION (BREEDER REACTORS) TECHNOLOGIES ARE EXPECTED TO BE IMPLEMENTED, ACCOUNTING FOR 18% OF THE BPP.

EXHIBIT 65

ALLOCATION OF RESEARCH BY ENERGY TECHNOLOGIES IN BPP
WITH RESPECT TO IMPLEMENTATION SCHEDULE

Implementation Schedule		Percent of BPP
Near-term		
Coal extraction, processing and combustion		22%
Fission (converter reactors)		10
Oil and gas		9
Conservation and efficiency		3
	Total	44%
Mid-term		
Coal conversion		12%
Oil shale		8
Geothermal		3
	Total	23%
Long-term		
Solar		2
Fusion		2
Fission (breeder reactors)		10
	Total	14%

Note: The comprehensive BPP will describe a research plan taking into account technology development schedules. The remaining BPP research effort (19%) is allocated to a multi-technology and supporting research category.

4.0 COORDINATION 165

4.1 Description of Additional Ongoing Health and Environmental Activities 166

4.2 Intra-ERDA Coordination 184

4.1 Description of Additional Ongoing Health and Environmental Activities

RESPONSIBILITY AND PERFORMANCE OF HEALTH AND ENVIRONMENTAL RESEARCH AND ASSESSMENT ARE SHARED BY SEVERAL GOVERNMENTAL AGENCIES AND PRIVATE ORGANIZATIONS: CONTINUING COORDINATION WILL BE REQUIRED TO ENSURE DEFINITION AND EXECUTION OF A COMPREHENSIVE NONREDUNDANT NATIONAL PROGRAM

- EACH ORGANIZATION HAS A SPECIFIC MISSION AND A UNIQUE SET OF GOALS WITH REGARD TO ITS HEALTH AND ENVIRONMENTAL RESEARCH PROGRAMS.
- PRIORITY RESEARCH TARGETS AND PROGRAM SCHEDULES, AS DEVELOPED BY EACH ORGANIZATION, MAY NOT BE CONSISTENT WITH THE NEEDS OF DEVELOPING ENERGY TECHNOLOGIES.
- PLANNING TODATE HAS NOT CONSIDERED IN DETAIL CURRENT HEALTH AND ENVIRONMENTAL RESEARCH EFFORTS; THE FOLLOWING PAGES, HOWEVER, BRIEFLY DESCRIBE THE GOALS AND RESEARCH PROGRAMS OF SEVERAL RELEVANT AGENCIES AND ORGANIZATIONS.

4.1 Description of Additional Ongoing Environmental Activities: USDA

SEVERAL AGENCIES WITHIN THE DEPARTMENT OF AGRICULTURE (USDA) CONDUCT ENVIRONMENTAL RESEARCH ON THE CHARACTERISTICS AND MANAGEMENT OF NATURAL AND MODIFIED ECOSYSTEMS.

- THE AGRICULTURAL RESEARCH SERVICE CONDUCTS BASIC, APPLIED, AND DEVELOPMENTAL RESEARCH PROGRAMS ON PLANT AND ANIMAL PRODUCTION AND WATERSHED HYDROLOGY.
- THE COOPERATIVE STATE RESEARCH SERVICE ADMINISTERS FEDERAL FUNDING FOR PROGRAMS AT STATE AGRICULTURAL EXPERIMENT STATIONS THAT INCLUDE ENVIRONMENTAL INVESTIGATIONS.
- THE ECONOMIC RESEARCH SERVICE PROVIDES SOCIOECONOMIC INTELLIGENCE PERTAINING TO THE CONSERVATION AND USE OF NATURAL RESOURCES.
- THE FOREST SERVICE CONDUCTS RESOURCE INVENTORIES AND ANALYSES OF NATIONAL FORESTS AND GRASSLANDS AND CARRIES OUT INVESTIGATIONS OF THE MANAGEMENT OF WATER, SOIL, FOREST, MINERAL, AND OTHER RESOURCES.
- SOIL CONSERVATION SERVICE PROGRAMS INCLUDE INVESTIGATIONS AND RESOURCE SURVEYS OF RIVER BASINS AND WATERSHEDS.
- OTHER USDA PROGRAMS DEAL WITH THE MANAGEMENT OF NATURAL RESOURCES.

4.1 Description of Additional Ongoing Environmental Activities: NBS

THE NATIONAL BUREAU OF STANDARDS (NBS) FOCUSES ON DEVELOPING SERVICES NEEDED FOR THE ASSESSMENT AND CONTROL OF ENVIRONMENTAL POLLUTION; ITS PRIMARY OBJECTIVE IS TO PROVIDE A SOUND TECHNICAL BASIS FOR PUBLIC AND JUDICIAL CONFIDENCE IN THE ACCURACY OF POLLUTION MEASUREMENTS.

- RESEARCH ON AIR QUALITY MEASUREMENTS AT NBS IS INTENDED TO OVERCOME THE LACK OF ADEQUATE TECHNIQUES FOR ASSESSING PROGRESS TOWARD, AND ULTIMATE FAIR ENFORCEMENT OF, AIR QUALITY STANDARDS.
- WATER POLLUTION RESEARCH IS ORIENTED TOWARD THE DEVELOPMENT OF TECHNIQUES FOR MEASURING LOW-LEVEL POLLUTANTS, INCLUDING RADIOACTIVE SUBSTANCES.
- CALIBRATION TECHNIQUES FOR THE MEASUREMENT OF FLUID FLOW ARE ALSO BEING DEVELOPED.
- NOISE POLLUTION RESEARCH EMPHASIZES THE DEVELOPMENT OF STANDARD METHODS FOR MEASURING NOISE LEVELS, INCLUDING TECHNIQUES FOR CALIBRATING NEEDED EQUIPMENT, AND FOR MONITORING.
- ONGOING WORK IN NBS INCLUDES: DEVELOPMENT OF NEW METHODS FOR MEASURING VOLTAGES AND POWER TRANSMISSION IN HIGH-VOLTAGE POWER LINES; LOW-TURBULENCE LOW-VELOCITY WIND TUNNEL MEASUREMENTS RELATED TO THE DISPERSION OF AIR POLLUTANTS AND TO MINE SAFETY; AND NEUTRON STANDARDS TO SUPPORT THE DESIGN AND DEVELOPMENT OF THE FAST BREEDER NUCLEAR REACTOR.

