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Leading Trends in Environmental Regulation That Affect Energy Development

Final Report

Published January 1980

U.S. Department of Energy
Division of Environmental Impacts
Office of Technology Impacts

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Flow Resources Corporation
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International Research
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Technology Corporation

August 1979

Prepared for:

U.S. Department of Energy
Division of Environmental Impacts
Office of Technology Impacts
Washington, D.C. 20585

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FOREWORD

The United States is faced with the difficult task of meeting public demands for both environmental quality and reliable sources of energy. As new sources and technologies for energy production are explored and developed, the Office of Technology Impacts, Department of Energy, will be responsible for determining their environmental effects.

The purpose of this study is to identify the most important environmental issues related to Department of Energy supported technologies and programs. Attention is focused on the impacts of future regulatory actions which may affect the implementation of developing technologies.

This study is a continuation of work done by Flow Resources Corporation for the Office of Fossil Energy Programs (DOE): Possible Future Environmental Issues for Fossil Fuel Technologies (July, 1979) under Contract #ET-78-C-01-2880. While the emphasis remains on fossil fuel-based resources and technologies, several others have been considered: nuclear, geothermal, and biomass.

In addition to broadening the scope of the study, this document also contains a quantitative analysis (Chapter 5) of selected issues to determine the economic and environmental effects of postulated regulatory actions.

Robert P. Pikul
General Manager
International Research and
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ACKNOWLEDGEMENT

Professor Gary Widman, Director of the Natural Resources and Environmental Law Program at Hastings College of the Law, University of California, was a consultant to this study. Although not listed as a coauthor, he was a central participant in the study and in the production of this report.

Flow Resources Corporation (FRC) recently consolidated its operations with International Research and Technology Corporation (IR&T) of McLean, Virginia. In the interim, several members of the IR&T staff were responsible for preparing the document for publication. Mark Sussin coordinated the technical review and compilation of the document. Reviewers included: Robert Pikul, Doug Britt, Dexter Hinckley, Richard Meyer and Beverly Williams. Ginger Spence, Fe Palpal-latoc, Libby Butterfield and Sue Hall provided invaluable typing and graphics support.

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GLOSSARY OF ABBREVIATIONS

AQCR - Air Quality Control Region
BAT - Best Available Technology
BACT - Best Available Control Technology
BART - Best Available Retrofit Technology
BATEA - Best Available Technology Economically Achievable
BDCT - Best Demonstrated Control Technology
BPCT - Best Practicable Control Technology
CAA - Clean Air Act
CLA - Coal Leasing Act
CMHSA - Coal Mine Health and Safety Act
CWP - Coal Workers Pnuemoconeosis
EDP - Environmental Development Plan
EIR - Environmental Impact Report
EIS - Environmental Impact Statement
EPA - Environmental Protection Agency
ESECA - Energy Supply and Environmental Coordination Act
FBC - Fluidized Bed Combustion
FMHSA - Federal Mine Health and Safety Act
FWPCA - Federal Water Pollution Control Act
GERDDA - Geothermal Energy Research Development and Demonstration Act
HLW - High Level Waste
ICRP - International Commission on Radiological Protection
LAER - Lowest Achievable Emission Rate
LNG - Liquefied Natural Gas
MHD - Magnetohydrodynamics
MPRSA - Marine Protection Research And Sanctuaries Act
NAAQS - National Ambient Air Quality Standard
NEPA - National Environmental Policy Act
NESHAPs - National Emission Standards for Hazardous Air Pollutants
NGPSA - Natural Gas Pipeline Safety Act
NIOSH - National Institute of Occupational Safety and Health
NPDES - National Pollutant Discharge Elimination System
NRC - Nuclear Regulatory Commission
NSPS - New Source Performance Standards

OCS	-	Outer Continental Shelf
OSHA	-	Occupational Safety and Health Act
PAH	-	Polycyclic Aromatic Hydrocarbon
PAN	-	Peroxyacetyl Nitrate
POM	-	Polycyclic Organic Matter
PSD	-	Prevention of Significant Deterioration
RACT	-	Reasonably Available Control Technology
RCRA	-	Resource Conservation and Recovery Act
SDWA	-	Safe Drinking Water Act
SIP	-	State Implementation Plan
SMCRA	-	Surface Mining Control and Reclamation Act
TSCA	-	Toxic Substances Control Act
TSD	-	Treatment, Storage and Disposal
TSP	-	Total Suspended Particulates
TWA	-	Time-Weighted Average
UMTRCA	-	Uranium Mill Tailing Radiation Control Act
WRPA	-	Water Resources Planning Act

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TABLE S-1. MAJOR ENVIRONMENTAL ISSUES

1.	Disposal of solid waste from conventional coal combustion and conversion technologies
2.	Water supply for by coal and oil shale conversion technologies
3.	Siting of coal conversion facilities
4.	The carbon dioxide greenhouse effect
5.	Emission of polycyclic organic matter (POM)
6.	Impacts of outer continental shelf (OCS) oil development
7.	Emission of trace elements
8.	Groundwater contamination
9.	Liquefied natural gas (LNG)
10.	Underground coal mining
11.	Fugitive emissions from coal gasification and liquefaction
12.	Boomtown effects
13.	Emission of fine particulates from coal, oil, and oil shale technologies
14.	Emission of radioactivity from the mining and conversion of coal
15.	Emission of nitrogen oxides
16.	Land disturbance from surface mining
17.	Effluent from geothermal facilities
18.	Nuclear waste disposal
19.	Environmental impacts of biomass energy production and conversion
20.	The nuclear fuel cycle

Results

The 20 environmental issues listed in Table S-1 are identified as those most likely for future regulatory actions that may significantly impact the implementation of energy technologies. The main features of, and the possible regulatory actions associated with, each of the 20 issues are as follows:

1. Disposal of Solid Waste from Conventional Coal Combustion and Conversion Technologies. The use of coal creates large quantities of solid wastes consisting of ash, tars, chars, slag, scrubber sludge, spent catalysts, fluidized bed media, and biological treatment sludge. Solid wastes can be disposed of directly back into the mine, into ponds, or into landfill sites with impermeable linings such as clay. Of major concern is the penetration of leachates into aquifers or surface waters via runoff. Because of the toxic nature of some of the components (trace metals, polycyclic organics, cyanides, etc.), the disposal of this material may pose a problem for siting and operation of facilities. Present regulations governing the disposal of hazardous materials will probably be extended to include coal conversion wastes. In addition, new regulations applying specifically to these wastes could place restrictions on: the concentration of toxic material in the waste; the method of handling and disposal; the choice of disposal sites; and the amount of leaching from the waste into ground water supply. Additional new regulations may require: the use of resource recovery technologies that simultaneously render solid waste innocuous; detailed guidelines for, and evaluation of, solid waste disposal sites; multimedia modeling of exposure; and the use of techiques to reduce leachability of toxic substances in solid waste.

2. Water Supply for Coal and Oil Shale Conversion Technologies. The supply of water for fossil energy conversion will be a major issue in resource-rich areas

located in arid or semi-arid parts of the country in which there will be competing demands for water from agriculture, municipalities and industry. In addition, there will be limitations placed on withdrawals from rivers and streams in many states in order to protect the aquatic environment and to ensure the quality of water for downstream uses. Further regulatory action affecting water supply probably will originate at the state level and could include: limitations on withdrawal to protect the aquatic environment; restrictions on withdrawal for certain purposes such as evaporative cooling; development of a comprehensive system for groundwater allocation; new definitions of priority for water rights allocation, possibly restricting indirect uses; and a requirement to use recycled municipal, irrigation, and industrial wastewaters.

3. Siting of Coal Conversion Facilities. This issue arises from a host of regulations, physical factors, and public attitudes. These can combine in a way that may severely limit the siting of coal conversion facilities and, in turn, inhibit the implementation of new conversion technologies. A number of current federal regulations affect siting indirectly by effectively prohibiting activities in certain areas (e.g., prevention of significant deterioration (PSD) areas defined in the 1977 Clean Air Act Amendments). In addition, many states will develop policies toward energy facility siting which, in connection with federal restrictions, will lead to more limitations on the siting of facilities. There could be state and federal guidelines developed for cost/benefit analysis requirements and procedures.

4. The Carbon Dioxide Greenhouse Effect. Fossil fuel combustion necessarily results in the atmospheric release of carbon dioxide (CO_2). The ambient CO_2 concentration has been increasing throughout the troposphere. This increase

may cause climatic changes by affecting the surface temperature of the earth. Possible actions include requiring: more efficient use of fossil fuels; re-establishment of forests in order to balance CO_2 "sinks" and "sources" to previous levels; limitation of the use of coal combustion/ conversion as a source of energy; increased emphasis on alternatives to fossil fuels in the National Environmental Policy Act (NEPA) process; and international agreements on long-range energy policy and goals (i.e., global controls or "levies" on fossil fuel use to offset predicted long-term climatic impacts).

5. Emission of Polycyclic Organic Matter (POM). The emission of polycyclic organic matter (POM) resulting from the production, processing, storage, transportation, and combustion of fossil fuels will continue to be among the most important environmental issues affecting future energy technologies. The difficulty in quantifying the various constituents of POM qualifies it as a candidate for further research and regulatory development. Future regulatory action to protect the air, water, land, and human health may include: imposing national emission standards for hazardous air pollutants (NESHAPS), new source performance standards (NSPS), national ambient air quality standards (NAAQS), and PSD; restriction on forms of syncrude end use; restriction on mobile source emissions of POM; imposition of effluent guidelines, based on the best available technology economically achievable (BATEA) via the national pollutant discharge elimination system (NPDES); Occupational Safety and Health Act (OSHA) standards for workplace concentrations of POM; Toxic Substances Control Act (TSCA) regulations for commercial use of by-products containing POM; Resource Conservation and Recovery Act (RCRA) classification for disposal of solid waste containing POM; and the requirement of combustion efficiency to achieve minimum emission of POM.

6. Impacts of Outer Continental Shelf (OCS) Oil Development. Four concerns have been identified regarding OCS development: water/oil contamination, air pollution (NO_x, SO_x and hydrocarbons), aesthetics, and the need for onshore facilities. Acquisition of OCS leases will necessitate preventive measures aimed at managing these four concerns. Possible future actions include: federal and state guidelines on public participation and cost/benefit analysis; increased emphasis on the NEPA process involving indirect effects (onshore developments) as well as alternatives identification; and preparedness requirements for emergency measures.

7. Emission of Trace Elements. Trace elements are associated with most energy technologies and are found in the products as well as all solid, liquid, and gaseous waste streams. The increasing use of coal will magnify the problem. Long-term, low-level exposure to man and his surroundings of these trace elements will have uncertain human health and other environmental effects. Possible future actions include: imposing emission and ambient air standards (NESHAPS, NAAQS, NSPS, and PSD) for certain trace elements; promulgating ambient water standards and effluent guidelines (BATEA) under the Federal Water Pollution Control Act (FWPCA); establishing hazardous waste disposal criteria under RCRA; and specification of concentration limits in surface and ground waters under the Safe Drinking Water Act (SDWA).

8. Groundwater Contamination. Groundwater contamination through deepwell injection, solid waste leaching, and *in situ* coal and shale processing will be of increasing concern in regard to toxic organic and inorganic chemicals. Toxic substances (including salts), injected or leached to aquifers, may greatly affect public drinking water quality

and surface water uses. The rapid commercialization of in situ coal gasification and in situ and surface oil shale retorting depends upon a better understanding of these technologies and their effects on groundwater and subsequent surface water contamination. Future regulatory action may include: stringent effluent standards; water allocation regulations designed to safeguard groundwater for uses deemed more beneficial than fossil fuel recovery; strict disposal practices under RCRA; applying drinking water standards to groundwater; and special techniques for isolating in situ locations from surrounding aquifers.

9. Liquefied Natural Gas (LNG). An increase in the importation of LNG will result in extensive controversy regarding the human health and safety and other environmental effects of terminal siting and regasification facilities. The National Energy Plan and regional energy needs will dictate whether LNG imports increase, and thus, will aid in determining the need for (LNG) facilities. Future regulatory action could affect LNG imports, as well as siting, design, construction, and operation of LNG transportation, storage and regasification facilities. Guidelines on LNG siting procedures can be expected on both the federal and state levels.

10. Underground Coal Mining. Underground coal mining has been called the most hazardous occupation in the U.S. The health and safety problems of the occupation are a result of roof cave-ins, explosions and fires from coal dust and methane gas generated in the mines, and exposure of workers to coal dust which may result in coal workers pneumoconeosis (CWP) or black lung disease. Future regulatory action concerning deep coal mining may involve improved health and safety protection in mines; including expensive technological solutions to health problems and much more stringent standards for respirable coal dust in mine atmospheres.

The impact of these actions will be increased coal costs, delays in expanding underground coal supplies, and bias towards development of coal supplies that can be surface mined.

11. Fugitive Emissions From Coal Gasification and Liquefaction. Gaseous emissions or leaks may occur from coal gasification and liquefaction plants because of the high temperatures and pressures used in the processes. Emissions from both processes are similar and may include numerous sulfur and nitrogen compounds, trace elements, and aliphatic and aromatic hydrocarbons. The main concern at present is over potential carcinogens which may be emitted from the plants. Synergisms and other undetermined effects of the various compounds emitted are also of concern. Future regulations of emissions from coal conversion plants are likely to be: emission standards or exposure limits for compounds not currently regulated; more stringent standards for currently regulated compounds; standards for carcinogens (perhaps zero emissions for some); and stringent application of best available control technology (BACT). Employee unions will probably demand greater health and safety protection, improved work practices, and higher pay for workers in coal conversion plants.

12. Boomtown Effects. Increased development of fossil energy technologies in the near and long term may cause large socioeconomic impacts in communities where energy facilities locate. Rapid growth resulting from these developments is likely to cause local housing shortages, unemployment, and burdens on community services (such as law enforcement, medical care, schools, and utilities). Areas which will be affected by boomtown developments are: coastal zones, because of offshore oil and gas projects; and Rocky Mountain, Northern Great Plains, and Appalachian states, because of their large coal and oil shale reserves. Concern

over preservation of coastal environments and undeveloped "frontier" areas in western states may prompt enactment of states to enact legislation imposing siting or other restrictions on energy projects. Programs aimed at improving the quality-of-life aspects of boomtowns also may be developed under pressure from employee unions and environmentalists. State laws and local ordinances may be established to maintain stable growth. Guidelines on revenue sharing and subsidies might be promulgated on the federal level.

13. Emission of Fine Particulates From Coal, Oil, and Oil Shale Technologies. The total atmospheric loading of fine particulates results from emissions of primary fine particulates from natural and other sources (including coal, oil, and oil shale technologies) and from the secondary fine particulates formed from chemical reactions in the atmosphere between other particulates and/or gases (e.g., SO_2, NO_x, hydrocarbons). The category of fine particulates includes a wide range of particle sizes. The impacts of fine particulates depend on the size and chemical nature of the compounds, which may cause both human health and other environmental problems. Future regulation of fine particulates will possibly include NAAQS and NESHAPS, for specific size and species of fine particulates; and NSPS, controlling conversion plant emissions of cationic species and other pollutants (SO_2, NO_x) that participate in the formation of secondary particulates.

14. Emission of Radioactivity From the Mining and Conversion of Coal. Radioactivity in coal stems primarily from the natural decay series of radionuclides 238U and 232Th. Concentrations of these radionuclides vary widely from the national average of 1.8 ppm uranium and 4.7 ppm thorium.

Biological exposure to ionizing radioactivity induces carcinogenic and mutagenic responses. Major potential regulatory candidates involve: the emissions of 222Rn (in underground mining, passthrough to gasification product gas, and emanation into air from solid waste disposal); stack emissions of alpha-emitting fine particulates; and surface and ground water contamination from runoff and solid waste disposal. The current regulations on air emissions and ambient air standards (NESHAPS, NAAQS, NSPS, and PSD), solid wastes (RCRA), groundwater, surface water, and drinking water (FWPCA, SDWA) are expected to be broadened to incorporate radioactive emissions. Modeling techniques may be required in the federal and state guidelines.

15. Emission of Nitrogen Oxides. Fossil fuel combustion is the major source of anthropogenic nitrogen oxide emission. NO_x plays an important role in the formation of photochemical oxidants. These oxidants may react with NO_x, SO_x, and organic compounds to form secondary fine aerosols which cause visibility reduction, human health hazards, damages to vegetation and material, acid precipitation, and the formation of nitrosamines. Possible future regulations may include: NAAQS for toxic NO_x species, emitted or secondary; NSPS or NESHAPS for toxic NO_x species or NSPS for emitted precursors of secondary toxics; regulation on location of NO_x sources; and PSD regulations based upon reactive aerochemistry.

16. Land Disturbance From Surface Mining. The principal environmental concerns associated with large-scale surface mining are: maintaining original topography and high quality of water supply; preserving local ecology and agricultural productivity. Possible future regulations may include: requirements for more efficient recovery of coal;

stringent requirements for landscape restoration and special placement of overburden; and effluent standards for acid mine drainage.

17. Effluent from Geothermal Facilities. There are five major categories that encompass geothermal resources. These include: dry steam field (vapor-dominated systems); wet- or hot-water field (liquid-dominated systems); geopressured resources; impermeable dry rock; and magna systems. Geothermal fluids withdrawn from the earth contain a variety of noxious substances which, unless carefully controlled, may be rejected into adjacent bodies of water or the atmosphere. The major issue concerns the safe disposal of these noxious substances. Future regulatory action may include: effluent guidelines, including National Standards of Performance under FWPCA; water quality standards, applicable to receiving waters under FWPCA; groundwater protection regulations under the SDWA; regulations applicable to subsurface brine and sludge impoundments at geothermal facilities, under RCRA; and NSPS, for H_2S under the CAA.

18. Nuclear Waste Disposal. One of the most controversial issues associated with the implementation of nuclear power concerns the method of nuclear waste (high-level and transuranic wastes generated at various stages of the nuclear fuel cycle). Various methods have been discussed, including disosal in: the ocean, polar ice, the desert, salt beds, granite, shale, and clay. Burial in salt beds is currently the most popular alternative. Possible future action includes the establishment of specific numerical standards applicable to waste classes. Specific standards may be developed for the following waste classes: high level waste; transuranic waste (in stable and other forms);

inactive uranium mill tailings; residual activity associated with decommissioning; and active uranium mills.