4.1 Description of Additional Ongoing Environmental Activities: NOAA

ONE OF THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION'S (NOAA) GOALS IS TO DEVELOP AND OPERATE SYSTEMS TO MONITOR WEATHER, OCEAN, LAND, AND THE SUN, AND TO PREDICT ENVIRONMENTAL CONDITIONS SO THAT THROUGH ENVIRONMENTAL INFORMATION SERVICES, AND HAZARD WARNINGS, LIFE AND PROPERTY CAN BE PROTECTED AND THE EFFICIENCY OF COMMERCIAL, INDUSTRIAL, AND AGRICULTURAL ACTIVITIES IMPROVED.

- THE "MARINE ECOSYSTEMS ANALYSIS AND OCEAN DUMPING" ACTIVITY PROVIDES CRITICAL ENVIRONMENTAL INFORMATION FOR EFFECTIVE MANAGEMENT OF THE MARINE ENVIRONMENT AND ITS RESOURCES.
- THE ACTIVITY "SPECIALIZED ENVIRONMENTAL SERVICES" SUPPORTS CLEAN AIR OPERATIONS BY GOVERNMENT AND INDUSTRY.
- THE "ENVIRONMENTAL DATA AND INFORMATION SERVICES" ACTIVITY PREPARES SPECIAL ANALYSES IN RESPONSE TO REQUIREMENTS FOR LOCATIONS OF POWER PLANTS AND SUPERPORTS, STRESSES ON OFFSHORE DRILLING RIGS, AND ENERGY ALLOCATION DECISIONS.
- THE "GLOBAL MONITORING OF CLIMATIC CHANGE" ACTIVITY REPRESENTS THE UNITED STATES' PART OF A UNITED NATIONS SPONSORED WORLD-WIDE PROGRAM TO MONITOR CAREFULLY THE LONG-TERM CHANGES TAKING PLACE IN THE EARTH'S ATMOSPHERE, ASSESS THE EFFECTS OF THESE CHANGES ON WEATHER AND CLIMATE, AND PREDICT THE CHANGES THAT WILL OCCUR IN GLOBAL WEATHER AND CLIMATE.

4.1 Description of Additional Ongoing Environmental Activities: DOD

THE ARMY CORPS OF ENGINEERS IS RESPONSIBLE FOR MANAGEMENT OF THE NATION'S NAVIGABLE WATERWAYS.

- THE CORPS PREPARES ENVIRONMENTAL IMPACT STATEMENTS AND DEVELOPS GUIDELINES FOR CONSIDERATION OF SOCIOECONOMIC AND ENVIRONMENTAL EFFECTS OF WATER-RELATED PROJECTS.
- AUTHORIZATION STUDIES, FRAMEWORK STUDIES, AND REGIONAL OR RIVER BASIN STUDIES BY THE CORPS INVOLVE COMPREHENSIVE RESOURCE INVENTORIES OF RELATIVELY LARGE AREAS.
- A WASTE WATER MANAGEMENT PROGRAM DEVELOPS ALTERNATIVE WASTE WATER MANAGEMENT PLANS FOR RURAL AND URBAN AREAS.
- AS PART OF ITS FIELD ACTIVITIES, THE CORPS COLLECTS BASIC DATA ON SEVERAL ENVIRONMENTAL PARAMETERS.

4.1 Description of Additional Ongoing Environmental Activities: FDA

THE FOOD AND DRUG ADMINISTRATION (FDA) ACTIVITIES ARE DIRECTED TOWARD PROTECTING THE HEALTH OF THE NATION AGAINST IMPURE AND UNSAFE FOODS, DRUGS, COSMETICS, AND OTHER POTENTIAL HAZARDS.

- ANALYTICAL METHODOLOGY WILL BE DEVELOPED TO DETERMINE PHOSPHATE ESTERS IN FOODS.
- SHORT & LONG-TERM STUDIES ARE BEING CONDUCTED TO ESTABLISH GUIDELINE LEVELS FOR CADMIUM, LEAD, MERCURY, ZINC, AND OTHER HEAVY METALS.
- DIET STUDIES AND OTHER EFFORTS WILL CONTINUE TO DETERMINE HEAVY METAL CONTAMINATION IN TOTAL DIET AND CERTAIN FISH.
- STUDIES ARE BEING CONDUCTED TO DETERMINE THE EXTENT TO WHICH ORGANIC MERCURY AND OTHER METAL ALKYLS ARE NATURALLY FORMED AND WHETHER THEY BIOACCUMULATE.
- DEVELOPMENT IS BEING COMPLETED OF A GRAIN PRODUCT AS A REFERENCE STANDARD IN ANALYZING THIS FOOD COMMODITY AND HEAVY METAL CONTAMINATION.
- SURVEY OF TRITIUM LEVELS IN COMMODITIES AND ESTABLISHMENT OF BASELINE DATA WILL AID IN DETERMINING IF THERE IS AN INCREASE IN UPTAKE.
- THE NATIONAL CENTER FOR TOXICOLOGICAL RESEARCH, PARTIALLY FUNDED BY FDA, CONDUCTS RESEARCH PROGRAMS TO STUDY THE BIOLOGICAL EFFECTS OF POTENTIALLY TOXIC CHEMICAL SUBSTANCES FOUND IN THE ENVIRONMENT.

4.1 Description of Additional Ongoing Environmental Activities: NIEHS

THE NATIONAL INSTITUTE OF ENVIRONMENTAL HEALTH SCIENCES (NIEHS) SEEKS TO INCREASE UNDERSTANDING OF ENVIRONMENTAL AGENTS WHICH CAN ADVERSELY AFFECT HEALTH EITHER IMMEDIATELY OR OVER A TIME PERIOD.

- GRANT SUPPORT OF RESEARCH ASSISTS IN EFFORTS TO IDENTIFY AND DEAL WITH HAZARDS IN THE ENVIRONMENT.
- INTRAMURAL PROGRAMS INVESTIGATE THE ACTIONS, INTERACTIONS, MECHANISMS OF ACTIONS OF ENVIRONMENTAL COMPONENTS ON BIOLOGICAL SYSTEMS.
- EXTRAMURAL AND INTRAMURAL PROGRAMS SERVE AS A FOCUS FOR EFFORTS TO DEAL WITH ENVIRONMENTAL EFFECTS ON HUMAN HEALTH.
- ENVIRONMENTAL HEALTH SCIENCE CENTERS DEVELOP FUNDAMENTAL, PRACTICAL INFORMATION ABOUT CAUSES AND NATURE OF ENVIRONMENTAL DISEASES TO GUIDE CORRECTIVE, THERAPEUTIC PROGRAMS.
- ENVIRONMENTAL MUTAGENESIS AND REPRODUCTIVE TOXICOLOGY PROGRAM PROVIDES AN UNDERSTANDING OF THE MOLECULAR BASIS FOR VISIBLE CHANGES IN THE BIOCHEMISTRY AND MORPHOLOGY DUE TO MUTAGENIC AND TERATOGENIC AGENTS.
- THE ETIOLOGY OF ENVIRONMENTAL DISEASES ESTABLISHES CAUSAL ASSOCIATIONS BETWEEN HUMAN DISEASES AND NOXIOUS CHEMICAL AND PHYSICAL FACTORS IN THE ENVIRONMENT.
- THE ENVIRONMENTAL PHARMACOLOGY AND TOXICOLOGY PROGRAM DEVELOPS UNDERSTANDING OF THE PRINCIPLES AND MECHANISMS INVOLVED IN THE TOXICITY OF ENVIRONMENTAL AGENTS AND CHARACTERIZES THE NATURE AND SITES OF MOLECULAR, CELLULAR, AND TISSUE INTERACTIONS.
- THE ENVIRONMENTAL PATHOGENESIS PROGRAM DEALS WITH DETAILS OF MOLECULAR AND CELLULAR EVENTS THAT CULMINATE IN DISEASES UPON EXPOSURE OF INDIVIDUALS TO TOXIC AGENTS.

4.1 Description of Additional Ongoing Environmental Activities: NIOSH

THE NATIONAL INSTITUTE OF OCCUPATIONAL SAFETY AND HEALTH (NIOSH) IS THE PRINCIPAL FEDERAL AGENCY ENGAGED IN RESEARCH SUPPORTING THE NATIONAL EFFORT TO ELIMINATE ON-THE-JOB HAZARDS TO THE HEALTH AND SAFETY OF THE NATION'S WORKING PEOPLE.

- UNDER THE OCCUPATIONAL SAFETY AND HEALTH ACT, NIOSH CONDUCTS RESEARCH FOR NEW OCCUPATIONAL SAFETY AND HEALTH STANDARDS. (DEPARTMENT OF LABOR HAS RESPONSIBILITY FOR SETTING, PROMULGATING, AND ENFORCING STANDARDS).
- UNDER THE FEDERAL COAL MINE HEALTH AND SAFETY ACT, NIOSH RECOMMENDS HEALTH STANDARDS. (DEPARTMENT OF INTERIOR HAS ENFORCEMENT RESPONSIBILITIES).
- MAJOR RESEARCH INCLUDES EFFECTS OF EXPOSURE TO HAZARDOUS SUBSTANCES USED IN THE WORKPLACE. (e.g., ASBESTOS, BERYLLIUM, CARBON MONOXIDE, LEAD, MERCURY, NOISE, AND HEAT STRESS).
- NIOSH'S APPALACHIAN CENTER FOR OCCUPATIONAL SAFETY AND HEALTH FOCUSES ON PNEUMONOCONIOSIS AND OTHER OCCUPATIONAL RESPIRATORY DISEASES.
- NIOSH'S WESTERN AREA OCCUPATIONAL HEALTH LABORATORY STUDIES THE HAZARDS OF URANIUM MINING AND PROVIDES TECHNICAL ASSISTANCE TO WESTERN STATES.

4.1 Description of Additional Ongoing Environmental Activities: DOI

THE DEPARTMENT OF THE INTERIOR (DOI) IS THE FEDERAL GOVERNMENT'S PRINCIPAL NATURAL RESOURCES MANAGEMENT AGENCY.

- THE FISH AND WILDLIFE SERVICE CONDUCTS A VARIETY OF RESEARCH PROGRAMS AND SURVEYS THAT DEAL WITH BIOTIC RESOURCES.
- A NEW OFFICE OF BIOLOGICAL SERVICES (FISH AND WILDLIFE SERVICE) WILL BE DIRECTLY CONCERNED WITH THE ACQUISITION, ASSIMILATION, AND EVALUATION OF ECOLOGICAL DATA PERTAINING TO ENERGY TECHNOLOGY DEVELOPMENTS.
- MAJOR PROGRAMS OF THE U.S. GEOLOGICAL SURVEY DEAL WITH INVENTORIES OF ENERGY RESERVES AND OTHER NATURAL RESOURCES.
- THE BUREAU OF LAND MANAGEMENT IS RESPONSIBLE FOR THE ALLOCATION OF NATIONAL RESOURCE LANDS FOR ENERGY DEVELOPMENT.
- RESEARCH PROGRAMS OF THE BUREAU OF MINES ARE AIMED AT THE DEVELOPMENT AND USE OF ENERGY RESOURCES.
- THE NATIONAL PARK SERVICE CONDUCTS INVENTORIES AND RESEARCH OF UNIQUE BIOTIC SYSTEMS AND OTHER RESOURCES IN THE NATIONAL PARK SYSTEM.
- THE BUREAU OF OUTDOOR RECREATION ASSESSES RECREATION NEEDS AND RECREATION IMPACTS OF VARIOUS FEDERAL PROGRAMS.
- THE OFFICE OF WATER RESOURCES RESEARCH PROMOTES THE COLLECTION AND DISSEMINATION OF INFORMATION ON NATIONAL WATER RESOURCES.
- THE BUREAU OF RECLAMATION DEVELOPS PLANS AND CONDUCTS INVESTIGATIONS PERTAINING TO THE CONSERVATION AND USE OF WATER AND RELATED LAND RESOURCES IN THE WESTERN U.S.