19. Environmental Impacts of Biomass Energy Production and Conversion. Conversion of biomass is one of five major approaches for utilizing solar energy. It is also the solar technology likely to have the greatest environmental impact. The major source for production and conversion of biomass is from photosynthetic species of terrestrial and marine plant life. Energy from the sun is utilized by these organisms to transform elements of the air, water, and soil in complex organic compounds. The conversion processes which utilize biomass (from both plant and animal sources) are: thermochemical (pyrolysis, producer gas generation, hydrogeneration, and hydrogasification); direct combustion; bioconversion systems (anaerobic digestion and fermentation); and direct hydrogen production. Future legislation that may have an impact on energy from biomass includes: CAA, specifically NSPS; FWPCA, specifically NPDES; RCRA, specifically the hazardous waste section; TSCA, with respect to the by-products of combustion and pyrolysis; OSHA, including proposed standards for hydrogen sulfide and ammonia.

20. The Nuclear Fuel Cycle. Health risks arise at all stages of the nuclear fuel cycle, from uranium mining to plant decommissioning. Proper assessment of these risks involves an analysis of occupational accident rates, radiation exposure for workers and population under normal operating conditions, and the probabilities and consequences of reactor accidents to public health. Possible future regulations include promulgating ambient air/emission standards for the various radionuclides, and lowering the allowable human exposure to low-level radiation.

Discussion

This detailed environmental review of key energy technologies contemplated for development and application between now and the year 2000 identifies specific technology targets and critical candidates for future regulatory action. The 20 major environmental issues that were summarized here display several aspects that are of interest.

First, these issues span most energy technologies; they represent a broad approach to the future. Even so, it is clear that these issues are focused upon the coal combustion and synfuels (coal and oil shale) technologies.

Second, these issues span a set of generic environmental goals identified by the policy and regulatory survey: long-term protection of climate, water availability and quality, most beneficial land use, human health and pristine environments.

Third, most of these issues represent departures from the classical environmental issues which have received the attention of public and regulatory bodies in the past. For example, the CO_2 greenhouse effect and fine particulates are explored, as opposed to total suspended particulates; groundwater, as opposed to surface water; water allocation, as well as quality; effective attention to solid waste disposal (rather than an air/water emphasis); and attention to carcinogens and toxics in all media (POM and trace elements as opposed to the classic air and water pollutants). Further, many of these issues differ from classic environmental analyses in that they are truly multimedia in nature; such as trace elements and POM released to land, air, and water.

Fourth, the solutions to many of these issues will tend to be in conflict with the solutions of others. For example: health effects of deep mining can be reduced by turning to surface mining (which, in turn, exacerbates the problems of water availability, groundwater quality, land use, trace elements, and pristine environments in the West); similarly, stringent controls on OCS development or LNG facilitites will lead to exacerbation of the above coal-related problems. The important point is that these issues represent a connected whole, within which there will be many antagonistic as well as cooperative interactions in solving specific issues.

Fifth and finally, unlike the classic issue where the public could see a polluted stream and demand it be cleaned up, the level of controversy and resolution of controversy are directly related to state of knowledge and research. For example, knowledge of potential climatic effects largely results from research published in the last 5 years. Intensity of debate, appraisals of the seriousness of the CO_2 issue and proposals for its resolution all depend on work in progress. The same applies to toxics, trace metals, NO_x, groundwater quality, and low-level radiation.

Possible forms of regulatory action have been discussed for each of the 20 major issues. The specific regulations eventually implemented will depend upon certain, as yet unspecified, variables. These include:

- Geographic location of technology.
- Scale of technology application.
- Economic circumstances nationally and worldwide.
- Public attitudes on conservation, environment and lifestyle.
- Level of research and knowledge on the seriousness of the problem, and on potential solutions.
- National trade-offs on basic aspects of energy development, such as health effects versus ecological effects.
- Implementation of existing laws and regulations.

These future regulatory actions can be at federal and state levels and can take several forms, including: air, water, and land ambient standards; air, water, and solid waste emission standards and handling guidelines; siting requirements for facilities and disposal sites; occupational health and safety guidelines; restrictions on water use for certain purposes, depending upon locale and competing beneficial uses; and restrictions upon the overall magnitude of fuels consumption. The trend is generally toward greater stringency and complexity, and may be accompanied by the following developments:

- Comprehensive multi-pollutant, multi-media and even regional regulatory packages for each major energy technology.
- Broadening of the conservation issue to include water and land resources, as well as energy; in particular, restrictive allocation of water to achieve the most beneficial use.
- National level mechanisms for balancing and distributing the costs and benefits of energy development (e.g., balancing the occupational health risks of deep mining versus the ecological hazards of surface mining).
- International programs to manage the long-term impacts of fossil fuel use, such as the CO_2 greenhouse effect.

The overall implications of the issues suggest that the energy-environment conflicts of the future will differ from the past in that:

- The arguments will be more sophisticated on all sides. There will be greater reliance on current research data, which will be watched more closely than in the past. There will be greater use of projections of long-range effects.
- There will be greater stress on agency decisions, balancing benefits and costs in disparate areas of interest; and there will be a premium on legislation and agency decisions rationally supported by recognition of widely disparate benefits and costs.
- Many problems may not be amenable to a "quick fix." If CO_2 comes from both damaged cuttings in forests and fossil energy combustion, the legislated solution may, nevertheless, require restricted use of fossil resources.

In general, this analysis suggests several major responses by the Department of Energy:

(1) More forward-looking research that attempts to obtain pertinent data on environmental effects further in advance, both to ensure

that national debates are informed by accurate data and to develop solutions for problems, insofar as possible.

(2) Greater use of forecasting of cumulative effects of planned energy activities and their effects in combination with other predicted activities in the world.

(3) Greater attention to agency decision methodologies that ensure that nonenergy values impacted by a decision are understood and effectively considered from the earliest stage of planning.

It is in the face of possible developments such as these, and in the context of the impact of extant laws and regulations, that the impact of possible future environmental regulations upon all energy technologies should be evaluated.

The following two tables briefly summarize the major findings of this report. Table S-2 highlights the discussion of the 20 environmental issues presented here. Table S-3 highlights the quantitative analysis conducted for selected issues utilizing the Strategic Environmental Assessment System (SEAS). These tables are intended to provide the reader with a quick reference capability for the various issues discussed.

TABLE S-2 HIGHLIGHTS OF ISSUE ANALYSIS

ISSUE	ISSUE DESCRIPTION	PROBABLE SOLUTIONS	LEGISLATIVE/REGULATORY BACKGROUND	POSSIBLE FUTURE REGULATORY ACTION	TIME FRAME FOR FUTURE REGULATORY ACTION
1. Disposal of solid waste from conventional coal combustion and conversion technologies. See pages 69-78.	• Coal conversion will generate large quantities of solid waste. • These wastes are likely to be classified hazardous by EPA.	• Return waste to mines. • Dispose of waste in lined ponds.	• SWDA of 1965 • FWPCA of 1972 • RCRA of 1976 • SMCRA of 1977 • Few if any states have regulated coal wastes.	• Federal air and water pollution standards. • Land use plans adopted at the state level.	• Some coal conversion waste should come under hazardous wastes regulation by 1985.
2. Water supply for coal and oil shale conversion technologies. See pages 78-86.	• Resource rich areas located in arid regions. • Competing demands from agriculture, municipality, industry and in-stream users.	• Reduce water consumption. • Site facilities closer to water resources.	• East vs West water laws. • WRPA of 1964. • President's Water Policy of 1978.	• State actions define instream flow, establish user priorities, restrict evaporative cooling. • SDWA regulation of groundwater.	• West states act by 1985 with increased pressure from interest groups.
3. Siting of coal conversion facilities. See pages 87-91.	• Associated with hazardous air, water and land pollution. • Few states in primary resource area.	• Emissions controls. • Reduce production.	• No direct federal regulation of siting though many indirect laws. • State and local zoning are prevalent.	• Affected states are establishing policies to minimize environmental impacts. • Potential federal legislation.	• Siting problems and regulations are likely to occur before 1985.
4. The carbon dioxide greenhouse effect. See pages 91-96.	• Fossil fuel combustion releases large amounts of carbon dioxide, causing climatic changes.	• Increase the earth's biomass (photosynthetic). • Reduce CO_2 releases through less fossil fuel combustion.	• No regulations by federal or state. • National Climate Bill (1978).	• Limit fossil fuel technologies. • Actions will depend on results of current study.	• No regulation until notice effects by 2000.
5. Emission of polycylic organic matter (POM). See pages 96-10.	• Carcinogenic substances released from fossil fuels production.	• Control technology for mobile and stationary sources.	• CAA of 1970 as amended. • OSHA of 1970. • SDWA of 1974, as amended. • RCRA of 1976. • TSCA of 1976.	• Federal air and water regulations (including NSPS, NESHAP's, PSD, BATEA, NPDES).	• Good chance of regulation by 1990; though RCRA standards should apply by 1985.
6. Impacts of outer continental shelf (OCS) oil development. See pages 101-107.	• Air, land and water hazards exist. • Accidents (blowout). • Aesthetics. • Aquatic toxicity.	• Control technologies. • Safety practices. • Advanced planning. • Reduce production.	• OCS of 1953 as amended. • FWPCA of 1972 as amended. • CZMA 1972. • MPRSA of 1972 as amended.	• BLM leasing policies. • NEPA process.	• Potential for more stringent BLM regulation.
7. Emission of trace elements. See pages 107-118.	• Toxic trace elements emitted from fossil fuel technologies to land, air and water.	• Control technologies. • Pre-treatment methods. • Reduce production.	• CAA of 1970 as amended. • RCRA of 1976. • TSCA of 1976. • SMCRA of 1977. • State standards often exceed federal.	• OSHA, NESHAP's, FWPCA, SDWA, TSCA. • State regulations.	• Most regulatory actions should be effective by 1985.
8. Groundwater contamination. See pages 118-124.	• Public drinking water pollution. • Degrading regional water systems.	• Increased study and monitoring effluents. • Higher recovery efficiency. • Erosion control. • GAC filtration.	• SDWA of 1974. • FWPCA of 1977. • RCRA of 1976. • State regulations are weak.	• Federal drinking water standards should regulate ground water.	• Regulations to control trace elements and organics by 1985. • New legislation by 1990.
9. Liquified natural gas (LNG). See pages 124-129.	• Major fire and explosion hazards on water. • Air pollution from regasification plants.	• Scheduling ship traffic. • Alternative vaporization processes. • Recirculate natural vapor loss.	• No specific laws or regulations. • PWSA of 1972. • CZMA of 1972. • DOE Organic Act 1977. • NGPSA of 1976. • Coastal state law.	• LNG Safety and Siting Act.	• Federal action is expected in 1980. • State laws are expected soon.
10. Underground coal mining. See pages 129-134.	• Occupational hazards, health and safety.	• Dust control and ventilation. • Respirators. • Workplace safety.	• FMHSA of 1977. • OSHA of 1970. • State laws.	• 1977 interim standards followed by stricter ones. • State laws.	• Action on new standards unlikely before 1985, but by 1990.
11. Fugitive emissions from coal gasification and liquefaction. See pages 135-145.	• Occupational hazards, health and safety.	• Continuous monitoring. • Wasteplace safety. • Industrial hygiene programs.	• OSHA of 1970. • NIOSH • CAA of 1977.	• TWA standards. • LAER applied. • Zero emissions.	• Doubtful activity before 1985.
12. Boomtown effects. See pages 145-152.	• Socioeconomic breakdown. • Aesthetic impacts. • Benefits only in the long run.	• Advanced planning. • New towns. • Reduce pace of development.	• No federal laws to date. • Western state laws.	• Western Governor's Regional Energy Policy Office. • Future federal and state legislation and loan guarantees.	• State action by 1990.
13. Emission of fine particulate from coal, oil, and oil shale technologies. See pages 152-160.	• Weather modification. • Health effects. • Ecological effects.	• Control technology. • Reduce production.	• CAA of 1977. • OSHA of 1970. • FMSHA of 1977. • State standards are often more stringent than federal.	• NAAQS, NESHAP's, NSPS result from study findings.	• NAAQS review every 5 years. • Secondary fine particulate standards by 1985.
14. Emission of radioactivity from the mining and conversion of coal. See pages 160-169.	• Carcinogens with no threshold level. • Mutagenic effects. • Air, land and water contamination. • Worker health and safety.	• Ventilation. • Control technologies.	• CAA of 1977. • NRC regulations. • SDWA of 1974. • State water regulations. • Few regulate air emissions.	• Regulations under RCRA, CAA, SDWA. • State controls.	• NESHAP's by 1985.
15. Emission of nitrogen oxides. See pages 169-176.	• Fossil fuel combustion by all sources leads to photochemical effects (smog) and acid precipitation.	• Control technology. • Reduce production.	• CAA of 1977. • LAER	• Federal regulations (including NAAQS, NSPS, PSD, BACT).	• Regulations by 1990.
16. Land disturbances from surface mining. See pages 176-181.	• Water quality and land preservation.	• Proper land reclamation. • Hydrologic surveys. • Revegetation to prevent runoff and restore wildlife.	• CMHSA of 1967. • ESECA of 1974. • FWPCA of 1977. • RCRA of 1976. • CLA of 1976. • NEPA of 1969. • SMCRA of 1977. • 38 state laws.	• Extension of federal law. • State laws become more stringent.	• Most activity will be after 1985.
17. Effluents from geothermal facilities. See pages 182-201.	• Air, land and water pollution. • Disposal of toxic and noxious substances.	• Reinject into wells. • Control technology. • Reduce production.	• NEPA • SDWA • FWPCA • GERDDA of 1974. • State laws.	• Federal regulations. • State and local regulations.	• Regulatory framework established by 1990, regulations beyond 1990.
18. Nuclear waste disposal. See pages 201-217.	• Sabotage. • Health and safety. • Long term effects. • Ground water contamination.	• Control technologies. • Reduce production. • Solidification and burial. • Reprocessing waste.	• ERA of 1974. • AEC of 1954. • UMTRCA 1978. • DOE Organic Act 1977.	• Federal activity in this area will continue. • State action is beginning.	• All actions should be taken before 1985.
19. Biomass production and conversion. See pages 217-229.	• Most significant impacts of solar energy alternatives. • Air, land and water impacts.	• Control technology. • No-till farming. • Sludge as fertilizer.	• FWPCA of 1977. • GERDDA of 1974. • NEPA • Few acts specifically mention biomass technology.	• Federal regulations. • State and local regulations.	• No promulgation of standards before 1985.
20. The nuclear fuel cycle. See pages 229-242.	• Occupational and public health and safety.	• Mine improvements. • Reprocessing.	• OSHA of 1970. • NRC regulations. • AEC of 1954. • CAA of 1977.	• Federal regulations on operational safety of power plants and low level radiation exposure.	• Such standards should be in place by 1985.

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TABLE S-3 HIGHLIGHTS OF SEAS ANALYSIS

ISSUE	DESCRIPTION	ABATEMENT COST	RESIDUALS GENERATION
1. Disposal of solid waste from coal technologies. See pages 246-248.	• Maximum Impact Case EPA designates all waste hazardous. • Intermediate Impact Case EPA designates some wastes hazardous.	• Maximum - 10 billion dollars will be spent by the year 2000 for disposal of coal wastes. • Intermediate - 5 billion dollars by 2000 for coal waste disposal disposal.	• More than 375 million tons of solid waste are generated by 2000. • More than 95% of this waste is from conventional coal.
2. Fine particulate emissions from coal combustion. See pages 248-253.	• Control technologies for coal fired electric utilities. • Future regulations may require up to 99.8% removal efficiency.	• Fabric filters are more costly to maintain than electrostatic precipitators (ESP's). o Western control costs will be greater than Eastern by 2000.	• Fabric filters remove considerable more fine particulates than ESPs. • Fabric filters are especially effective on western coal (i.e. high resistivity fly ash).
3. Trace element emissions from coal combustion. See pages 253-257.	• Level of control varies widely among trace elements. • By 1985, regulations may require fabric filters for trace element control.	• Abatement cost using fabric filters will be over $1 billion by 2000.	• By the year 2000 over 17000 tons of trace elements will still escape BAT control technology.
4. NO_x emissions from coal combustion. See pages 257-261.	• NSPS regulates coal-fired utilities for various coal types. • Future regulations may force the adoption of more effective and expensive controls.	• By 2000 almost $2 billion will be spent on NO_x controls.	• Over 1000 tons of net H_2S residual are generated by 2000.
5. Treatment of Geothermal Effluents. See pages 261-264.	• Hot water and hydrogen sulfide are the main pollutants from this energy technology. • Reinjection into the producing zone is the likely solution.	• Cost of 99% control by 2000 will be over $100 million.	• Over 1000 tons of net residual are generated by 2000.
6. Disposal of nuclear wastes. See pages 264-266.	• Uranium mining contributes more radioactivity than any other part of the nuclear fuel cycle.	• By 2000 it will cost an additional $100 million to produce electricity with control of uranium mine tailings.	• By 2000, about 75% of the radioactivity generated by uranium milling will be controlled.
7. Waste from biomass conversion. See pages 266-269.	• Wood fired utility boilers may be regulated to 99% of their residuals by 1980.	• By 2000, control costs will exceed $75 million.	• Net residuals after 99% control will be 900 tons by 2000.

1. INTRODUCTION

The work reported here was carried out for the Department of Energy to identify and assess major environmental issues that are likely to affect the implementation of energy technologies between now and the year 2000. The energy technologies specifically addressed are: oil recovery and processing; gas recovery and processing; coal liquefaction; coal gasification (surface); in situ coal gasification; direct coal combustion; advanced power systems; magnetohydrodynamics; surface oil shale retorting; true and modified in situ oil shale retorting; geothermal energy; biomass energy conversion; and nuclear power (fission). Environmental analysis of these technologies included, in addition to the main processing steps, the complete fuel cycle from resource extraction to end use.