4.1 Description of Additional Ongoing Environmental Activities: CEQ

THE COUNCIL ON ENVIRONMENTAL QUALITY (CEQ) HAS BEEN ASSIGNED DUTIES AND RESPONSIBILITIES UNDER THE NATIONAL ENVIRONMENTAL POLICY ACT, THE ENVIRONMENTAL QUALITY IMPROVEMENT ACT, AND EXECUTIVE ORDER 11514, WHICH REQUIRE IT TO ANALYZE CONDITIONS AND TRENDS, APPRAISE THE EFFECT OF FEDERAL PROGRAMS, AND EVALUATE THE EFFECTS OF TECHNOLOGY RELATED TO ENVIRONMENTAL CONCERNS, AND TO PREPARE REPORTS AND RECOMMENDATIONS FOR THE PRESIDENT.

- CEQ'S MAJOR PROGRAMS WHICH RELATE TO DBER ARE AS FOLLOWS:
  - INVESTIGATE IMPACTS OF ENERGY ON THE OCEANS
  - EXAMINE RELATIONSHIPS BETWEEN MAINTENANCE OF AIR QUALITY AND ELECTRIC POWER RELIABILITY
  - STUDY TRANSPORTATION, ENERGY, AND LAND USE
  - STUDY EFFECTS OF URBAN GOODS MOVEMENT
  - DEVELOP FLOW CHARTS OF TOXIC SUSBTANCES
  - STUDY ENERGY AND AIR QUALITY
  - ASSESS WATER QUALITY
  - DEVELOP METHODOLOGIES FOR BIOTIC MONITORING

4.1 Description of Additional Ongoing Environmental Activities: EPA

THE ENVIRONMENTAL PROTECTION AGENCY (EPA) IS THE FEDERAL ORGANIZATION MOST CONCERNED WITH ENVIRONMENTAL ISSUES AND HAS RESPONSIBILITY FOR PROMULGATING STANDARDS AND REGULATIONS REGARDING ENVIRONMENTAL QUALITY.

- EPA DEVISES AND ENFORCES STANDARDS (AIR, WATER, LAND) DESIGNED TO PROTECT HEALTH, ECOLOGY, AND MATERIALS FROM DETERIORATING AS A RESULT OF ENVIRONMENTAL POLLUTION LEVELS.
- EPA PERFORMS RESEARCH INTO THE NATURE AND MAGNITUDE OF EFFECTS CAUSED BY ENVIRONMENTAL POLLUTION AND DISRUPTION.
- EPA IDENTIFIES CONTROL TECHNOLOGIES AND OTHER MITIGATING MEASURES DESIGNED TO ALLOW OPERATION OF PROCESSES AND FACILITIES WITHOUT SIGNIFICANT ENVIRONMENTAL DEGRADATION.
- EPA MONITORS PROGRESS TOWARD ENVIRONMENTAL STANDARDS AND ASSISTS OTHER FEDERAL AGENCIES AND STATE AND LOCAL GOVERNMENTS IN POLLUTION REDUCTION PROGRAMS.

4.1 Description of Additional Ongoing Environmental Activities: NASA

THE NATIONAL AERONAUTIC AND SPACE ADMINISTRATION'S (NASA) ENVIRONMENTAL PROGRAMS ARE DESIGNED TO ASSESS AEROSPACE TECHNOLOGY STRATEGIES.

- THE "POLLUTION MONITORING" PROGRAM APPLIES SPACE AND REMOTE SENSING TECHNOLOGY TO THE MONITORING OF THE QUALITY OF THE ATMOSPHERE.
- ONE OF THE OBJECTIVES OF "EARTH RESOURCES SURVEY" PROGRAM IS TO PROVIDE TECHNOLOGICAL MEANS FOR ACQUIRING AND INTERPRETING INFORMATION ON MANAGING EARTH'S RESOURCES.
- THE "EARTH AND OCEAN PHYSICS APPLICATIONS PROGRAM" PROVIDES THE FOCUS FOR THOSE APPLICATIONS WHICH MAKE USE OF SPACE-DERIVED TECHNIQUES FOR PRECISE MONITORING OF EARTH CRUSTAL MOTION, POLAR MOVEMENT, AND CHANGES IN ROTATION RATE; AS WELL AS MONITORING OCEAN PHENOMENA SUCH AS SEA STATE, CURRENTS, SURFACE WINDS, AND GENERAL OCEAN CIRCULATION.
- THE OBJECTIVE OF THE "ENERGY AND ENVIRONMENTAL SYSTEM TECHNOLOGY" PROGRAM IS TO REDUCE THE FUEL CONSUMPTION AND POLLUTION ATTRIBUTABLE TO STATIONARY AND MOBILE POWER SYSTEMS.
- UNDER THE "WASTE REDUCTION" PROGRAM, NASA HAS INITIATED SEVERAL PROJECTS IN LIQUID WASTE (SEWAGE) REDUCTION AND ENERGY RECOVERY FROM SOLID WASTE (REFUSE) DISPOSAL.

4.1 Description of Additional Ongoing Environmental Activities: NSF

THE NATIONAL SCIENCE FOUNDATION (NSF) IS CONCERNED WITH THE ADVANCED PROBLEMS IN THE ENVIRONMENTAL EFFECTS OF ENERGY, WEATHER MODIFICATION, AND THE ENVIRONMENTAL ASPECTS OF TRACE CONTAMINANTS.

- FY76 SUPPORTED EFFORTS INCLUDE:
  - HEAVY METAL CHEMICAL ANALYSIS TECHNIQUE IMPROVEMENT
  - STUDY OF OZONE FORMATION FROM POWER PLANT EFFLUENTS
  - LEAD MINING AND SMELTING EFFLUENT CONTROL
  - LEAD PARTICLE TRANSPORT AND DIFFUSION MODELING
  - WATER QUALITY - ECONOMIC INTERACTION MODELS FOR FIVE MAJOR INDUSTRIES
  - HAIL SUPPRESSION - ECONOMIC INTEGRATED ASSESSMENT
  - RESISTANCE OF CALIFORNIA DAMS TO EARTHQUAKE DAMAGE
  - NEW EARTHQUAKE DESIGN CRITERIA FOR REACTOR DESIGN

4.1 Description of Additional Ongoing Environmental Activities: TVA

THE TENNESSEE VALLEY AUTHORITY (TVA) PARTICIPATES IN MANY ENVIRONMENTAL QUALITY PROJECTS SELECTED ON THE BASIS OF THE SERIOUSNESS OF THE PROBLEM, TVA PROGRAM RESPONSIBILITY, AND TVA TECHNICAL COMPETENCE AND EXPERIENCE.

- WATER QUALITY MANAGEMENT ACTIVITIES HAVE AS THEIR OBJECTIVE THE MAINTENANCE OF SURFACE AND GROUNDWATER SUFFICIENT TO PERMIT THEIR OPTIMUM DEVELOPMENT FOR MUNICIPAL, INDUSTRIAL, AND AGRICULTURAL WATER SUPPLIES; PROPAGATION OF FISH AND WILDLIFE; WATER-CONTACT RECREATION; AND ESTHETIC SATISFACTION.

- AS A MAJOR BUYER OF STRIP-MINED COAL, TVA REQUIRES AND ENFORCES EFFECTIVE MINED LAND PLANNING, ENVIRONMENTAL PROTECTION, AND A HIGH ORDER OF RECLAMATION ON ALL LANDS DISTURBED IN SUPPLYING ITS COAL.

- TVA WORKS WITH VALLEY COUNTIES AND CITIES IN ESTABLISHING EFFECTIVE SOLID WASTE COLLECTION AND DISPOSAL SYSTEMS.

- TVA CONDUCTS ONE OF THE LARGEST KNOWN MONITORING AND RESEARCH EFFORTS RELATED TO ATMOSPHERIC EMISSIONS FROM STEAM POWER PLANTS.

- TVA IS CONDUCTING EXTENSIVE IN-HOUSE RESEARCH ON THE REMOVAL OF SULFUR OXIDES FROM FLUE GASES.

- TVA, ERDA, AND OTHERS ARE COOPERATING TO USE THIS UTILITY SYSTEM - LARGEST IN THE USA - AND ITS PLANNING ACTIVITIES AS A LEADING DEMONSTRATION FOR ASSESSMENT AND ITS IMPLEMENTATION.

4.1 Description of Additional Ongoing Environmental Activities: State Agencies

STATE AGENCIES CONDUCT A VARIETY OF RESEARCH PROGRAMS, SURVEYS, AND MANAGEMENT ACTIVITIES PERTAINING TO NATURAL, HUMAN, AND OTHER RESOURCES.

- STATE GOVERNMENTS ARE STRUCTURED SIMILAR TO THE FEDERAL GOVERNMENT AND HAVE AGENCIES WITH COMPARABLE RESOURCE RESEARCH AND MANAGEMENT FUNCTIONS.
- THE STATES POSSESS CONSIDERABLE LAND AREAS WHICH MAY BE SUITABLE FOR ENERGY DEVELOPMENT.
- STATE-SUPPORTED UNIVERSITIES AND COLLEGES CONDUCT A VARIETY OF ENVIRONMENTAL RESEARCH PROGRAMS.
- STATE ENVIRONMENTAL LAWS, REGULATIONS, AND POLICIES MAY IMPOSE SIGNIFICANT CONSTRAINTS ON ENERGY TECHNOLOGY DEVELOPMENTS.

4.1 Description of Additional Ongoing Environmental Activities: AGA

THE AMERICAN GAS ASSOCIATION (AGA) ACTIVITIES INCLUDE, BUT ARE NOT LIMITED TO, AREAS OF NEW TECHNOLOGICAL AND ECONOMIC R&D CONCERNING NEW SOURCES AND THE USE OF NATURAL GAS.

- FY74 ACTIVITIES HAVE INCLUDED:
  - ENVIRONMENTAL PROTECTION - NO_X AND CH_4 EMISSIONS, EFFECTS, AND INSTRUMENTATION.
  - HOME CLIMATE CONTROL - ENERGY CONSERVATION.
  - IMPROVEMENT OF HOME APPLIANCES - ENERGY CONSERVATION.
  - LARGE NEW COMMERCIAL USES BRAYTON-RANKINE CYCLE HEAT PUMP.
  - LARGE NEW INDUSTRIAL USES.
  - LARGE NEW ON-SITE POWER USES - ORGANIC RANKINE CYCLE TOTAL ENERGY SYSTEM.
  - INDUSTRIAL OPERATIONS - STORAGE, SPILL, AND FIRE HAZARDS ON LIQUID NATURAL GAS.
  - BASIC RESEARCH - NO AND NO_2 FORMATION, FLAME NOISE, TURBULENCE AND CONVECTION RESEARCH, ETC.

4.1 Description of Additional Ongoing Environmental Activities: EPRI

THE ELECTRIC POWER RESEARCH INSTITUTE (EPRI) IS CONCERNED WITH DEVELOPING AN IMPROVED DATA AND ANALYTICAL BASE FOR ASSESSING THE COMPARATIVE ENVIRONMENTAL IMPACTS OF ALTERNATIVE ENERGY TECHNOLOGIES AND SYSTEMS AND THEIR ENVIRONMENTAL POLLUTION CONTROL.