To be as comprehensive as possible in identifying future environmental issues, the project team considered it important, in addition to carrying out an analysis of the technologies, to obtain a wide range of opinion from the environmental community. This was done by surveying environmental groups, researchers, and federal and state regulatory agencies. This survey was helpful in narrowing the several hundred issues identified in the technical analysis to a more manageable number. This reduced set of issues was further narrowed to a list of 20 by the Flow Resources Corporation (FRC) project staff, using a panel system. This system also solicited a wide range of viewpoints, with panel members' expertise ranging from environmental law to engineering.

The final list of 20 issues is by no means complete, nor is it unique. However, it does have several important features. First of all, each issue on the list has at least some consensus within the environmental community that it is an important problem area that must be dealt with. Secondly, each issue has been identified as a likely candidate for future regulatory action, based on either existing legislation or likely future legislation. Finally, each issue deals with a major environmental aspect of future energy development.

The following chapters contain: descriptions of the methods used for identifying candidate issues and selecting the final list of 20 issues; analyses of the major issues, including their regulatory status and the implications of future regulations; an assessment of the impact of future regulations on energy costs and nationwide emissions of pollutants; and finally a discussion of the impacts of environmental regulatory activities on the implementation of energy technologies. The appendices contain a breakdown of the fuel cycles associated with each technology into modules and submodules, a list of candidate issues generated by an environmental analysis of the technologies, and a discussion of the emission and location requirements resulting from the Clean Air Act Amendments of 1977.

One of the outstanding features of this report is the determination of economic and environmental effects of various energy technologies under future regulatory controls. The quantitative analysis in Chapter 5 was accomplished in part by using the Strategic Environmental Assessment System (SEAS).

This document is designed to assist DOE personnel who are planning the research, development, demonstration and commercialization of energy technologies by providing an awareness of the important future environmental issues associated with these technologies, and by indicating where advanced planning will facilitate compliance with environmental regulations as well as help mitigate some of the major impacts.

2. IDENTIFICATION OF CANDIDATE ISSUES

The general approach to identifying future environmental regulatory issues was divided into three major components: (1) a public and regulatory policy survey, (2) a legislative analysis, and (3) a technical analysis. The first component generated candidate issues via an analysis of environmental interest group and policy maker/regulator attitudes and goals. The second component provided a review of legislative and environmental status at the federal level. The third component generated candidate issues via a detailed environmental examination of energy technologies independent of any environmental policy or regulatory bias. Finally, a panel system was employed to screen the issues so that they could be ranked according to the seriousness of their environmental impact.

2.1 Public and Regulatory Policy Survey

Citizen Groups and Federal Agencies

Leading environmental and citizen groups were contacted regarding potential interaction between their future environmental objectives and energy technology research and development (R&D) and implementation. Groups contacted included: Environmental Policy Center, Friends of the Earth, Izaac Walton League of America, Natural Resources Defense Council, Sierra Club, Wilderness Society, and Environmental Defense Fund. Also contacted were selected staff members of policy/regulatory agencies such as the U.S. Council on Environmental Quality and the U.S. Environmental Protection Agency (EPA). A member of the Coal Task Force was also contacted. In addition, some members of the study group were associated with the following professional law groups, and therefore reflected their objectives in the analysis: The Natural Resources Section and the Special Committee on Energy Law of the American Bar Association; the International Council on Environmental Law; the Rocky Mountain Mineral Law Foundation; and the Public Land Law Review Commission.

Environmental Interests - Primary Concerns

Environmental groups, citizen groups and leading environmentalists (hereinafter referred to as Environmental Interests) appear more future oriented than the states, who tend to focus upon more immediate concerns. This future orientation reflects the increasing sophistication of the Environmental Interests. Contributing to the Environmental Interests' effectiveness will be the formation of new alliances, such as environmentalists with agricultural interests. As the sophistication and power of Environmental Interests grow, pressure will mount for resource inventories and forecasting of the future, especially in the area of energy supply and demand. Decentralized "soft" technologies and conservation are viewed as partial solutions to the energy problem. Major areas of concern to Environmental Interests include:

Greenhouse Effect. Environmental Interests predict that the effects on climatic changes of burning fossil fuels will be a high priority issue in 10 years. Some leading environmentalists feel that the greenhouse effect, only one of several possible climatic impacts of fossil fuel combustion, will be the primary issue. They believe their concern is justified because continued research suggests increasing probabilities that harm has occurred or will soon occur and the magnitude of the potential harm is enormous. (Incidentally, it appears that other effects of world economic expansion also contribute to the climatic impacts, e.g., the decrease in the rate of CO_2 assimilation caused by extensive timber cutting in tropical forests.)

Synthetic Fuels. Environmental Interests are, as a whole, opposed to long term national commitments to centralized "hard" technology systems. Opposition to centralized technologies will be focused upon pricing and subsidies. The rationale for this opposition is the belief that, without price increases and subsidies, industry will be unable to obtain the financing necessary to construct synthetic fuel plants.

There is also growing concern about possible health and safety hazards related to working in the synthetic fuel industry. Of major concern are polycyclic organic matter (POM) and trace metals in fugitive gas. Many of these substances are classified as known or potential carcinogens. Environmental Interests can expect assistance from unions and suits by injured employees.

Coal Industry in General. Most Environmental Interests are committed to firm environmental controls on the coal industry. Specific areas of concern are: strip mining and land reclamation; coal slurry pipelines and effluent disposal; union health and safety demands for coal miners; and air pollutant emissions resulting from mining, conversion, and combustion processes.

Land Use. There is growing concern over energy facility siting. The use of public land for energy mineral leasing is being challenged by recreation and agricultural interests. Environmental Interests are asking for restrictions on site locations of large energy facilities, pipeline construction, and expanding rail spurs to mine mouths. Increasing intensification of the controversy can be expected.

Water Use. Environmental Interests are very concerned about water resources in the West. They perceive a lack of estimates of the impact that energy-related water consumption might have on agriculture, recreation and pollution, although such estimates have been made by several study groups. Large amounts of water are needed in in situ and conventional coal gasification and coal liquefaction. These technologies are expected to cause water allocation problems. More restrictions on water use for energy facilities, especially in the western U.S., are expected.

Water Quality. Most groups hope to preserve minimum instream water flows in western states. They also believe that water quality can be maintained through tightening of existing water quality regulations. Acid mine drainage is of major concern in the eastern states.

Offshore Energy Development. The proposed Outer Continental Shelf (OCS) Leasing Act is encouraging to Environmental Interests. They see the act as a step in the right direction. They also believe that the states will be able to exercise greater control of OCS activity through state coastal plans promulgated under the Coastal Zone Management Act of 1972.

Trace Metals. It is predicted that research on trace metals will accumulate damaging evidence on health effects. Siting of coal conversion facilities and refinery operations, burning fossil fuels that contain trace metals, practices for disposal of ash and sludge, and emission of particulates will be questioned. Trace elements are generated in all media (air, water, and solid waste) of conversion processes. There is strong belief that trace metals will be tied to occupational health concerns.

Visibility. Visibility, especially in the West, is being stressed. There is expectation that the 1977 Clean Air Act (CAA) Amendments will help alleviate the problem. Visibility is an issue that generates broad support in Congress.

Nitrogen Oxides. There are expectations that evidence will accumulate on the formation and effects of acid precipitation (acid rain). As the data increase so will the controversies. Automobile emissions of nitrogen oxides that contribute to a photochemical smog problem are also a concern. Environmental Interests are pushing for short term NO_2 standards.

Groundwater Quality. Groundwater contamination during and after *in situ* coal gasification is of major concern, especially in the West where underground aquifers are major sources of water supply. Well injection of processing water and leaching of mineral residuals into the underground aquifer may significantly deteriorate the groundwater quality. Surface coal mining might also detrimentally affect groundwater quality. More attention will be focused on this issue as more coal extraction and conversion activities develop.

Solid Waste Disposal. There are studies under way to determine if mining residuals are hazardous. Environmental Interests predict that overburden generated in surface mining and ash/sludge generated in coal conversion and combustion processes will require special placement (Class I Disposal Site).

Prevention of Significant Deterioration (PSD) Regulations. Environmental Interests are lobbying for Class I designation for pristine areas. Some Indian tribes are requesting Class I designation for their reservations, even in areas where their coal is located. Because of the dispersive nature of most air pollutants, these groups are likely to ask for more stringent regulations to protect Class I areas.

Efficiency in End Use. It is generally believed that more attention will be given to questions of efficiency in end use. Electric space heating is described as "using an ax to slice butter."

Boomtown Effects. The socioeconomic effects of boomtown development are well recognized by the Environmental Interests. Local environmental groups are expected to have major influence on this issue.

Protection of Wildlife and Endangered Species. OCS drilling, surface mining and in situ processing of resources are expected to have major effects on some local ecosystems. Siting of other energy facilities is being closely examined in relation to this issue.

Tanker Accidents. Oil spills resulting from tanker accidents are viewed by the Environmental Interests as having potentially disastrous and irreversible effects.

Liquefied Natural Gas. Environmental Interests are calling for more safety restrictions on transporting and handling of LNG, and stringent regulations on construction of LNG storage facilities for tanker unloading.

Geothermal Energy. An overall consensus of various environmental interest groups has indicated a strong support of the expanded development of geothermal resources; and has proposed that research and development occur in the following areas:

- The gathering of base-line data, monitoring environmental impacts, and effecting appropriate safeguards for all geothermal development projects;

- The possible use of heat and other forms of energy contained at depth in dry, hot rock in sedimentary basins and in geo-pressurized systems;

- The containment of geothermal steam or brines and accompanying gases and chemicals within enclosed production systems;

- Geothermal reservoir management which will allow a balance to be maintained between field recharge and heat and fluid withdrawal; and

- The use of the earth's heat and geothermal fluids for space and agricultural heating, water desalination, mineral by-products and other non-electric applications.

In addition, the interest groups felt that the siting of these facilities should be consistent with the protection of the ecological, educational, aesthetic, and recreational values of thermal pools, hot springs, geysers, mud pots and fumaroles. Because of the probable rate of depletion, making geothermal energy a short-term resource, various organizations have pointed out the relatively small contribution to the nation's energy supply by geothermal resources.

Nuclear Power. The environmental groups surveyed with respect to the development of nuclear energy are split between those in favor (albeit guardedly) of the development and those against. All of the environmental groups acknowledge the same problems; that is, the disposal of radioactive spent fuel and wastes, reactor safety, the health consequences and disposal of uranium tailings and the possible illegal diversion of nuclear material for blackmail or weapons fabrication. However, those in favor of nuclear energy are optimistic concerning the solutions to these problems, while those against nuclear development argue that the cost of solving these problems makes nuclear energy an infeasible energy source. Several groups came out in favor of fusion and against the breeder reactor (plutonium recycling issue). In conclusion, most organizations have taken the same stance as that of the Sierra Club, which is:

> "The Sierra Club opposes the licensing, construction, and operation of <u>new</u> nuclear reactors pending. . .resolution of the significant safety problems inherent in reactor operations, disposal of spent fuel, and possible diversion of nuclear material capable of use in weapons manufacture. . ."

<u>Solar Energy</u>. Environmental interest groups generally have come out in favor of solar energy sources. The arguments in favor of their development are:

- Solar energy represents a renewable energy resource, and when used wisely will have fewer negative environmental consequences than will conventional energy sources;
- There are no harmful chemical or radioactive wastes
- Solar sources tend to be labor-intensive, stable, and resilient.

Various groups have also asked Congress to significantly increase the allocation of funds for federal research and development of solar energy.

State Agencies

A number of states were identified as having high potential for future production of energy and, therefore, as having importance in terms of the impact of their environmental policies on energy development. Several of these producer states were contacted to determine whether any state action was contemplated that would affect energy technology R&D and its application. The states were first catergorized into three levels of priority. The highest level included states where environmental action is likely to have a significant impact on energy development. The next highest level included states where moderate impact can be expected, and the lowest level included states where insignificant or no impact is foreseen. Factors considered in assigning levels of priority were: (1) the magnitude of the state's resources; (2) the likelihood that the resources will be exploited and developed; and (3) the magnitude of the state's existing energy industry. Alaska, for example, was assigned to the highest priority level because it has large energy resources, and those resources are being actively exploited on a large scale. Only those states in the two highest levels were contacted (Table 2-1).

Some states have no significant intrastate sources of energy and must import most of their energy needs from producer states or foreign sources. The environmental policies of these consumer states will also affect energy development, particularly with respect to siting energy facilities. Several representative consumer states were contacted regarding their anticipated environmental regulations for energy facilities. These states are listed in Table 2-1.

Primary Concerns of the States

Overall, both eastern and western states are interested in energy development. But there will be varying restrictions from state to state. Some states, especially in the South and East will have regulatory programs as encouraging to energy industries as possible. Other states, particularly in the West, will have regulatory programs that will result in procedural delays

Table 2-1. STATES CONTACTED BY PRIORITY LEVEL

Producer States

Highest Priority

- Alaska
- California
- Colorado
- Montana
- North Dakota
- Pennsylvania
- Texas
- Utah
- West Virginia
- Wyoming

Second Highest Priority

- Arizona*
- Idaho
- Illinois
- Indiana
- Kentucky
- Louisana
- New Jersey
- New Mexico*
- North Carolina
- Ohio
- Tennessee
- Virginia

Consumer States

- Florida
- Massachusetts
- Minnesota
- New York
- Washington

*Includes Navajo Lands.

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and more expensive control technology than is required by federal law. Issue areas important to many of the producer states are discussed below.

Air Quality. Many states, especially in the West, have more stringent air quality standards than required by the CAA. SO_x and particulate standards are particularly more stringent. Industry will have to meet restrictive air quality limits on particulate emissions associated with coal and oil shale mining.

Another difficulty which fossil energy development will encounter is the siting of any energy-related facility near PSD Class I areas. If review of large western tracts of federal and Indian lands results in large scale reclassification to PSD Class I areas, plans for mining and siting energy facilitites could be severely hindered. However, since much of the nation's energy resources are in the West, these air quality barriers will have to be overcome. Expensive control technology is one solution. This high cost of control technology will make alternative energy sources, such as solar and geothermal energy, more attractive. Another possible solution is trade-offs between energy costs and environmental quality.
Some eastern states are concerned that the 1977 new source performance standards (NSPS) and PSD requirements are too strict. They feel that these standards will severely hamper development of their energy-related industries.

Water. States are concerned both with allocation of water and water quality. Many states have done extensive water resource studies. Arizona, for example, now studies groundwater resources to determine, on a basin-by-basin analysis, allocation of water. Montana is determining minimum flow requirements for the Yellowstone River. Other states are moving toward establishment of priorities for new uses and are considering new techniques for allocation of water rights. These water priority movements are aimed at preventing private parties, such as coal companies, from buying existing water rights and monopolizing a basin's water resources. The water-conscious western states are concerned about coal slurry pipelines transporting their water to other states. Finally, states are hesitant about making any large water commitments to energy technologies that have not proven their long range feasibility and practicality.

Most states are simply meeting federal water quality standards. However, some states have enacted more stringent nondegradation standards, especially in pristine areas. These standards could severely curtail coal and oil shale mining in the nondegradation areas. Further curtailment could result from the sampling of well water to determine if trace elements and other contaminants are leaching into the groundwater from mining operations. Federal requirements on drinking water are also stringent enough to impact many mining operations which currently discharge trace elements into surface and groundwaters used, or potentially used, for drinking supplies. Lastly, federal water quality "zero discharge" deadlines, if not modified, cannot be met in some states without a severe impact on many coal-related operations.

Land Management. Siting of energy-related industries will become increasingly difficult and controversial. Depending on the site, permits will be required from either the Bureau of Land Management or the states, and in some cases both. In most instances more public input will be encouraged. The permit process is likely to be time consuming. Siting near PSD Class I areas, historical sites and pristine areas will become more and more controversial and, if upwind from these areas, next to impossible. Colorado is contemplating a facility siting act that would give the state greater control over land use decisions regarding siting of utility plants. Strong resistance to the act is expected from industry. Of question in Colorado is whether coal companies have the power of eminent domain, and if so, whether rights of way may be overruled for the building of coal slurry pipelines.

One of the biggest problems faced by energy industries, especially coal, is finding the land required to dump their enormous amounts of solid waste. Some states hope to locate industries that can utilize the solid waste near conversion facilities.

Surface reclamation laws such as the Surface Mining Control and Reclamation Act will close down some small coal mines, located primarily in the East, which lack the capital to comply with the regulations.

Alaska has proposed leasing regulations which will include public input and consideration of adverse environmental impacts connected with proposed leases. Also, there is proposed legislation that will prevent drilling during certain seasons and near wildlife areas.

OCS. States have jurisdiction within a 3-mile limit. However, the Coastal Zone Management Act assures cooperation between the states and the federal agencies. States can affect OCS activity in a large way by regulating onshore facilities. Wetland acts, preventing environmental damage to wetlands, are prevalent in the East. These acts may prevent dredging and the construction of onshore facilitites necessary to support some OCS activity. East Coast states are also concerned about the compatibility of their fishing industries and OCS energy activity. As long as no major oil spills occur there will probably be no excessively strict regulations.

California, since the 1969 Santa Barbara oil spill, has had a moritorium on offshore drilling on state land. Some existing leases have been authorized to resume drilling, but only after filing an environmental impact report (EIR). New regulations are being promulgated for floating platforms that will open up new drilling operations. However, tight control can be expected on all OCS activity in California.

The U.S. Geological Survey expects lengthening delays for permit approval of drilling exploratory wells in federal waters. The Survey also expects at least a 6-year time lag between the date of the lease and commercial well production.

Health and Safety. No new occupational health and safety regulations are contemplated that would impact fossil R&D. Perhaps when some of the technologies become commercialized and health and safety data accumulate, occupational health and safety regulations will be promulgated by the states.