- EPRI IS SUPPORTING EFFORTS IN ALL BERC CATEGORIES
- PRESENT ENVIRONMENTAL IMPACT PROJECTS INCLUDE:
  - COOLING WATER DISCHARGE STUDIES
  - BIOLOGICAL EFFECTS OF EXPOSURE TO HIGH-INTENSITY ELECTRIC FIELDS
  - TRACE ELEMENTS IN URBAN AEROSOLS AND COMBUSTION SYSTEMS
  - INTERACTION OF SULFURIC ACID MIST AND NITROGEN DIOXIDE
  - LARGE POWER PLANT EFFLUENTS AND THEIR INTERACTIONS
  - SO_X DATA BASE
  - DEVELOPMENT OF AN ORGANIC COMBUSTION EFFLUENT SAMPLING SYSTEM
  - MEASUREMENT AND IDENTIFICATION OF SULFATES IN THE ATMOSPHERE
- PRESENT ENVIRONMENTAL POLLUTION CONTROL AND COMBUSTION PROJECTS INCLUDE:
  - ELECTROSTATIC PRECIPITATOR TECHNOLOGY DEVELOPMENT
  - FLUE GAS RECIRCULATION

(Continued)

4.1 Description of Additional Ongoing Environmental Activities: EPRI (Continued)

- CATALYTIC REDUCTION OF NO_X
- SLUDGE DISPOSAL TECHNIQUES

4.2 Intra-ERDA Coordination

THE RAPIDLY DEVELOPING CHARACTER OF ENERGY SUPPLY TECHNOLOGIES AND CONSERVATION REQUIRE THAT THE DBER BPP BE CONTINUALLY REVIEWED AND UPDATED TO ENSURE RELEVANCE AND COMPATIBILITY.

- MANY TECHNOLOGICAL ALTERNATIVES WILL RECEIVE PRELIMINARY SCREENING, INCLUDING A PRELIMINARY ENVIRONMENTAL ASSESSMENT.
- AS ALTERNATIVES ARE SELECTED FOR FURTHER DEVELOPMENT, DEMONSTRATION, ETC., MORE EXTENSIVE AND DETAILED ENVIRONMENTAL RESEARCH EFFORTS MUST BE MOUNTED.
- RESEARCH METHODOLOGIES AND INSTRUMENTATION MUST BE DEVELOPED (OR ADAPTED FROM OTHER STUDIES) FOR EACH TECHNOLOGY UNDER DEVELOPMENT.
- CONTINUING SURVEILLANCE OF DEVELOPING TECHNOLOGIES WILL HELP TO ENSURE THAT A LACK OF HEALTH OR ENVIRONMENTAL DATA DOES NOT LIMIT OR DELAY THE COMMERCIALIZATION OF THE TECHNOLOGY.

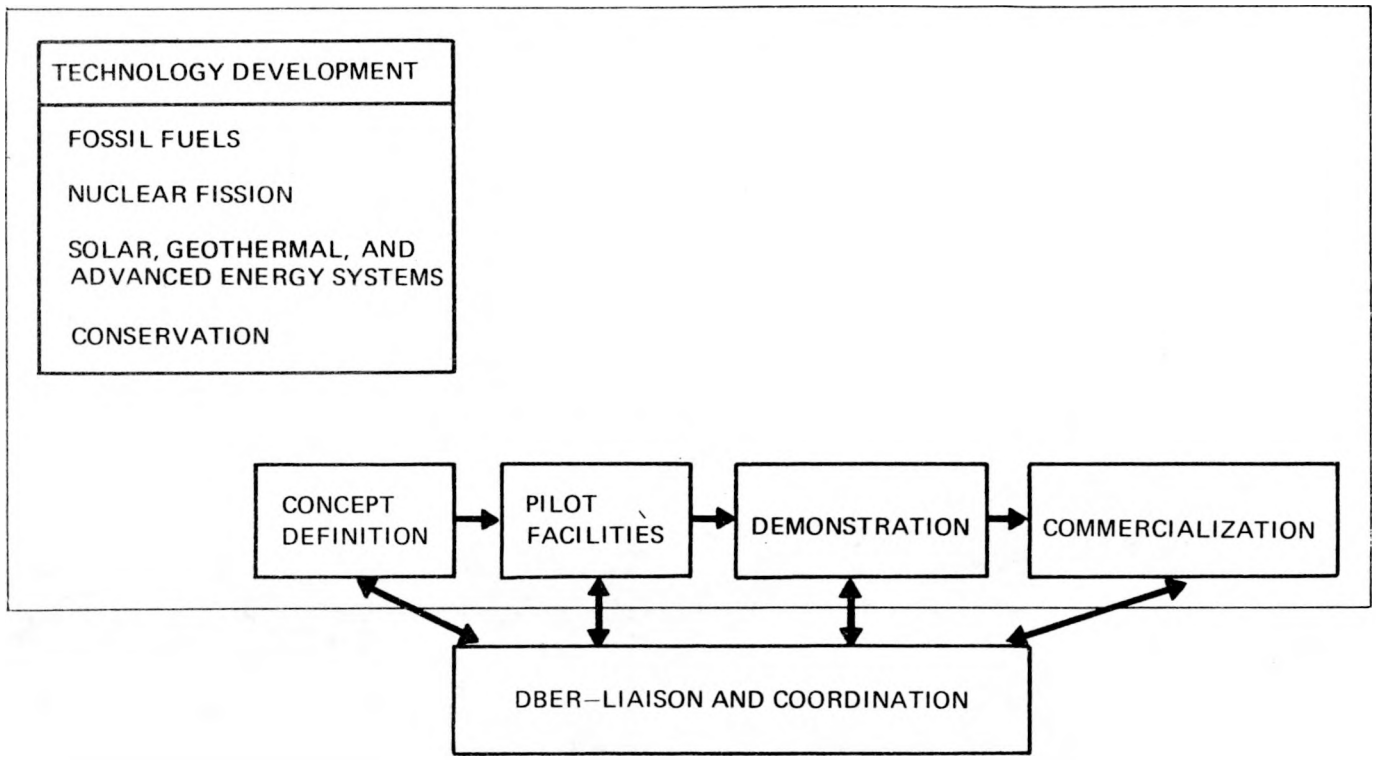


EXHIBIT 66

COORDINATION OF BER PROGRAM WITH TECHNOLOGY DEVELOPMENT. Technologies slated for early commercialization require the rapid collection, analysis, and assessment of environmental effects data.