Nuclear Energy. The two major issues that have generated the most controversy among the states are the disposal of nuclear wastes and uranium mine and mill tailings. With respect to nuclear waste, most states have taken a "sit back and wait" attitude, until the federal government can develop a cohesive policy. There has been much activity in the Illinois state legislature concerning the transporting, handling, and disposal of nuclear waste. Illinois has adopted the attitude felt by many states (Washington, New York, Pennsylvania, Minnesota, Michigan, etc.) that they do not want to be the nation's dumping ground. Senator Percy of Illinois is trying to get a bill (Nuclear Waste Management Political Institute Construction Bill) through Congress in which the U.S. Department of Energy will own and operate storage facilities away from reactor sites. However, the states may disagree with this approach. The general consensus among the states is that nuclear waste is a federal issue which transcends state bounds. Illinois is presently having problems in monitoring and managing low-level waste (e.g., groundwater contamination, the migration of tritium 70 to 80 feet, and other unpredictable events). In addition, the placing of spent fuel in ponds has caused considerable controversy. In New York bills are frequently introduced requesting moratoriums which require no further waste disposal in New York. The N.Y.S. Energy Office recently placed a moratorium on further nuclear development. The state has minimized its proposed activities in the nuclear industry; presently, there are only 2 or 3 facilities in the planning stages. The State of California also has legislation prohibiting the building of additional reactors until a suitable method of waste disposal can be found. However, this legislation was recently ruled null and void in a federal court.

With respect to uranium mine and mill tailings, many states already have legislation and some foresee the promulgation of future legislation. New Mexico has proposed several new state regulations. There will be a section in the new regulations which addresses the stablization of tailings. NRC published a draft EIS on uranium milling in April 1979 (NUREG-0511) which also contains several draft NRC regulations. EPA, under Title II of the Uranium Mill Tailings Control Act, is mandated to look into and develop standards for active and inactive tailings. In the meantime, New Mexico plans on establishing its own regulations and updating them as the federal regulations become available. New Mexico also indicated that they may not have the same type of standards as the federal government. It is expected that New Mexico will have regulations on tailings piles in the form of a bonds program, in addition to an existing care-fund regulation by which active mills pay the state ten cents for every pound of yellowcake up to a million dollars. In Utah, uranium tailings are under federal control. However, Utah requires a 3/4-mile buffer zone around the "tailings" and perpetual control of the land. This is in addition to the NRC regulations. If the NRC establishes more stringent regulations to protect health from radon emissions, the Utah regulation may change. Wyoming presently has draft regulations concerning the containment of mill tailings which will be above the federal standard. These should be in effect in mid-1979. Colorado was the first state to pass legislation providing for a remedial tailings control program. However, EPA will set the criterion for the tailings sites. There is also a bill to remove uranium mines from the control of the health department. The intent of the bill is to establish licensing fees for mines. Colorado also has a bill that provides for licensing fees for all radiactive materials which is to exclude mines, but include mills, and like New Mexico, Colorado has a bond program that provides for the cleanup of inactive mill tailings. The biggest problem Colorado foresees is that the federal government has not decided whether underground mining, in situ mining or solvent mining of an ore body constitute mill tailings. If this issue is not resolved, the administrative impacts could be considerable.

Geothermal Energy. With respect to geothermal development, neither California nor Wyoming foresee any major problems. Wyoming does not see the development of geothermal energy as a real issue, however. The State of California does not anticipate any new regulations; if anything they expect a deregulation to occur. The State of New Mexico presently has a restrictive hydrogen sulfide

(H_2S) ambient air quality standard of 30 ppb. The Public Service Company of New Mexico is trying to get a public hearing to revise this standard to that of the California standard. This request for revision was based on monitoring and dispersion modeling, in which it was concluded that the background levels of H_2S were above the standard. New regulations in New Mexico are being devised as a combined effort between Union oil and the Public Service Co. of New Mexico concerning the Jemez area. Exploratory wells have been drilled to [illegible] of the field. [illegible] discnarge has been done on a small scale. Presently, discharges to surface water will require an NPDES permit, while discharging into ponds, discharges which contaminate aquifers, or any contamination below the ground surface will be regulated by state water regulations. The state of New Mexico is also conducting a preliminary evaluation of the radon levels from geothermal heating. The state feels that the water used might carry radon, which if released, could present an inhalation hazard. At present, New Mexico does not anticipate hazardous regulations; this will, however, depend on the results of the preliminary study. The state of Idaho already has a state statute--the Geothermal Resource Act--which provides for the development of geothermal resources. Idaho foresees the biggest problem with respect to geothermal energy being the discharge of heated water, not only because of the thermal effects, but the mineral content as well. However, Idaho does not anticipate any other regulations. Its current water quality regulations can handle geothermal developments on a case-by-case basis.

Biomass Energy Conversion. Many states were contacted concerning the research and developmental stages of their biomass programs and the foreseeable environmental consequences and legislation that could potentially impact the development of this technology. Most of the states contacted indicated that they were only in the development stages and had not, at this point in time, considered the environmental impacts.

Presently, the California Energy Commission is working on legislation for the funding of biomass energy conversion. This potential legislation is actually a staff proposal divided into four parts: (1) define the Energy Commission's role in the biomass area; (2) Co-funding demonstration programs with private industry (these demonstration programs include direct combustion, anaerobic digestion, gasification of agricultural waste and forest residue, etc); (3) tax incentives, such as, accelerated depreciation on equipment; (4) funding provisions for the demonstration programs. In California, the Governor's Office of Appropriate Technology is fostering small-scale residential and commercial utilization of biomass.

California is looking at various biomass projects. These include: (1) fermentation and hydrolysis to produce ethanol from cannery wastes, (2) the combustion of agricultural waste (80%) with natural gas or oil (20%) as a source of fuel for boilers, (4) controlled incineration of cotton gin trash, (5) a mobile anaerobic digestion unit which travels to various waste producers to see which type of waste is the most efficient for the anaerobic digestion process; and (6) energy forms in the desert (an analysis of how many BTU/acre can be generated from certain types of plants grown in the desert with natural rainfall).

The state of Montana hopes to grant economic incentives once the technologies are developed. Colorado has several alcohol plants in the development stages. One huge 75 million gallon-per-year plant may come into existence on January 1, 1981. Three projects are currently before USDA loan guarantee program: (1) 20 million gal/year plant which converts a wheat, barley, and molasses mixture into alcohol; (2) 7.5 million gal/year plant converting corn, oats, and barley into alcohols; and (3) 7.5 million gal/year plant converting high moisture milow (maize) into alcohols.

Welch Western State Hospital in Washington has been burning wood pellets for approximately 2-1/2 years. These pellets when burned were found to be less polluting and less expensive than coal. It is expected that in-state production of the pellets from waste wood will begin in the near future; however, a license must be granted from Biosolar Co. in Oregon because it owns the patent. There is also a state project for growing a test plot of trees. These fast-growing trees (poplars, black cottonwood, red alder, and various hybrids) will be used for chips or gasification. Also, Oregon has investigated over 80 different straw harvest and utilization systems. Combined with other residues in pellet or cube form, straws and stalks can be used as a solid fuel or gasifier feed. Montana envisions growing high carbohydrate crops solely for energy production. Biomass in Idaho will not be grown exclusively as a source of energy, but rather as a by-product of other agricultural activities. (Because of the water problem, energy-producing crops such as corn and wheat which yield alcohols, etc., are not being grown).

In Northern Idaho commercial wood growing for burning purposes has been considered; however, it has not proven economically feasible since the growing of christmas trees brings in a higher price. As part of the Northwest Energy Policy Project, investigators at the University of Idaho have analyzed the environmental impacts associated with the utilization of forest residues. Some of the universities are looking at feedlot waste (manure) as potential sources of methane and gasahol.

In Minnesota, the long-standing interest in the potential of peat continues. The State has over 3 million hectares (7.5 million acres) of peat, equivalent to 200 Quads. However, many legal, technical and environmental problems must be resolved before this resource can be utilized.

Corn-belt states (especially Illinois, Iowa, and Indiana) have a strong interest in the use of surplus corn as a feed-stock for an expanded alcohol industry. State laws provide tax relief and other incentives for production of the ethanol and its blending with gasoline and "gasohol."

Presently, the states involved with biomass energy consumption are in the early research and development stages, and some thought has been given to legislative action; however, this is only in the form of securing grants for the development. The environmental impacts of this technology have not been fully evaluated by any of the states contacted.

Coal

One of the biggest concerns of the consumer states is a reliable, uninterrupted supply of energy. Several states, Florida, New York, and Massachusetts, in particular, anticipate that coal will be increasingly used as an alternative to nuclear power and petroleum. By using coal, these states can avoid the nuclear waste issue and are assured of a domestic supply of energy. Massachusetts is also giving attention to solar, biomass, hydropower, and magnetohydrodynamics as alternative energy sources.

New York has already received applications for coal-fired power plants. Because of its air pollution and acid precipitation problem, New York will require the plants to use low sulfur coal. However, high sulfur coal could be used in emergencies, such as an oil embargo. To help alleviate the sulfur problem, a coal desulfurization plant might be built near Buffalo. The state is hoping that technological improvements, such as the desulfurization plant, will reach a stage where there is little or no adverse impact from coal use.

State officials in Florida feel that utilities and large industrial facilities will inevitably convert to coal as their power source. The energy-consuming industries that are expected to convert are pressing for a relaxation of various environmental requirements. Environmental interests, on the other hand, want to maintain the present requirements. The State Office, along with the State Environmental Office, is trying to avoid potential clashes by anticipating controversies and handling them on an informal basis. Florida also anticipates problems with transporting the coal into the state. Both the rail and barge facilities are inadequate to handle large volumes of coal. Coal slurry pipelines have been viewed as a possible transport solution. However, the highly acidic wastewater from the pipeline potentially could create problems that would outweigh the benefits.

A major concern for the consumer states is facility siting. Generally, states prefer large facilities to locate in areas where the least adverse impacts occur. Some states have set up facility siting councils which oversee the siting procedure. In Washington, for example, an applicant must submit to the facility siting council an assessment of the proposed facility's environmental, socioeconomic and aesthetic impact. These impact assessments are double-checked by an independent consultant hired by the state. The council also holds public hearings before giving its recommendation for any particular site. Finally, the council's recommendation is given to the governor who either accepts or rejects the proposed siting.

Minnesota is presently experiencing some difficulty locating energy facilities and establishing rights of way for transmission lines. There is especially stiff resistance to coal-fired power plants. Potential reaction to nuclear power plants is hard to gauge because there have been no recent proposals. Problems in locating power plants and transmission lines are centered around land use issues. Many Minnesotans, especially in the farming portion of the state, have negative attitudes toward any taking of private lands for transmission lines and power plants. Objections to power plants also include air quality, water quality and noise issues. Additional objections to high voltage lines include health concerns over the effect of electrostatic fields under the lines and shock potential from currents induced in objects around the field. Ultimately, state authorities may approve the projects with conditions that provide for adequate compensation for rights of way and protective measures for health, safety and the environment. The state approval process requires a project to apply for a certificate of need with the State Energy Agency. The application for the certificate should include: forecasts demonstrating need for a project; the type and size of the project; and the expected time of operation. Hearings open to the public are also held before any project is approved.

In summary, the consumer states are very concerned about dwindling oil supplies and are looking for economically and environmentally feasible alternatives. Coupled with this switch in energy supply is an emphasis on the increasingly expensive and time-consuming siting process.

2.2 Legislation Affecting Energy Development

An analysis of environmental legislation was carried out to provide an understanding of current federal law in relation to energy development, and to provide a basis for anticipating future legislative activity. Federal environmental legislation considered to have potential for affecting energy development is reviewed and summarized in this section.

Six Major Acts

Of the many pieces of environmental legislation examined, it was felt that the six acts reviewed below provide the broadest coverage and would have the most significant impacts on energy development.

National Environmental Policy Act (NEPA) of 1969

NEPA declares a national policy which will encourage productive and enjoyable harmony between man and his environment. NEPA requires an environmental impact statement (EIS) for every major federal action significantly affecting the quality of the human environment. This statement must include the environmental impact of the proposed action, the unavoidable adverse environmental effects of the proposal should it be implemented, any irreversible and irretrievable commitments of resources, and alternatives to the proposed action. NEPA will impact fossil energy technology R&D and implementation by potentially requiring an EIS for many major federal actions in fossil energy R&D and its application. The EIS must be reviewed and approved by the Council on Environmental Quality before the action can proceed.

Clean Air Act (CAA) of 1970 and Amendments (1977)

The CAA was enacted for various purposes including the protection and enhancement of the quality of the nation's air resources. Air quality control regions (AQCR) were established in which national primary and secondary ambient air quality standards will be achieved and maintained. Ambient air quality standards were set for air pollutants which may reasonably be anticipated to endanger public health or welfare. National emission standards for hazardous air pollutants must also be met.

A state whose implementation plan meets EPA approval, may set its own standards which may be more stringent than those set by the EPA. In 1977 important amendments were added which include more stringent NSPS and provisions aimed at preventing significant deterioration of air quality in areas now meeting national primary and secondary ambient air quality standards. The CAA will impact fossil energy technology R&D and implementation by: requiring expensive emission control technology, limiting development to those areas where Class I PSD areas will not be affected, restricting the level of development in Class II areas, and delaying development through the permit and regulatory processes. As an example of a detailed examination of how one of these major environmental acts can impact the implementation of fossil energy technologies, the emission and siting restrictions of the CAA (as amended in 1977) are explored in Appendix C.

Federal Water Pollution Control Act (FWPCA) of 1972 and Amendments (1977)

The objective of this act is to restore and maintain the chemical, physical, and biological integrity of the nation's waters. In order to achieve this objective, comprehensive programs were developed to eliminate the pollution of navigable waters and groundwaters and to improve the sanitary conditions of surface and underground waters. Included in these programs are permit processes, effluent limitations, water quality standards and technology-based performance standards. The most recent amendments were adopted in 1977. One of the highlights of the amendments was the establishment of a toxic substances list. Point sources discharging listed toxic pollutants are subject to effluent limitations resulting from the application of the best available technology economically achievable (BATEA). FWPCA will impact on fossil energy technologies by regulating pollution discharges from point sources. Expensive preventive measures and control technologies may be required in some cases.

Resource Conservation and Recovery Act (RCRA) of 1976

The RCRA has four primary objectives: (1) to provide technical and financial assistance to states for the development of solid waste management programs; (2) to develop guidelines for solid waste management; (3) to regulate the management of hazardous wastes; and (4) to promote resource recovery from solid and hazardous wastes. Minimum levels of performance have been established for solid waste collection and management. Affected by these minimum standards are generators and transporters of hazardous waste. Also affected are hazardous waste treatment, storage and disposal (TSD) facilities. TSD facilities must meet the minimum performance standards in order to obtain an operating permit. States are encouraged to develop their own solid waste management plans so that their varying regional needs can be more adequately met. The state plans, however, must meet minimum RCRA requirements before they are approved. RCRA might impact fossil energy technologies by: limiting site selection to areas with hazardous waste management facilities; increasing the possibility for procedural and/or legal delays; and subjecting the technologies to varying state and local laws which may be more stringent than federal standards.

Safe Drinking Water Act (SDWA) of 1974 and Amendments (1977)

The SDWA was enacted primarily to protect public health. The act provides for the promulgaton of national primary and seconday drinking water regulations and for the establishment of minimum requirements for state programs to prevent underground injection which endangers groundwater. Although state underground injection control regulations have not been promulgated, permits will be required. The state permit process will be similar to the National Pollution Discharge Elimination System (NPDES) permit process. The state regulations will also specify a maximum contaminant level or require the use of treatment techniques for certain contaminants. This act will impact fossil energy technologies by requiring technologies that contaminate drinking water to meet applicable federal and state standards. Public hearings on permit applications will open each permit to public scrutiny and could impede commercialization of technologies. Finally, regulations for underground injection may vary from state to state. These differing regulations may, practically speaking, restrict certain technologies to just a few states.

Occupational Safety and Health Act (OSHA) of 1970

OSHA protects the safety and health of working men and women by promulgating safety and health standards. These standards prescribe suitable protective equipment and control or technological procedures to be used in connection with hazardous working conditions. Any fossil fuel industries which pose safety or health hazards to working men and women will be required to meet any protective regulations that are promulgated under this act. If certain technologies create grave health and safety risks that cannot be mitigated, these technologies may be effectively prohibited.

Acts Dealing With Water Use and Water Pollution

Acts Governing Discharges Into Water (Other than FWPCA and SDWA)

The Marine Protection, Research, and Sanctuaries Act of 1972 and Amendments (1977) prevents or strictly limits the transportation and dumping of material into ocean water that would adversely affect human health and welfare or the marine environment. This act (also known as the Ocean Dumping Act) might impact fossil fuel technology R&D and implementation by requiring treatment of any waste that flows into the ocean from energy industries. OCS activities can also expect dumping regulations in accordance with this act.

The Rivers and Harbors Act of 1899 (also known as the Refuse Act) forbids the discharge into navigable waters of any material that impedes or obstructs navigation. Because discharges into water have been regulated in more detail by the FWPCA, the discharge facet of the Rivers and Harbors Act has in practicality been replaced. However, the act also provides that any construction or modification of structures, such as bridges and dams, be approved by the Corps of Engineers. Environmental considerations are included in their permit process. This act could impact fossil energy technology R&D and implementation by affecting such things as siting of offshore pipelines, location of refinery outfalls, and placement of LNG terminals

Acts Governing Construction and Operations Affecting Water

The Ports and Waterways Safety Act of 1972 and Amendments (1978) was enacted in part to protect navigable waters and their resources from environmental harm resulting from vessel or water-located structure damage. Minimum safety requirements for all vessels and structures located on or in navigable waters are required. Rules and regulations specifying vessel speed limits, routes and handling must also be met. This act probably will not have a severe impact on fossil fuel technology R&D and commercial application. At the most, OCS activities and tanker operations might be moderately hampered with safety regulations and routing inconveniences.

Another act with will affect shipping of fossil energy resurces is the Deep Water Port Act of 1974. A deep water port must be constructed and operated using the best available technology (BAT) to prevent or minimize adverse impacts on the marine environment. Certain procedural regulations regarding such things as loading, unloading and ship movement must also be followed. However, overall impact on fossil energy technology R&D and commercial application will be slight.