5.0 FUTURE PLANNING 187

5.1 Health and Environmental data needs of Technologies 188
5.2 Ranking Criteria 192

5.1 Environmental Data Needs of Technologies (a)

TIMELINES AND MILESTONES FOR THE DEVELOPMENT OF ENERGY TECHNOLOGIES (PILOT AND DEMONSTRATION PLANTS) MUST BE SYNTHESIZED IN DETAIL; KEY BIOMEDICAL AND ENVIRONMENTAL DATA NEEDED TO SUPPORT THE MILESTONE MUST BE THEN DEVELOPED.

- ERDA-48 WILL PROVIDE MAJOR INPUT.
- LABORATORY TASK FORCE INPUTS WILL BE USED.
- ERDA DEFINITION STUDIES WILL BE USED (WHERE AVAILABLE) FOR INDIVIDUAL TECHNOLOGIES.
- DISCUSSIONS WITH LABORATORY PERSONNEL AND OTHER BRANCHES OF ERDA WILL BE USED TO DEFINE HEALTH AND ENVIRONMENTAL DATA REQUIREMENTS FOR EACH SUCCESSIVE STAGE IN TECHNOLOGY DEVELOPMENT.

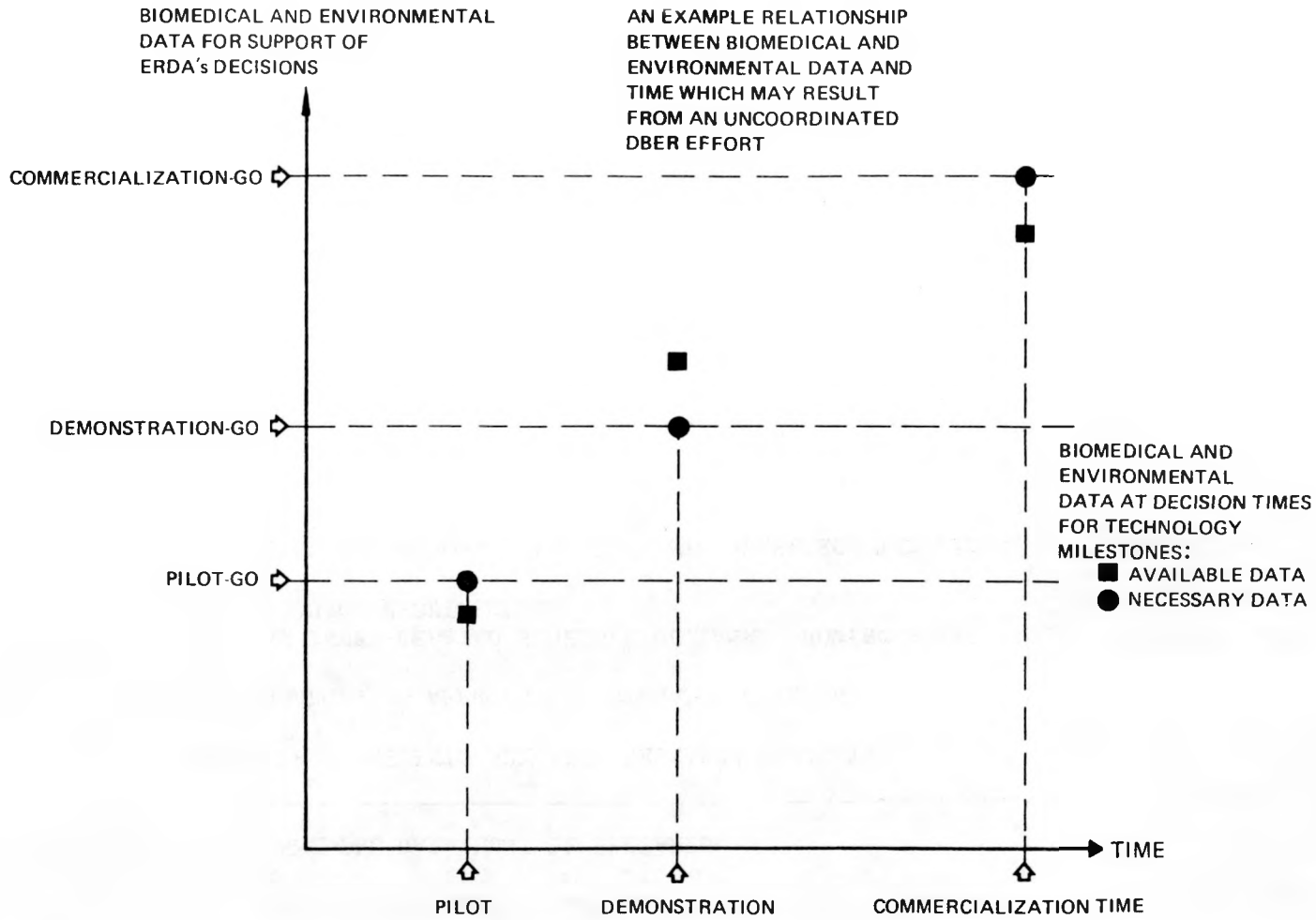


EXHIBIT 67

ENVIRONMENTAL DATA NEEDS FOR TECHNOLOGY DECISIONS. Environmental research programs must be coordinated with specific data requirements arising during the technology development cycle.

5.1 Health and Environmental Data Needs of Technologies (b)

SCIENTIFIC STATEMENTS OF PROBLEMS WHICH REQUIRE SOLUTION IN ORDER TO GENERATE THE NEEDED HEALTH AND ENVIRONMENTAL DATA MUST BE PREPARED.

- BREAK UP PROBLEMS INTO SPECIFIC RESEARCH PROJECTS
- ASSIGN PROJECTS TO APPROPRIATE RESEARCH CATEGORY
- DEVELOP AN INTER-RELATED SCHEDULE OF TASKS SHOWING START DATES, END DATES, AND DOLLAR RESOURCE REQUIREMENTS
- DEPICT TOTAL R&D REPORT - ENVIRONMENTAL RESEARCH TIMELINES, MILESTONES, AND BUDGETS.