The Outer Continental Shelf Lands Act of 1970 provides for the jurisdiction of the U.S. over the submerged lands of the outer continental shelf and to authorize leasing of such lands, and exploration and removal of oil and gas. Regulations will provide for the conservation of natural resources and the prevention of waste. Rights of way will also be granted through the submerged lands for pipeline purposes. This act could significantly affect offshore oil technology application if the federal government restricts the amount of submerged land it leases or if highly restrictive conservation or safety regulations are established.

Miscellaneous Acts Affecting Water

The Federal Non-Nuclear Energy Research and Development Act of 1974 provides for the development and commercializaton of non-nuclear energy technologies in an economically and environmentally acceptable manner. Assessments of water resource requirements and water supply availability for non-nuclear technologies requires an assessment of water availability and evaluation of the environmental, social, and economic impacts of the dedication of water to such uses. Potential impacts of this act on fossil energy R&D and technology application include possible curtailment of development and application of technologies that require unreasonable amounts of water. Other forms of energy that require small amounts of water, such as solar, might receive more favorable treatment, especially in water-scarce areas.

The Water Resource Planning Act of 1965 was enacted to stimulate optimum development of the nation's natural resources through coordinated planning of water and related land resource programs. It requires a study of regional or river basin plans to be made to assess the adequacy of water supplies in relation to water requirements. Impact on fossil energy technology applications could be significant if the results of the studies show that water supplies for certain regions are insufficient to support water-demanding energy technologies.

Acts Dealing With Land Use

The Surface Mining Control and Reclamation Act of 1977 established a program to protect society and the environment from the adverse effects of surface coal mining operations. This program includes provisions for the reclamation of mined areas and sets performance standards for surface coal mining. Surface coal mining permits are granted only if mines meet all applicable performance standards. Permits are not issued unless the application includes a determination of the probable hydrologic consequences and the effects of reclamation operations both on and off the mine site. A reclamation fee is to be paid by coal mining operations for the restoration of land and water sources adversely affected by the coal mining. This reclamation cost may force many of the smaller coal mines, especially in the East, to close down. However, extraction of coal by a landowner for noncommercial use and surface mining operations which affect 2 acres or less are not subject to this act.

The Coastal Zone Management Act of 1972 was enacted to develop a national policy and program for the management and protection of the nation's coastal zones. The states were encouraged to develop and implement coastal zone management programs for the land and water resources of the coastal zone. The programs are to include, among other things, identification of coastal zone boundaries, definition of permissible land uses and water uses within the zone, and a planning process for energy facilities likely to be in, or which may significantly affect, the coastal zone. This act impacts fossil energy R&D and implementation by subjecting proposed and existing energy industries that are in or near coastal areas to potentially stringent approval and operation requirements. These stringent requirements might cause delays and/or force industry to install costly control technology above that required by federal air and quality laws.

The Federal Land Policy and Management Act of 1976 establishes public land policy and provides for the management, protection, development, and enhancement of the public lands. Public lands will be managed under principles of multiple use and sustained yield. Multiple use means a combination of balanced and diverse resource uses that take into account the long term needs of future generations. In certain areas the balanced use of public lands may favor recreation or natural scenic use over mineral use. However, the overall impact on fossil energy R&D and commercialization will be minimal.

Acts Aimed at Protecting Historical, Aesthetic and Other Natural Resources.

The Fish and Wildlife Coordination Act of 1934, as amended, the Endangered Species Act of 1973 and the Migratory Bird Conservation Act of 1929 are aimed at protecting American wildlife and their habitats. Federal actions which might jeopardize or adversely affect the habitat of a listed endangered species may be stopped or required to adopt procedures that will lessen the impact on the affected wildlife. In practice, few federal projects have been seriously impeded by these wildlife laws. (The Tellico Dam is the most widely known exception.)

The Wild and Scenic Rivers Act of 1968, as amended, The Coastal Zone Management Act of 1972, as amended, the Wilderness Act of 1964 and the National Historic Preservation Act of 1966 were enacted to preserve pristine and historical areas in their natural or present state. Guidelines for placing certain areas under the protection of these acts are provided. Fossil energy R&D and technology application may have siting problems, especially public opposition, if any attempt is made to locate a large energy-related facility near an area protected by these acts.

Acts Dealing With Safety and Health (Other Than OSHA)

The Federal Coal Mine Health and Safety Act of 1977 set mandatory health and safety standards for the protection of coal or other miners. Health and safety provisions may cover such issues as dust in the mine atmosphere, noise levels, ventilation, and roof support. State standards may be more strict than federal, and they may include provisions not covered by the federal standards. This act will impact fossil energy development by requiring coal mines to meet minimum federal standards and state standards that are possibly more stringent. Some smaller mines that lack capital might be forced to close if they cannot meet health and safety standards. Also, differing state standards may stimulate coal mining in states with more lenient standards and suppress mining in states with more stringent standards. If states with large coal reserves enact extemely strict standards, coal development could be hindered considerably.

The Natural Gas Pipeline Safety Act of 1978 provides safety standards for the transportation of natural and other gas by pipeline. Minimum safety standards were promulgated for the transportation of gas and for pipeline facilities. The impact that this act will have on fossil energy development will be to increase the cost of gas transportation. However, its impact as a whole will be slight.

Other Acts That May Affect Energy Development

The objective of the Toxic Substances Control Act (TSCA) of 1976 is to regulate commerce and protect human health and the environment by requiring testing and necessary use restrictions on certain chemical substances destined for the marketplace. Regulations will be established for any chemical substance that poses an unreasonable risk of injury to health or the environment. Those who process or manufacture such substances will be required to develop data on those substances with respect to their effects on health and the environment. The manufacturer or processor may also be required to submit a description of relevant quality control procedures followed in the manufacturing or processing of such substances. Should these procedures be found inadequate, the manufacturer or processor may be required to revise those procedures to remedy the inadequacy.

TSCA may have a significant impact on fossil energy technology R&D and application. Many of the end products of coal conversion are known to contain toxics. Industry will be required to provide control measures and also to research the effects that such toxics will have on health and the environment. Expensive process control techniques may be required for fossil fuel industries that produce toxics; control techniques for end uses and disposal may also be required. Procedural delays are also likely to be encountered.

The Energy Reorganization Act of 1974 and the Department of Energy Organization Act of 1977 are acts that help coordinate energy technology R&D and its application. These acts provide for the development of efficient, reliable energy sources, keeping in mind any adverse environmental effects that those sources might have. Their impact on fossil fuel R&D will be more on a policy level. For instance, there might be a shift in emphasis from one technology to another environmentally more sound technology.

The Energy Supply and Environmental Coordination Act of 1974 was enacted in the wake of the 1973 Arab oil embargo. The act may require power plants or other major fuel-burning installations to convert to coal as their primary energy source. This act will probably not have any significant impact on fossil energy technology R&D and its application.

The objective of the Atomic Energy Act of 1954, as amended, is to establish an Atomic Energy Commission (AEC) granted the authority to conduct research and development activities relating to (1) nuclear processes; (2) the utilization of special nuclear material, atomic energy, radioactive material, and the processes necessary in the production or utilizaton of atomic energy or such material for all other purposes, including industrial, commercial and the generation of useable energy; and (3) the protection of health and promotion of safety. The Commission is also given the responsibility of regulating the disposal of by-product, source or special nuclear wastes into the ocean or sea, and the granting of a license for permission to dispose of those wastes deemed hazardous by the Commission.

The Act also established an advisory committee on reactor safety whose responsibility is to review safety studies and facility licensing applications and subsequently advise the AEC of any hazards associated with proposed or existing facilities. Most of the authority originally granted the AEC has since been transferred to the Nuclear Regulatory Commission (NRC) and DOE under the Energy Reorganization Act.

The Solar Energy Research, Development, and Demonstration Act of 1974 was enacted for the purpose of introducing a vigorous federal program of research, development, and demonstration to assure the utilization of solar energy as a viable source to meet the nation's needs.

The objectives of the Geothermal Energy Research Development and Demonstration Act of 1974 are to initiate a research and development program for the purpose of resolving all major technical problems associated with the utilization of geothermal energy; to assure that the environment and the safety of persons or property are protected, and to design and construct geothermal demonstration plants.

The Uranium Mill Tailings Control Act of 1978 was passed after findings by Congress that uranium mill tailings located at both active and inactive mill operations may pose a potential and significant hazard to public health. The purposes of the Act are: (1) to provide for a program of assessment and remedial action at inactive mill tailings sites, including where appropriate, the reprocessing of tailings to extract residual uranium and other minerals in order to stablize and control such tailings in a safe and environmentally sound manner and to minimize or eliminate radiation health hazards to the public, and (2) a program to regulate mill tailings during uranium or thorium ore processing at active mill operations, and after termination of such operations, a method to stabilize and control such tailings in a safe and environmentally sound manner to minimize or eliminate radiation health hazards to the public.

International Agreements

The 1958 United Nations Law of the Sea Convention on the High Seas makes it the general responsibility of nations to exercise "reasonable regard to the interests of other states in their exercise of the freedom of the high seas." With respect to this Convention, nations have the following obligations: (1) nations are to promulgate their own regulations so as to prevent pollution "from the exploitation and exploration of the seabed and its subsoil"; (2) "taking into account" any international regulations, nations "shall take measures to prevent pollution of the seas from the dumping of radioactive waste"; and (3) nations have a duty to "cooperate with the competent international organizations in taking measures for the prevention of pollution of the Seas or atmosphere." The High Seas Convention obligations are by no means stringent. The U.S. and other nations can choose to interpret the "reasonable regard" standard strictly or loosely and then act accordingly.

The 1959 Antarctic Treaty specifically prohibits the "disposal" of radioactive waste in Antarctica. The parties to the treaty further agree "to exert appropriate efforts, consistent with the Charter of the United Nations," to insure that no one engages in radioactive waste diposal in Antarctic. Thus, the use of the Antarctic ice sheet as a permanent repository for high level waste is clearly prohibited for the parties of the treaty. In 1991, however, the treaty becomes subject to review and possible modification on request of any party, and the ice sheet disposal option may be considered in negotiating a modification.

2.3 Technical Analysis

Issue Identification

The identification of environmental issues likely to be the focus of future regulatory activity required a multi-leveled approach. First of all, it was necessary to define the scope of DOE's energy activities likely to produce significant environmental impacts. This was done by examining the list of technologies and processes for which environmental development plans (EDPs) have been prepared. The purpose of the plans is to identify and link key events in the technology research and development cycle with applicable environmental, health, and safety research requirements. Thus, while the EDPs do not provide comprehensive analysis of environmental impacts of the technology they do provide an awareness of the environmental, health, and safety issues associated with them, and may be used as a guide to the scope and breadth of the problems posed by each technology. The list of EDPs issued to date by DOE are shown in Table 2-2.

Using the EDP's as a guide, the following energy technologies were selected as those most likely to pose environmental problems to the extent that future environmental regulatory activities could significantly affect their development:

- Nuclear
  - LWR commercial waste management
  - Decontamination and decommissioning
  - Uranium mining, milling, and conversion
  - Uranium enrichment
- Solar/Geothermal
  - Fuels from biomass
  - Geothermal
- Fossil Energy
  - Coal Gasification
  - Coal Liquefaction
  - Magnetohydrodynamics
  - Fossil fuel utilization
  - Advanced power systems
  - Underground coal conversion
  - Oil supply
  - Coal extraction, beneficiation, and transport
  - Enhanced gas recovery
  - Oil Shale

TABLE 2-2. ENVIRONMENTAL DEVELOPMENT PLANS (EDPs) ISSUED BY THE DEPARTMENT OF ENERGY

SOLAR/GEOTHERMAL	DOCUMENT DATE
Solar Heating and Cooling of Buildings	November 1978 Draft
Wind Energy Conversion	November 1978 Draft
Photovoltaics	November 1978 Draft
Fuels from Biomass	December 1978 Draft
Solar: Agricultural and Industrial Process Heat	November 1978 Draft
Ocean Thermal Energy Conversion	November 1978 Draft
Solar Thermal Power Systems	November 1978 Draft
Geothermal	November 1978 Draft
CONSERVATION	
Energy Storage Systems	December 1978 Draft
Electrical Energy Systems	November 1978 Draft
Industrial Energy Conservation	December 1978 Draft
Building and Community Systems	November 1978 Draft
Transportation Energy Conservation	November 1978 Draft
FOSSIL ENERGY	
Coal Gasification	December 1978 Draft
Coal Liquefaction	December 1978 Draft
Magentohydrodynamics	December 1978 Draft
Fossil Fuel Utilization	November 1978 Draft
Advanced Power System	April 1979 Final
Underground Coal Conversion	November 1978 Draft
Oil Supply	November 1978 Draft
Coal Extraction, Beneficiation, and Extraction	November 1978 Draft
Enhanced Gas Recovery	November 1978 Draft
Oil Shale	November 1978 Draft
NUCLEAR	
Magnetic Fusion	March 1978
LWR Commercial Waste Management	Incomplete
Defense Waste Management	Incomplete
Decontamination and Decommissioning	July 1978 Final
Special Nuclear Materials Production	June 1978 Draft
Advanced Isotope Separation	March 1978 Final
Space Applications	April 1978 Final
Uranium Mining, Milling, and Conversion	June 1978 Draft
Uranium Enrichment	June 1978 Final

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In future discussions, the various technology areas will be addressed in terms of the entire fuel cycle associated with them. Thus, for example, coal extraction, beneficiation, and transport will not be considered as separate technologies, but as part of the overall fuel cycle associated with coal conversion technologies. Likewise, the entire nuclear fuel cycle, including reactor operations, will be considered as a single technology area.

The next step in the technical analysis was to determine significant possible environmental impacts resulting from future energy development. This process was initiated by reviewing the aforementioned energy technologies in terms of their interactions with the environment. Each of the technologies was divided into modules spanning exploration through end use, with each module consisting of various submodules. Each of the submodules was carefully examined to identify the possible environmental impacts that could result from it. The following steps were taken in identifying the complete set of impacts from a submodule:

a. Identify all residuals resulting from a submodule.

b. Identify all the impacts of residual and non-residual effects on different areas of concern.

The areas of concern for these effects are air quality, water quality, land use, ecology, health and safety, socioeconomic effects, and resource availability.

The generalized technology modules and the submodules of one technology (oil) are shown in Figure 2-1. The complete list of all the submodules of the technologies is included as Appendix A.

Ranking of Issues

Several hundred issues in the technical analysis were ranked according to the seriousness of their possible environmental impact. Based principally on feasibility, simplicity, and acceptability to decision makers, a panel system was selected as the most appropriate method for ranking the issues. This

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MODULES

SUBMODULES

1. Surveying	1. Pumping	1. Terminals	1. Topping operation	1. Refining	1. Barge	1. Transportation
2. Drilling	2. Water-flooding	2. Tanker		- Fuel Production	2. Pipeline	2. Electricity
	3. Enhanced recovery	3. Pipeline		- Petrochemical Feedstock	3. Rail	3. Industrial
	- thermal				4. Truck	
	- chemical					

FIGURE 2-1

MODULES AND SUBMODULES OF OIL RECOVERY AND PROCESSING

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system was based primarily on the use of experts to review the available information on each issue and to establish its relative priority. The panel consisted of three members and a monitor. The three members were selected from the FRC staff to provide expertise in each of the following areas:

- Health and safety effects
- Environmental engineering
- Environmental impact analysis

Each issue was reviewed by the panel relative to the cause, dimension and receptor of the impact delineated in the issue. Each member was asked to provide an evaluation of each of the following six factors: (1) overall magnitude of the impact, (2) controllability, (3) time interval of impact, (4) space involved, (5) the nature of the receptor, and (6) the extent of the receptor. The scales of the six factors used in the estimation are listed in Table 2-3. Separate estimates of the six factors were transformed into numbers that were then consolidated into a composite numerical estimate (i.e., priority number) for each issue. Issues with low priority numbers were eliminated from the candidate list. However, the actual numerical rankings were not published.

Identification of Generic Issues

The next step was to identify generic issues from the list of specific issues with high priority numbers--issues which span several technology modules, or separate issues which collectively contribute to and exacerbate a particular environmental impact. Each of these specific issues was originally generated within a specific module of a specific technology.

For example, certain generic issues were generated within the same module of different technologies, such as "acid mine drainage (surface and underground)" which is an issue generated within the "extraction" module of all technologies using coal as the energy resource. Other generic issues were generated within different modules of different technologies. For example, the boomtown issue was generated both in the extraction module of coal-using technologies and in the conversion module of shale retorting technologies.

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TABLE 2-3

FACTORS USED IN PRIORITY ESTIMATION

CAUSE	DIMENSION	OBJECT
<u>Overall Magnitude of Impact</u>	<u>Time Interval</u>	<u>Nature of Receptor</u>
Very large	Irreversible	Human health and safety - Major
Large	Very long term (~10 years)	Human health and safety - Minor
Medium	Long term (~1 year)	Public welfare - Major
Small	Short term (~1 day)	Public Welfare - Minor
<u>Control</u>	<u>Space</u>	<u>Extent of Receptor</u>
No control alternative available	Global	Very large
Very costly and technically uncertain	Large regional (e.g. NE U.S.)	Large
Costly and difficult to control	Regional (radius ~50 miles)	Medium
Can be controlled with a reasonable cost	Local (radius ~5 miles)	Small
Very easy to avoid	Very local	Very small

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This process of issue identification, issue ranking, and generic issue identification was used to generate a list of 65 future regulatory candidates. This list is shown in Appendix B.

2.4 Discussion

Comparability of Candidate Issues Selected Via thePolicy/Regulatory Survey and the Technical Analysis

In Table 2-4 are displayed the 65 candidate generic issues identified via the technical analysis (rows) and those identified via the policy/regulatory survey (columns). At the intersections of these rows and columns are symbols indicating the degree to which these differently derived candidate issues correspond. It can be seen that all of the technical issues coincide with at least one of the policy/regulatory issues. Further, it can be seen that, with the exception of the End Use Efficiency issue, all policy/regulatory issues have at least one technical issue to which they bear a direct relationship. It would appear, therefore, that this dual approach identifies comparable and highly interrelated environmental issues. It would also appear that the technical issues provide a highly correlated set of specific examples of the more general policy/regulatory issues, examples of which are specific enough to permit further identification of future regulatory actions. This was a major reason for pursuing the parallel approach.