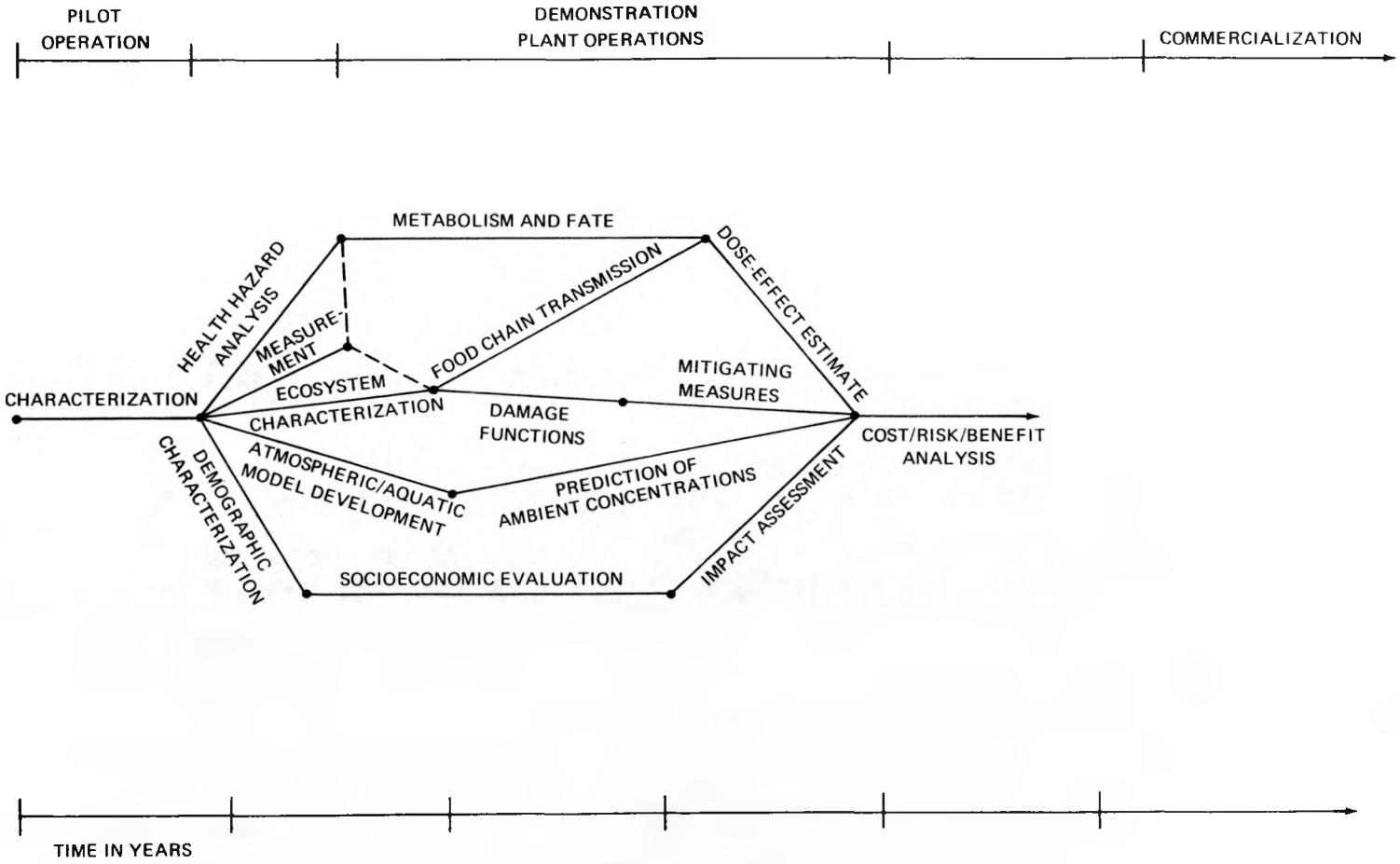


EXHIBIT 68
HEALTH AND ENVIRONMENTAL RESEARCH TASKS RELATED TO SAMPLE TECHNOLOGY DEVELOPMENT CYCLE

5.2 Ranking Criteria

AN OBJECTIVE SET OF PROJECT SELECTION CRITERIA WILL BE DEVELOPED AND USED TO FACILITATE COMMUNICATION AND TO HELP ENSURE PROGRESS TOWARD A BALANCED HEALTH AND ENVIRONMENTAL RESEARCH PROGRAM.

- OBJECTIVE CRITERIA WILL BE DEVELOPED COVERING ENERGY POTENTIAL, ENVIRONMENTAL HAZARDS, EXISTING KNOWLEDGE, AND OTHER FACTORS.
- A FORMAL METHODOLOGY WILL ALLOW THE COMPARISON AND RANKING OF DIVERSE RESEARCH AREAS AND PROJECT SETS.
- THE SELECTION OF AN OPTIMAL RESEARCH PROGRAM FOR ANY BUDGET LEVEL WILL BE AN INTEGRAL ELEMENT OF THE PROJECT RANKING AND SELECTION PROCESSES.
- WITHIN THE FRAMEWORK SUPPLIED BY THE RANKING SCHEME, THE SELECTION OF PROJECTS WILL CONTINUE TO BE BASED ON CONSIDERATIONS OF SCIENTIFIC MERIT.

Criteria	Notes
Fraction of Net Energy Produced by Technology(s) Under Study	Estimates based on current energy production and for selected future years will be required to quantify this criteria.
Capital Investment in Technology(s) Under Study	Current and future investments should be estimated. A quantification of the resource commitments to energy sources is desired.
Human Population Exposed to Pollutant(s) and/or Technology(s)	Total population potentially exposed due to introduction of the technology(s). Estimates required for current situation and future years.
Risk of Human Exposure	Quantitative measure of the effect of exposure: mortality or morbidity per thousand exposed per year.
Ecological Systems Exposed to Pollutant(s) and/or Technology(s)	Extent of possible ecological damage measured in square miles of land or water effect at specific future points in time; modified by geographical location or ecological type.
Risk (Extent) of Potential Ecological Damage	Type of damage anticipated and degree to which recovery is possible. (Requires description and quantification.)
Social (Demographic) Implications of Technology(s)	Number of workers and support personnel required to install and operate technology(s) as an aggregate total and as fraction of existing labor force in geographical areas impacted.

EXHIBIT 69
EXAMPLES OF PROJECT SELECTION CRITERIA