Relationships of Technical Issues to Energy Technologies

Table 2-5 displays jointly the technically derived generic issues (rows) versus the major energy technologies (columns). At the intersections of each row and column is shown the degree of relationship between each issue and each technology. Other things being equal, an issue which is directly related with most of the technologies can be expected to be an important one, since it will be difficult to avoid it by substituting another technology. This phenomenon is borne out in the following section, in that 10 of the 18 issues relating directly to at least 5 of the major technologies were chosen as major candidates for regulatory action.

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TABLE 2-4. COMPARABILITY OF CANDIDATE ISSUES SELECTED VIA THE POLICY/REGULATORY SURVEY AND THE TECHNICAL ANALYSIS

TECHNICAL ISSUES

1. Siting of LNG facilities
2. Water availability for slurry line
3. Siting of coal-related facilities
4. Land required for solid waste disposal (coal)
5. Water required for coal conversion
6. Land required for disposal of spent shale
7. Water required for retorting, upgrading of shale oil and disposal of solid waste
8. Land required for the construction of slurry pipeline
9. Hydrocarbon emission from oil transportation, conversions and end use
10. Sulfur plant tail gas emission from oil refineries, gas processing, coal liquefaction and gasification and oil shale
11. Particulate emission (fine particles) from burning coal, oil and shale oil
12. Asphalting precursor emission from oil conversion
13. CO_2 greenhouse effect related to fossil fuel combustion
14. NO_x emission from burning all kinds of fossil fuel
15. CO emission (mobile source)
16. SO_x emission from burning coal, shale oil, and oil
17. Radioactive gas emission caused by nuclear fracturing
18. Particulate emission/surface mining
19. PAH emission caused by all technologies burning coal
20. Trace elements emission resulting from coal combustion
21. Emission of radioactive material (mining and converting coal)
22. Air pollutant emission through fissures and cracks in in-situ coal gasification and in-situ shale retorting (CO, CO_2, H_2S, HCN, COS)
23. Surface and underground water contamination by oil water formed in the oil pretreatment conversion processes
24. Water/oil spill (tanker accidents)
25. Aquifer contamination by injected chemicals in secondary and tertiary recovery of oil and gas
26. Radioactive contamination of groundwater (nuclear fracturing)
27. Acid mine drainage (coal, surface and underground)
28. Leaching of solid waste resulting from coal combustion (especially for MHD because of the high salt content)
29. Contamination of surface water by organic condensate
30. Contamination of aquifers by leaching of salt and trace metals in in-situ gasification of coal, in-situ retorting, and surface retorting of coal
31. Leaching of solid waste in surface retorting of shale
32. Land/oil spill in the process of exploration, extraction and transportation of oil
33. Subsidence caused by extraction of oil and gas
34. Impact of pipeline (especially in Artic)
35. Land disturbance and reclamation by surface mining of coal and shale
36. Subsidence caused by over extraction of groundwater for slurry lines
37. Land impact caused by powerline and underground cable
38. Land disturbance and subsidence caused by in-situ coal gasification and in-situ shale retorting
39. Health and safety associated with catalysts in oil conversion
40. Health and safety relevant to H_2S mercaptan and chemicals in gas conversion
41. LNG explosion
42. Health and safety associated with deep mining of coal
43. High voltage impact of transmission line
44. Health and safety of workers in a MHD plant exposed to magnetic field, high pressure boiler, potassium salt, and toxin in slag
45. Radioactivity associated with nuclear fracturing of shale, coal (occupational hazard to workers)
46. Socioeconomic impact of land use for mining and energy extraction
47. Boomtown associated with coal mining, in-situ coal gasification, shale retorting
48. High pressure/high temperature-imposed occupational hazards (coal gasification and liquefaction processes)
49. Fugitive emission in coal gasification and liquefaction processes impose occupational and public health problems (including refinery of liquefied syncrude)
50. Health and safety problems associated with end use of coal liquids
51. Waste water generated in coal gasification and liquefaction
52. Impact of solid waste generated in coal gasification and liquefaction (radioactivity, trace elements, site selection)
53. Polycyclic organic matter emission from coal gasification and liquefaction
54. OCS oil and gas drilling, leasing and impacts
55. Groundwater aquifer and surface water contamination from surface mining of coal in West (other than acid mine drainage)
56. Onshore development related to offshore oil recovery, especially in sensitive coastal areas (pipeline, refineries, petrochemical plants, etc.)
57. Subsidence associated with advanced underground coal mining techniques (longwall and shortwall mining)
58. Brine disposal from recovery of natural gas from geopressure zones
59. Water discharge from dewatering coal slurry
60. Hydrogen sulfide emissions from geothermal energy
61. Geothermal liquid effluent disposal
62. Nuclear waste disposal
63. Land disturbance from biomass production
64. Air and water effluents from biomass conversion
65. Nuclear fuel cycle - health and safety

	Greenhouse Effects	Synthetic Fuel Plants	Coal Use Controls	Land Use	Water Use	Water Quality	Offshore Developments	Trace Metals	Visibility	Nitrogen Oxides	Groundwater Quality	Solid Waste Disposal	PSD Regulations	End Use Efficiency	Boomtown Effects	Protection Wildlife	Tanker Accidents	LNG Activities
1.		◐		●			◐							◐	◐		●	●
2.			●		●	●												
3.		●	●	●	●	●		◐	◐	◐		◐	●		●	◐		
4.		◐	◐	●								●						
5.		●	●		●	◐					◐					◐		
6.		◐		●								●				◐		
7.		◐			●	◐					●	●				◐		
8.			●	●		◐						◐						
9.	◐								●	◐			◐	◐				
10.	◐	●	●						●				●					
11.	●	●	●					●	●	◐			◐					
12.								●	●	◐			◐					
13.	0	●	●															
14.		●	●						●	0			●			◐		
15.														◐	◐			
16.	◐	●	●						●				●			◐		
17.			◐			●					●					◐		
18.	◐		●	◐				●	●				●					
19.		●	●						◐				◐					
20.		●	●			◐		0	◐		◐	●	◐			◐		
21.		●	●			●					●	●	◐			◐		
22.	◐		●					●	●				◐			◐		
23.						●					●							
24.					●	●	◐									●	0	
25.				●	●	●	◐	◐			●							
26.						●					●							
27.			●	●	●	●		●			●	●				●		
28.		●	●	●	●	●		●			●	●						
29.		●	●			●												
30.		●	●			●					●	●				◐		
31.		●		●		●		●			●	●				◐		
32.				●												●		
33.				●														
34.				●												●		
35.				●			◐									●		
36.				●								◐						
37.				●														
38.				●														
39.		●						●				●						
40.		●	●															
41.																	●	0
42.			●															
43.				●														
44.			●															
45.			●															
46.				●											●			
47.		●	●	●											0			
48.		●	●															
49.		●	●					●	●				●					
50.			●					●		●			●	◐				
51.		●	●		◐	●		●			●					◐		
52.		●	●	●		●		●			●	●				◐		
53.		●	●			●					◐	◐	●			◐		
54.					●	●	0	◐								●	●	
55.			●	●	●	●		●			●					●		
56.				●	●	●									●	●	●	
57.			●	●														
58.				●		●		●			◐					●		
59.			●	●		●		●			◐	◐				●		
60.													●			●		
61.						●		●			●					●		
62.				●		◐					◐	●						
63.				●	◐				◐							●		
64.	◐					●		●	●				●					
65.				●								◐						

0 Same Issue ● Direct Relationship

◐ Indirect Relationship Blank No Relationship

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TABLE 2-5. RELATIONSHIP BETWEEN TECHNICAL ISSUES AND MAJOR TECHNOLOGIES

TECHNICAL ISSUES

1. Siting of LNG facilities
2. Water availability for slurry line
3. Siting of coal-related facilities
4. Land required for solid waste disposal (coal)
5. Water required for coal conversion
6. Land required for diposal of spent shale
7. Water required for retorting, upgrading of shale oil and disposal of solid waste
8. Land required for the construction of slurry pipeline
9. Hydrocarbon emission from oil transportation, conversions and end use
10. Sulfur plant tail gas emission from oil refineries, gas processing, coal liquefaction and gasification and oil shale
11. Particulate emission (fine particles) from burning coal, oil and shale oil
12. Asphalting precursor emission from oil conversion
13. CO_2 greenhouse effect related to fossil fuel combustion
14. NO_x emission from burning all kinds of fossil fuel
15. CO emission (mobile source)
16. SO_x emission from burning coal, shale oil, and oil
17. Radioactive gas emission caused by nuclear fracturing
18. Particulate emission/surface mining
19. PAH emission caused by all technologies burning coal
20. Trace elements emission resulting from coal combustion
21. Emission of radioactive material (mining and converting coal)
22. Air pollutant emission through fissures and cracks in in-situ coal gasification and in-situ shale retorting (CO, CO_2, H_2S, HCN, COS)
23. Surface and underground water contamination by oil water formed in the oil pretreatment conversion processes
24. Water/oil spill (tanker accidents)
25. Aquifer contamination by injected chemicals in secondary and tertiary recovery of oil and gas
26. Radioactive contamination of groundwater (nuclear fracturing)
28. Leaching of solid waste resulting from coal combustion (especially for MHD because of the high salt content)
29. Contamination of surface water by organic condensate
30. Contamination of aquifers by leaching of salt and trace metals in in-situ gasification of coal, in-situ retorting, and surface retorting of coal
31. Leaching of solid waste in surface retorting of shale
32. Land/oil spill in the process of exploration, extraction and transportation of oil
33. Subsidence caused by extraction of oil and gas
34. Impact of pipeline (especially in Artic)
35. Land disturbance and reclamation by surface mining of coal and shale
36. Subsidence caused by over extraction of groundwater for slurry lines
37. Land impact caused by powerline and underground cable
38. Land disturbance and subsidence caused by in-situ coal gasification and in-situ shale retorting
39. Health and safety associated with catalysts in oil conversion
40. Health and safety relevant to H_2S mercaptan and chemicals in gas conversion
41. LNG explosion
42. Health and safety associated with deep mining of coal
43. High voltage impact of transmission line
44. Health and safety of workers in a MHD plant exposed to magnetic field, high pressure boiler, potassium salt, and toxin in slag
45. Radioactivity associated with nuclear fracturing of shale, coal (occupational hazard to workers)
46. Socioeconomic impact of land use for mining and energy extraction
47. Boomtown associated with coal mining, in-situ coal gasification, shale retorting
48. High pressure/high temperature-imposed occupational hazards (coal gasification and liquefaction processes)
49. Fugitive emission in coal gasification and liquefaction processes impose occupational and public health problems (including refinery of liquefied syncrude)
50. Health and safety problems associated with end use of coal liquids
51. Waste water generated in coal gasification and liquefaction
52. Impact of solid waste generated in coal gasification and liquefaction (radioactivity, trace elements, site selection)
53. Polycyclic organic matter emission from coal gasification and liquefaction
54. OCS oil and gas drilling, leasing and impacts
55. Groundwater aquifer and surface water contamination from surface mining of coal in West (other than acid mine drainage)
56. Onshore development related to offshore oil recovery, especially in sensitive coastal areas (pipeline, refineries, petrochemical plants, etc.)
57. Subsidence associated with advanced underground coal mining techniques (longwall and shortwall mining)
58. Brine disposal from recovery of natural gas from geopressure zones
59. Water discharge from dewatering coal slurry

			COAL						SHALE	
	Oil	Gas	Liquefaction	Gasification	Combustion	Advanced Systems	MHD	In-Situ Gas	Retort	In-Situ
1.		●								
2.			●	●	●	●	●			
3.			●	●	●	●	●	●		
4.			●	●	●	●	●			
5.			●	●						
6.									●	
7.									●	
8.			●	●	●	●	●			
9.	●									
10.	●	●	●	●					●	◐
11.	●		◐	◐	●				●	
12.	●		◐	◐						
13.	●	●	●	●	●	●	●	●	●	●
14.	●	●	●	●	●	●	●	●	●	●
15.	●		◐						◐	
16.	●		●	●	●	●	●	●	●	●
17.	●	●						●		●
18.			●	●	●	●	●		●	
19.			●	●	●	●	●			
20.					●					
21.			●	●	●	●	●	●		
22.								●		●
23.	●									
24.	●		◐							
25.	●	●								
26.								●		●
27.			●	●	●	●	●			
28.			●	●	●	●	●		●	
29.	●	●	●	●						
30.			●	●				●		●
31									●	
32.	●									
33.	●	●								
34.	●	●								
35.			●	●	●	●	●		●	
36.			●	●	●	●	●			
37.										
38.								●		●
39.	●		◐	◐						
40.	●	●	●	●						
41.		●	◐							
42.			●	●	●	●	●			
43.										
44.							●			
45.								●		
46.	●	●	●	●	●	●	●	◐	●	◐
47.	●	●	●	●	●	●	●	●	●	●
48.			●	●						
49.			●	●						
50.			●	◐						
51.			◐	●						
52.			●	◐						
53.			●	●	◐	◐	◐	◐		
54.	◐	●								
55.			●	●	●	●	●			
56.	●									
57.			●	●	●	●	●			
56.	●									
57.			●	●	●	●	●			
58.		●								
59.			●	●		●	●			

● Direct Relationship

◐ Indirect Relationship

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Conversely, a technology which is directly related to many of the critical issues can be be expected to be more critical technology. Coal gasification and liquefaction have this distinction, in that order. The non-fossil technologies and issues were not listed in Table 2-5 because the issues are so directly related to specific technologies.

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3. SELECTION OF MAJOR ISSUES

3.1 Method of Approach

Candidate environmental issues associated with the implementation of technologies were identified in the public and regulatory policy survey (Section 2.1) and in the technical analysis (Section 2.3). To determine the potential for further regulatory action in these issue areas, existing regulations (as discussed in Section 2.2) which are related to each issue were identified and examined. If the existing regulations were found adequate to achieve the goals identified in the public and regulatory policy survey, there would be little likelihood of additional regulatory actions. For issues that are not considered adequately regulated at the present time, the nature of the inadequacy was examined. The possibility of future regulatory action was then assessed based on the adequacy of current regulations and the technical feasibility of implementing such action.

In addition, the potential effects of these future regulatory actions on the implementation of fossil fuel technology were analyzed. The consequences of these actions were examined in relation to their possible effects on:

- Energy production rates
- Cost or benefit of compliance
- Shifts in areas of concentration in the production and consumption of energy
- Availability of energy resources

A final panel system was adopted to address each candidate issue in the areas discussed above, and to rate each issue for inclusion in the final list of major issues.

The panel members were selected from the FRC staff to represent a broad range of expertise. The specialties of the panel members included:

- Environmental health and safety
- Toxicology
- Public health and epidemiology
- Energy technology/engineering
- Environmental law
- Environmental impact analysis

Each panel member was asked to consider each of the 65 candidate issues in relation to the three areas of concern--adequacy of current regulations, technical feasibility of reducing environmental impact. impact of regulation on implementation of technology. Based on these considerations, they were asked to select 10 issues as having the highest priority and 10 having the next highest priority. These selections were tabulated and ranked according to the number of times an issue was selected by the panel members.

Figure 3-1 is a block diagram showing the complete approach used to select the major issues for future regulatory action.

3.2 Results of Issue Selection

In Table 3-1 are shown the results of the panel's judgment as to: (1) adequacy of current regulation; (2) technical feasibility of reducing the level of impact, and (3) potential impact of possible regulations on technology application.

As indicated in Column (1) of Table 3-1, only one issue (15: CO emissions from mobile sources) was considered to have existing regulations adequate to accomplish the goals identified in the policy/regulatory survey. From this standpoint, all but 1 of the 65 issues were candidates for future regulatory action.

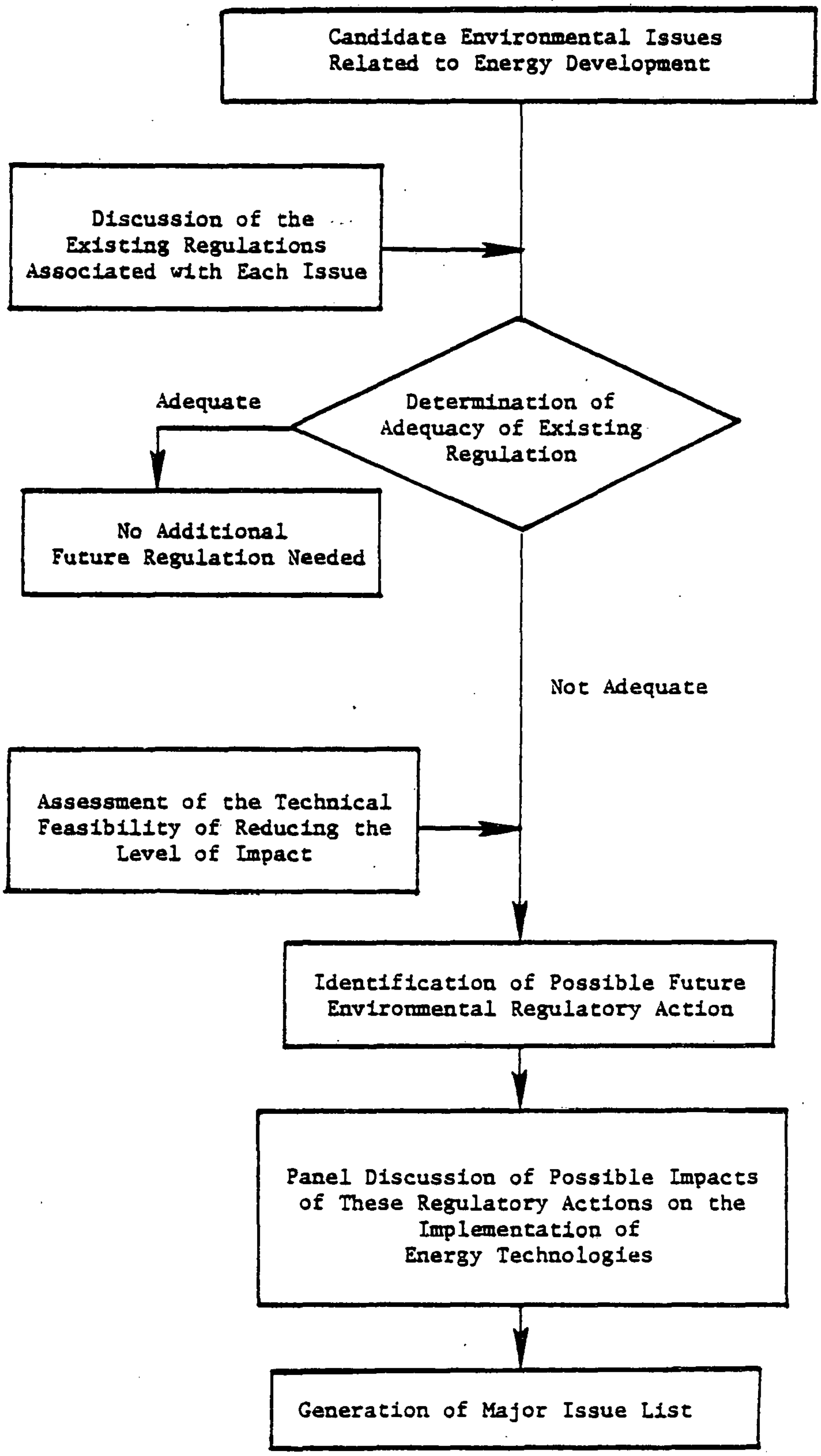

FIGURE 3-1

METHOD OF APPROACH FOR SELECTING MAJOR ENVIRONMENTAL ISSUES

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TABLE 3-1. PANEL EVALUATION OF CANDIDATE ISSUES

TECHNICAL ISSUES

1. Siting of LNG facilities
2. Water availability for slurry line
3. Siting of coal-related facilities
4. Land required for solid waste disposal (coal)
5. Water required for coal conversion
6. Land required for disposal of spent shale
7. Water required for retorting, upgrading of shale oil and disposal of solid waste
8. Land required for the construction of slurry pipeline
9. Hydrocarbon emission from oil transportation, conversions and end use
10. Sulfur plant tail gas emission from oil refineries, gas processing, coal liquefaction and gasification and oil shale
11. Particulate emission (fine particles) from burning coal, oil and shale oil
12. Asphalting precursor emission from oil conversion
13. CO_2 greenhouse effect related to fossil fuel combustion
14. NO_x emission from burning all kinds of fossil fuel
15. CO emission (mobile source)
16. SO_x emission from burning coal, shale oil, and oil
17. Radioactive gas emission caused by nuclear fracturing
18. Particulate emission/surface mining
19. PAH emission caused by all technologies burning coal
20. Trace elements emission resulting from coal combustion
21. Emission of radioactive material (mining and converting coal)
22. Air pollutant emission through fissures and cracks in in-situ coal gasification and in-situ shale retorting (CO, CO_2, H_2S, HCN, COS)
23. Surface and underground water contamination by oil water formed in the oil pretreatment conversion processes
24. Water/oil spill (tanker accidents)
25. Aquifer contamination by injected chemicals in secondary and tertiary recovery of oil and gas
26. Radioactive contamination of groundwater (nuclear fracturing)
27. Acid mine drainage (coal, surface and underground)
28. Leaching of solid waste resulting from coal combustion (especially for MHD because of the high salt content)
29. Contamination of surface water by organic condensate
30. Contamination of aquifers by leaching of salt and trace metals in in-situ gasification of coal, in-situ retorting, and surface retorting of coal
31. Leaching of solid waste in surface retorting of shale
32. Land/oil spill in the process of exploration, extraction and transportation of oil
33. Subsidence caused by extraction of oil and gas
34. Impact of pipeline (especially in Artic)
35. Land disturbance and reclamation by surface mining of coal and shale
36. Subsidence caused by over extraction of groundwater for slurry lines
37. Land impact caused by powerline and underground cable
38. Land disturbance and subsidence caused by in-situ coal gasification and in-situ shale retorting
39. Health and safety associated with catalysts in oil conversion
40. Health and safety relevant to H_2S mercaptan and chemicals in gas conversion
41. LNG explosion
42. Health and safety associated with deep mining of coal
43. High voltage impact of transmission line
44. Health and safety of workers in a MHD plant exposed to magnetic field, high pressure boiler, potassium salt, and toxin in slag
45. Radioactivity associated with nuclear fracturing of shale, coal (occupational hazard to workers)
46. Socioeconomic impact of land use for mining and energy extraction
47. Boomtown associated with coal mining, in-situ coal gasification, shale retorting
48. High pressure/high temperature-imposed occupational hazards (coal gasification and liquefaction processes)
49. Fugitive emission in coal gasification and liquefaction processes impose occupational and public health problems (including refinery of liquefied syncrude)
50. Health and safety problems associated with end use of coal liquids
51. Waste water generated in coal gasification and liquefaction
52. Impact of solid waste generated in coal gasification and liquefaction (radioactivity, trace elements, site selection)
53. Polycyclic organic matter emission from coal gasification and liquefaction
54. OCS oil and gas drilling, leasing and impacts
55. Groundwater aquifer and surface water contamination from surface mining of coal in West (other than acid mine drainage)
56. Onshore development related to offshore oil recovery, especially in sensitive coastal areas (pipeline, refineries, petrochemical plants, etc.)
57. Subsidence associated with advanced underground coal mining techniques (longwall and shortwall mining)
58. Brine disposal from recovery of natural gas from geopressure zones
59. Water discharge from dewatering coal slurry
60. Hydrogen sulfide emissions from geothermal energy
61. Geothermal liquid effluent disposal
62. Nuclear waste disposal
63. Land disturbance from biomass production
64. Air and water effluents from biomass conversion
65. Nuclear fuel cycle - health and safety

	Technology	Adequacy of Regulations[1]	Technical Feasibility of Reducing the Level of Impacts[2]	Potential Impact of Regulation on Technology[3]
1.	Gas	◐	0	●
2.	Coal	●	◐	●
3.	Coal	◐	◐	●
4.	Coal	●	◐	●
5.	Coal	●	0	◐
6.	Shale	●	●	◐
7.	Shale	●	◐	◐
8.	Coal	●	◐	◐
9.	Oil	◐	0	◐
10.	All	◐	0	0
11.	All	◐	◐	●
12.	Oil	◐	◐	◐
13.	All	●	●	●
14.	All	◐	◐	●
15.	Oil	0	0	◐
16.	All	◐	0	0
17.	All	◐	●	◐
18.	Coal	◐	◐	●
19.	Coal	◐	◐	●
20.	Coal	◐	◐	●
21.	Coal	●	●	◐
22.	Coal and Shale	●	●	◐
23.	Oil	◐	0	◐
24.	Oil	◐	◐	◐
25.	Oil and Gas	●	◐	◐
26.	Oil and Gas	●	●	◐
27.	Coal	◐	◐	●
28.	Coal	◐	◐	●
29.	Coal	●	◐	◐
30.	Coal	◐	◐	●
31.	Shale	●	◐	●
32.	Oil	◐	0	◐
33.	Oil and Gas	◐	◐	◐
34.	Oil and Gas	◐	0	◐
35.	Oil and Shale	◐	◐	●
36.	Coal	●	◐	◐
37.	All	◐	0	0
38.	Coal and Shale	●	◐	●
39.	Oil	●	0	◐
40	Gas	◐	0	◐
41.	Gas	◐	0	●
42.	Coal	◐	◐	●
43.	All	●	0	0
44.	Coal	●	0	0
45.	Coal and Shale	●	●	◐
46.	All	◐	◐	◐
47.	All	◐	◐	●
48.	Coal	◐	0	◐
49.	Coal	◐	◐	●
50.	Coal	●	◐	◐
51.	Coal	●	◐	◐
52.	Coal	●	◐	●
53.	Coal	◐	◐	●
54.	Oil and Gas	◐	0	●
55.	Coal	◐	◐	●
56.	Oil	●	◐	◐
57.	Coal	◐	◐	◐
58.	Gas	◐	0	◐
59.	Coal	◐	◐	◐
60.	Geothermal	◐	0	◐
61.	Geothermal	◐	0	0
62.	Nuclear	●	◐	●
63.	Biomass	◐	◐	◐
64.	Biomass	◐	0	◐
65.	Nuclear	●	◐	●

[1]Regulations
● Inadequate
◐ Incomplete
0 Adequate

[2]Technical Feasibility
● Next to impossible
◐ Difficult
0 Feasible

[3]Technical Impacts
● Large
◐ Medium
0 Minor

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As indicated in Column (2), four issues were considered to be almost impossible to solve technically:

(6) Land required for disposal of spent shale

(13) CO_2 greenhouse effect

(17) Radioactive gas emissions caused by nuclear fracturing

(22) Air emissions from in situ processes

Unless technology or related measures promise to help ameliorate an issue, special regulations (e.g., banning, reduced use) may be required.

As indicated in Column (3), the potential impact of future regulations designed to meet these issues were considered to have large or medium impact on technology implementation for most issues. The exceptions were five in number (10, 16, 37, 43, and 61).

The result of the panel's consideration of these criteria for the 65 technical issues is displayed in Table 3-2, where 20 issues are identified as those likely to have the greatest significance for energy development.

Interrelationships of Major Issues

Many of the 20 major issues are interrelated physically. For example, fine particulates, trace elements, radioactive elements or POM may actually be one and the same entity. Therefore, control of one problem can help control others. These interrelationships are displayed in Table 3-3.

Just the converse situation can occur relative to some control measures. For example, regulation to help decrease the incidence of black lung among coal miners can lead to increased development of surface coal mining with all its attendant problems of arid-area water supplies, land disturbance, aquifer disturbance, trace metals, and so on. Therefore, control of this one issue can lead to exacerbation of several others.

TABLE 3-2 MAJOR ENVIRONMENTAL ISSUES

1. Disposal of solid waste from conventional coal combustion and conversion technologies
2. Water supply for by coal and oil shale conversion technologies
3. Siting of coal conversion facilities
4. The carbon dioxide greenhouse effect
5. Emission of polycyclic organic matter (POM)
6. Impacts of outer continental shelf (OCS) oil development
7. Emission of trace elements
8. Groundwater contamination
9. Liquefied natural gas (LNG)
10. Underground coal mining
11. Fugitive emissions from coal gasification and liquefaction
12. Boomtown effects
13. Emission of fine particulates from coal, oil and oil shale technologies
14. Emission of radioactivity from the mining and conversion of coal
15. Emission of nitrogen oxides
16. Land disturbance from surface mining
17. Effluent from geothermal facilities
18. Nuclear waste disposal
19. Environmental impacts of biomass energy production and conversion
20. The nuclear fuel cycle

TABLE 3-3. PHYSICAL INTERRELATIONSHIPS OF MAJOR ISSUES

Major Issues	Major Issue Number* 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1. Disposal of solid waste from coal technologies																				
2. Water Supply for coal and oil shale technologies	0																			
3. Siting of coal conversion facilities	●	●																		
4. The carbon dioxide "greenhouse effect"	0	0	0																	
5. Polycyclic organic matter	◐	0	◐	0																
6. Outer continental shelf (OCS) oil development	0	0	0	0	0															
7. Trace elements	●	0	◐	0	◐	0														
8. Groundwater contamination	●	◐	◐	0	◐	0	●													
9. Liquified natural gas (LNG)	0	0	0	0	0	0	0	0												
10. Underground coal mining	0	0	0	0	0	0	●	0	0											
11. Fugitive emissions from coal gas./liquefaction	0	◐	◐	0	●	0	●	0	0	0										
12. Boomtown effect	0	0	●	0	0	●	0	0	0	0	0									
13. Fine particulate emissions from coal, oil, and oil shale	◐	0	◐	0	◐	0	●	0	0	●	●	0								
14. Radioactive emissions from the mining and conversion of coal	●	0	◐	0	0	0	●	◐	0	●	●	0	●							
15. NOx emissions	0	0	◐	0	0	0	0	0	0	0	●	0	●	0						
16. Land disturbance from surface mining	◐	0	0	0	0	0	0	0	0	0	0	◐	0	0	0					
17. Geothermal effluent discharges	0	0	0	0	0	0	●	●	0	0	0	0	0	◐	0	0				
18. Nuclear waste disposal	◐	0	0	0	0	0	0	0	0	0	0	0	0	◐	0	0	0			
19. Environmental impacts of biomass	0	0	0	◐	●	0	0	0	0	0	◐	0	0	0	◐	◐	0	0		
20. The nuclear fuel cycle	0	0	◐	0	0	0	0	0	0	0	0	0	0	0	0	0	0	●	0	

STRONGLY RELATED ● MODERATELY RELATED ◐ NOT RELATED 0

*Major issue numbers are a key to the major issues. Ex: Major issue number 9 (LNG) is not physically related to the other issues.

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Legislative Status of Major Issues

In Table 3-4 are displayed the final 20 major environmental issues (rows), along with the 30 environmentally related laws which potentially could enable regulations for their control. Seventeen of the 20 issues have significant coverage from at least one law (1,2,3,5,6,7,8,10,11,13,14,15,16,17,18,19, and 20). Nevertheless, many of 17 issues are not covered by regulations specifically controlling them. For example, POM has not been regulated under the CAA, RCRA, FWPCA, SDWA, OSHA or TSCA. POM, as is the case for many of the 17 issues, faces future regulatory action under these laws.

Three others (4,9,12) are without directly-related enabling legislation, and they will be regulated directly under future laws or indirectly through those in place to the extent such regulation becomes necessary. For example, the CO_2 greenhouse effect could be regulated indirectly via both NEPA and the CAA, but more direct, and perhaps international, law will be needed to deal with the issue effectively.

As can be seen from Table 3-4, six federal laws provide the major coverage for these issues: NEPA, CAA, RCRA, FWPCA, SDWA, and OSHA. Several other laws are critical: Water Resources Planning Act, Outer Continental Shelf Lands Act, Surface Mining Control and Reclamation Act, Coal Mine Safety and Health Act, and TSCA.

Because the issues can also be covered by state laws and regulations, the coverage depicted by Table 3-4 is the minimum that can be expected. Applicable state laws and regulations are discussed in the following sections.

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TABLE 3-4 EXISTING REGULATIONS ASSOCIATED WITH THE MAJOR ISSUES

● Significant Coverage
◐ Moderate Coverage
0 Little Coverage
Blank No Coverage

	6 Major Acts						Water Use Acts							HQ Acts			Land Use Acts							H&S		Miscellaneous					
	Natural Environmental Policy Act (NEPA)	Clean Air Act (CAA)	Resource Conser. & Recovery Act	Fed. Water Poll. Control Act	Safe Drinking Water Act	Occupational Safety and Health Act (OSHA)	Marine Protection Res. and Sanct. Act	Fed. Non-Nuclear Energy R&D Act	Rivers & Harbors Act	Water Resoures Planning Act	Fish & Wildlife Coordination Act	Wild & Scenic Rivers Act	Coastal Zone Management Act	Ports & Waterways Safety Act	Deepwater Port Act	Outer Continental Shelf (OCS) Act	Wilderness Act	Fed. Land Policy & Management Act	Surface Mining Cont. & Reclamation Act	Coastal Zone Management Act	Endangered Species Act	Migratory Bird Conservation Act	Natural Historic Preservation Act	Fed. Coal Mine S&H Act	National Gas Pipeline Safety Act	Toxic Substances Control Act (TSCA)	Federal Environmental Pesticide Control Act	Noise Control Act	Energy Supply & Environmental Coordination Act	Atomic Energy Act	Uranium Mill Tailings Act
1. Disposal of solid waste from coal conversion and combustion technologies	◐		●	◐	◐		0				0	0	0				0	●	0	0	0	0	0								
2. Water consumption by coal and oil shale conversion technologies	◐			◐	0			◐		●	0	◐	0				0			0	0	0									
3. Siting of coal conversion facilities	◐	●	●	◐	◐		0	0		0	◐	◐	◐				◐	◐		◐	◐	0	◐					0			
4. The CO_2-greenhouse effect	◐	◐																													
5. Polycyclic organic matter (POM)	◐	●	●	●	●	●	0	0		0	0		0													●			0		
6. Outer continental shelf (OCS) oil development	◐		0	◐		0	◐						0	0	0	●		0		●	0				0						
7. Trace element	◐	●	●	●	●	●	0						0						0		0			0		◐			0		
8. Groundwater contamination	◐		0	●	●		0	0		0	0	0	0				0		◐	0	0										
9. Liquefied natural gas (LNG), safety & environmental factors	◐	0		0		◐	0		0				0	0	0		0			0	0	0	0		0						
10. Underground coal mining - health and safety	0					●																		0							
11. Fugitive emissions from coal gasification & liquefaction-health and safety	◐	●				●																							0		
12. Boomtown effects	◐	0		0																											
13. Fine particulate emissions from coal, oil and oil shale technologies	◐	●				●															0			●					0		
14. Radioactivity emissions from the mining and conversion of coal	◐	◐	●	◐	●	◐	0	0			0	0	0						0					◐		0			0	◐	
15. NO_x emissions	◐	●				0																							0		
16. Land disturbances from surface mining	◐		◐	◐	◐				0	0								◐	●												
17. Geothermal effluent discharges	◐	●	●	●	●	◐	0	◐	0	0	0	0					0	0										●			
18. Nuclear waste disposal	◐	◐	◐	◐	◐	◐	◐											0												●	●
19. Environmental impacts of biomass	◐	●	◐	◐	0	◐	0	◐	0	◐	0	0	0				0	◐		0	0	0				0					
20. Health and safety of the nuclear fuel cycle	◐	●	0	◐	◐	●	0																	0						●	◐

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4. ANALYSIS OF MAJOR ISSUES

Each of the 20 major issues selected by the panel was analyzed in detail to determine the important environmental problems associated with the issue, the probable solutions to these problems, the status of existing federal and state regulations, the impact on energy development of likely future regulations, and the time frame over which such regulations might be implemented.

In analyzing the various issues, likely future regulatory actions were proposed on the basis of previously identified environmental problem areas that are not currently subject to regulation, as well as extrapolations of recent regulatory trends to the future. Thus, the proposed actions reflect the near-term trend of more comprehensive regulation of pollutants, as well as increasingly tighter standards. In the longer term, however, these trends could change. Court challenges by industrial groups as well as improved scientific knowledge could result in relaxation of standards in some cases. The EPA is required by law to review most standards periodically, and such review may indicate a need to make standards more or less stringent. EPA's recent relaxation of certain water quality criteria is an example of a case where standards were relaxed based on recent evidence on the effects of pollutants. However, it may be stated with some certainty that once an activity or pollutant has been identified as having adverse effects on the environment and has come under regulation, either through existing or new legislation, it is unlikely that the regulations would ever be entirely rescinded, even though the standards promulgated under the regulations could change.

The method employed to estimate time frames of occurrence was simple and straightforward. First, the legislative and regulatory background associated with each issue has been addressed in the past. Also, existing legislation was examined to determine whether there were any built-in timetables for future action. (For example, some of the provisions of the Clean Air Act Amendments of 1977 do not take effect until 1987.) If the issue had no legislative/regulatory history, then its background as a topic of scientific or technical interest and its emergence as a public policy issue were examined.

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Next, the recent literature was surveyed, and key people in government regulatory bodies were contacted to obtain a sense of the regulatory trends associated with each issue. Regulatory trends may be defined as a combination of the pace at which regulatory activities (standard setting, identification of hazardous pollutants, and so forth) have taken place in the recent past, and the qualitative nature of the regulatory activities (stringency of standards, comprehensiveness of regulations, or complexity of regulations).

Finally, the pace of legislative activity and current regulatory trends were extrapolated into the future to obtain an estimation of both the probability and the time frame of future actions. For example, an issue that had been addressed by legislation several times in the past 5 to 10 years and that was currently the subject of much attention by the regulatory agencies might be expected to have of regulatory action affecting it within the near future--for example, by 1985. On the other hand, an issue that had barely begun to be addressed by legislation and was seen by regulatory authorities as being of importance, but as requiring long-term study before meaningful regulations could be formulated, would probably not be subject to regulation before 1990, or perhaps later.

In the discussions that follow, emphasis has been placed on identifying, in general terms, the types of regulations that are likely to be adopted, without specifying standards in a quantitative way.

4.1 Disposal of Solid Wastes From Conventional Coal Combustion and Combustion Technologies

Description of Issue

The conversion of coal to gaseous or liquid fuels and electricity generates large quantities of solid waste. This waste can include coal ash, scrubber sludge, biological treatment sludge, tar, spent catalysts, and so on. Because of the toxic nature of some of the components (trace metals, polycyclic organics, cyanides, etc.), the disposal of this material may pose a problem for siting and operation of conversion facilities.

The technologies for coal gasification, liquefaction and electricity generation all contribute to the problem in approximately the same way. The conversion of coal to other energy forms means that its mineral matter (ash) component must be removed and ultimately disposed of. The ash content of coals varies from 5 to 25 percent, with typical values on the order of 10 percent. On the basis of heating value, the ash content varies from 6 to 30 lbs per 10^6 Btu.

In direct combustion, approximately 20 percent of the coal ash is discharged from the combustion chamber as bottom ash, and the remaining 80 percent exits the chamber as fly ash. To meet NSPS for coal-fired boilers, 95 to 99+ percent of this fly ash must be recovered by electrostatic precipitators, venturi scrubbers, baghouses or other devices. Thus, nearly all the ash originally present in the coal becomes solid waste.

The other major source of solid waste in direct combustion is the stack gas scrubber that removes SO_2. Depending on the sulfur content of the coal, 2.5 to 12 pounds of scrubber solids can be generated per 10^6 Btu of coal fired, if lime/limestone scrubbing is used. In fluidized bed combustion the bottom ash and desulfurization solids are removed from the combustion chamber as a mixture.

In coal gasification, coal ash settles out of the bottom of the gasifier as the organic portion of the coal is converted to gaseous form. In addition, a portion of the carbon in the coal may remain with the ash as char. Ash is also recovered from the combustion of coal as a source of steam and power for the gasification plant, and scrubber solids are likewise generated. A final source of solid waste is the sludge from the biological oxidation pond in which wastewater is treated prior to recycling or discharge.

In coal liquefaction, the sources of solid waste are approximately the same, except that coal ash is not removed during the liquefaction process. It remains with the liquid product and must be removed by filtering, centrifuging, or distillation. When distillation is employed, a heavy, high-ash residue is left behind which can be gasified to produce hydrogen for the liquefaction reactions. The ash and char are thus recovered as in gasification.

To give some conception of the magnitude of the solid waste produced in coal conversion, the following estimates may be cited. They are based on the conversion of a western sub-bituminous coal (8,800 Btu/lb) containing 6 percent ash and 0.66 percent sulfur. The yearly solid waste generated by the three types of coal conversion facilities is shown below (Bomberger, 1978).

Facility Type	Solid Waste (tons/yr)
1,000 MW power plant (75% capacity factor)	475,000
250 x 10^6 SCF/day coal gasification plant (90% capacity factor)	805,000
50,000 Bbl/day coal liquefaction plant (90% capacity factor)	845,000

The figures cited above include a 30 to 50 percent moisture content that is derived from slurry water, scrubber solution, and so forth.

The impacts of solid waste generated from coal conversion are two-fold. The first is the problem of the physical disposal of such a large quantity of material. The second is the possibility of release of the toxic materials contained in this waste into the environment. The most likely route of contamination is the leaching of toxic materials into groundwater aquifers from the disposal site. This is particularly a problem if the waste is disposed of by ponding.

Another potential health hazard is the emission of radon-222 from the decay of radium-226 (a uranium daughter product) contained in the coal ash (Lee et al., 1977) (see Section 4.14).

Probable Solutions

Two solutions have been proposed to the problem of the disposal of solid wastes from coal conversion facilities. The first, appropriate where the conversion facility is located near a surface coal mine, is to return the waste for burial in the mined-out area. Care must be taken, however, that shallow-lying aquifers are not contaminated by toxic materials leached from the waste. The second solution, to be used where the conversion facility is distant from the mine, or where underground mining is employed (making disposal in the mine impractical), is to dispose of the waste in ponds that have been lined with an impermeable material, such as clay. The location of an appropriate site is important, especially in populated or agricultural areas where available land for such purposes is scarce. The disposal of waste from the coal conversion facilities previously discussed would require several hundred acres over the 20- to 30-year life of the facility.

In either case, wastes declared hazardous will be subject to disposal practices required under Section 3004 of RCRA.

Legislative/Regulatory Background

The federal government has on several occasions enacted legislation to deal with the problem of solid waste, namely the Solid Waste Disposal Act of 1965, the Resource Recovery Act of 1970, and the Resource Conservation and Recovery Act of 1976 (RCRA). Of these three, only the latter gives the federal government direct authority for the classification and disposal of hazardous solid waste. The Administrator of EPA is empowered to establish criteria for the classification of wastes as hazardous and for promulgating standards for disposing of wastes so classified. An initial list of hazardous wastes is to be established, and both this list and the criteria for classifying wastes may be periodically revised.

As in any other activities, the treatment, storage, and disposal of hazardous wastes may not be allowed to violate air and water pollution regulations established under the CAA, FWPCA, SDWA, and others.

RCRA also provides for the establishment of an Office of Solid Waste within EPA and requires the Administrator to formulate guidelines, including performance standards, for solid waste management to be used by the states. These guidelines would apply to all solid waste, both hazardous and nonhazardous. These guidelines will have to be followed, at a minimum, for coal conversion wastes, whether or not they are declared hazardous.

The EPA has recently proposed rules under Section 3001 of RCRA and has also established an initial list of wastes which are to be considered hazardous. No coal conversion wastes appear on the list. However, it seems likely that the proposed testing procedures for classification of wastes as hazardous will result in such a classification for several types of coal conversion wastes. Of particular concern is the recent finding that coal fly ash shows mutagenic properties in the Ames assay test.

The conditions under which a solid waste may be listed as hazardous are defined in 40 CFR 250, Section 250.12. These include: (1) the solid waste has any of the following characteristics - corrosive, ignitable, reactive, or toxic; (2) the solid waste causes or significantly contributes to an increase in serious irreversible or incapacitating reversible illness; or (3) the solid waste poses a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, disposed of, or otherwise managed (the latter two criteria will be dependent upon the first criteria stated).

Although it is not likely that wastes from most energy conversion processes will be characterized as corrosive, ignitable, or reactive under the proposed rules, it is almost certain that many (especially coal conversion wastes) will satisfy some of the criteria for toxic wastes which are summarized below.

The purpose of the toxic waste characteristic is to determine those wastes which may release toxicants to the environment in sufficient concentration to pose a potential human health or environmental hazard if disposed of improperly. Toxicity can manifest itself in several forms, some of which are: (1) genetic activity (oncogenic, mutagenic, and teratogenic), (2) potential for bioaccumulation in tissue, and (3) acute or chronic toxicity to humans, aquatic vertebrates, and terrestial plants. All of these factors were considered in formulating the toxicity characteristic. However, because of scientific and other uncertainties, only chronic toxicity to humans as expressed through the Interim Primary Drinking Water Standards (40 CFR 141) are addressed in the proposed toxicity characteristic. A solid waste is toxic if the extract obtained from the Toxicant Extraction Procedure (TEP) has a concentration of any substance for which an EPA Primary Drinking Water Standard has been established, which is greater than or equal to ten times that standard.

The Toxicant Extraction Procedure is used to assess the concentration of the toxic species in the waste in terms of its ability to migrate and to contaminate and degrade the environment. Leachate formation and runoff are the pathways most often responsible for the contamination of the environment from disposed or stored wastes. The object of the Toxicant Extraction Procedure is to subject a waste sample to the type of leaching action which might occur under disposal or storage conditions.

In addition to the tests described above, a solid waste is deemed hazardous if it gives a positive response in any one of the tests for mutagenic activity. The procedures used for determining mutagenicity can be divided into categories: (1) the detection of mutations, and (2) the effects on DNA repair or recombination as an indicator of genetic damage. The former category utilizes three different organisms which are capable of detecting gene mutations. These include the use of bacteria, mammalian somatic cells in culture, and fungal microorganisms. With respect to the latter category, DNA repair or recombination, there are four tests, each utilizing different cell-types. There are: the DNA repair in bacteria (including differential diploid cells); sister-chromatid exchange in mammalian cells; and mitotic recombination and/or gene conversion in yeast.

Solid wastes that are radioactive are also considered hazardous, provided the average radium-226 concentration exceeds 5 picocurie/l and if it is not source, special nuclear or by-product material as defined by the Atomic Energy Act of 1954, as amended.

The Surface Mining Control and Reclamation Act of 1977 requires mining operations to restore affected land to a condition equal to or better than its original condition. Disposal of any toxic or acid-forming materials must be done in a manner designed to prevent contamination of ground or surface waters. Potential leaching of toxics from solid wastes will probably prevent solid waste disposal in mined-out areas.

Any solid waste that affects ground or surface drinking water will be regulated under the SDWA. This act is particularly concerned with underground waste injection and the quality of ground water. Control measures may include contaminant concentration limits, site restrictions, and emphasis on low-toxic waste-producing technologies.

The FWPCA will force solid waste TSD facilities to meet local and federal water quality standards. Effluent emission, technological, and ambient water quality-based standards may be imposed upon TSD facilities.

Acts such as the Wilderness Act of 1964, the Endangered Species Act of 1973 and the Natural Historic Preservation Act of 1966 will prevent siting of disposal facilities in certain areas.

Most states have laws requiring solid waste management permits. These permits require waste management operators to employ specified disposal techniques in order to prevent and abate pollution of the air, water and land. However, the comprehensiveness of state permit requirements varies. Some examples of states with more comprehensive permit processes and a few of their requirements are listed below.

Colorado specifies that permit applications contain engineering, geological, hydrological and operational data. Kentucky is even more specific, requiring that either the subsoil structures be such that solid waste will not contaminate groundwaters or streams in the area, or that procedures be used to prevent contamination. Ohio has one of the most comprehensive solid waste management programs. Ohio's requirements include such site information as the existing land uses within 1,000 feet of a site, the number of habitable buildings and communities within 1,000 feet, and the topography near the site. Also required in the Ohio plan is hydrological and surface drainage information. Such things as the direction of the flow of groundwater and the groundwater development potential must be addressed. Ohio also specifies that if leachate is detected on the site, or is draining from the site in quantities that threaten surrounding water sources, then the leachate must be collected and treated.

Nearly all states have restrictions on the siting of solid waste disposal facilities. The major concerns are to locate the facilities away from population centers and water supplies.

No states that were contacted had laws or regulations that specifically mentioned solid waste from coal conversion and combustion facilities. However, many states including Alaska, California, Montana, North Dakota, Pennsylvania, Texas, West Virginia, and Wyoming all identified certain wastes as hazardous. Since solid wastes from coal conversion technologies are likely to be declared hazardous, state requirements for hazardous wastes will have to be followed. These state requirements do not appear to be more stringent than federal requirements imposed by RCRA and the other acts cited above.

Possible Future Regulatory Actions and Their Impacts

The long term regulatory trend is toward further regulation of the handling and disposal of all manner of waste materials. Because of the high visibility that coal conversion activities will have, and the potentially hazardous nature of their solid wastes, they are certain to come under further scrutiny and regulation. The EPA has been primarily concerned to date with air and water pollution from coal conversion. But because the solution of these problems exacerbates the solid waste problem, and because of an emphasis on the formulation of multimedia environmental goals, attention is certain to be focused on solid wastes at some point in the future.

Future regulations could assume several possible forms, including the following: limits on concentration of certain substances in waste materials, requirements on the kinds of disposal sites that can be employed, and specification of disposal methods. Land use plans adopted at the state level could further limit the number of sites that can be used for disposal. There might be requirements to use recovery technologies that simultaneously render solid waste innocuous, as well as detailed guidelines and evaluation requirements for solid waste disposal sites.

The major impacts of solid waste disposal regulations will be increased costs and siting limitations. The cost increases will result from more expensive handling, disposal and site preparation methods. If disposal areas cannot be sited near the conversion facilities, increased transportation costs will be incurred.

Impacts will be felt most strongly in coal-bearing regions where conversion activites will be concentrated. However, greater problems may be encountered in the more densely populated eastern states where disposal sites will be limited.

Time Frame for Future Regulatory Action

The major regulatory action of interest resulting from RCRA is the identification of coal conversion solid wastes, or one or more of their constitutents, as hazardous. Because power plant ash and sludge, currently the only coal conversion wastes produced in significant quantities, do not pose an imminent hazard as do some other types of wastes, it does not seem likely that these will be declared hazardous in the near future. (They are currently classified as "special" wastes by EPA.) Testing of coal-fired utility wastes to determine their hazardous characteristics under RCRA criteria is still in early stages. Results to date are not definitive, and because the regulations are not in final form, the implications for utility wastes are not clear. However, there is enough evidence to suggest that some types of coal conversion wastes will come under hazardous waste regulation by 1985, as more coal conversion technologies are commercialized.

4.2 Water Supply for Coal and Oil Shale Conversion Technologies

Description of Issue

The conversion of solid fossil fuels to gaseous and liquid fuels or electricity requires substantial amounts of water. There are three primary uses of water in these processes: (1) as a source of steam for power generation and heat supply, (2) as a source of hydrogen in the fuel conversion reactions, and (3) as a supply for evaporative cooling towers used to dissipate waste heat. The supply of water for fossil energy conversion will be a major issue in resource-rich areas located in arid or semi-arid parts of the country in which there will be competing demands for water from agriculture, municipalities and industry. In addition, there will be limitations placed on withdrawals from rivers and streams in many states in order to protect the aquatic environment and to ensure the quality of water for downstream uses. The major fossil energy technologies under consideration, and their water requirements, are discussed below.

Coal Combustion for Electricity Generation. Water requirements for electricity generation are large--approximately 20,000 acre-feet per year for a 1,000 MW plant if evaporative cooling is used (Water Purification Associates, 1976). Once-through cooling requires much larger quantities, but is not considered a consumptive use in that the water is returned to its source (at an elevated temperature). Because of limitations on thermal discharges and the limited number of sites available near large bodies of water, the tendency is toward the use of evaporative cooling in new plants. Because of the large quantities of waste heat produced in power generations, the overwhelming consumptive use of water (75 to 80 percent) in a power plant is for evaporative cooling. The remainder is used for boiler makeup, stack gas scrubbing and so on.

Coal Gasification. Coal gasification is a more thermally efficient process than electricity generation (60 to 70 percent as opposed to 30 to 40 percent), so that less water is required for cooling purposes. However, there is a large requirement for water as a chemical reactant in the gasification process. Because coal is deficient in hydrogen compared to the desired conversion product (methane), water is used as a source of hydrogen, mainly through the steam-carbon and CO shift reactions:

$$C + H_2O \text{ --- } CO + H_2$$
$$CO + H_2O \text{ --- } CO_2 + H_2$$

Water is also used for other nonchemical purposes such as boiler makeup, stack gas scrubbing, ash quenching, and so on.

The design of coal gasification plants for use in areas of limited water supply has indicated consumptive water use of 7,000 to 10,000 acre-feet per year for a 250 million standard-cubic-foot-per-day facility (Water Purification Associates, 1976; Levine et al., 1975).

Coal Liquefaction. The uses of water for coal liquefaction are similar to those for coal gasification. Hydrogen required in the liquefaction reactors is produced by using water in the gasification of coal or by-product heavy liquids, or through steam reforming of by-product hydrocarbon gases.

The water requirements for a surface retorting facility are estimated at 8,000 to 10,000 acre-feet per year for a 50,000 barrel-per-day plant (Levine et al., 1975; Dickson et al., 1976).

Oil Shale. Water uses for oil shale retorting and upgrading are similar to those for other synthetic fuel processes with the exception that a large quantity is used for spent shale moisturizing and disposal. If in situ retorting is used, this use of water can be eliminated.

The water requirements for a surface retorting facility are estimated at 8,000 to 10,000 acre-feet per year for a 50,000 barrel-per-day plant (Dickson et al., 1976).

The impacts of water consumption by fossil energy conversion technologies will be felt most strongly in the western part of the country (west of the 100th meridian) where water resources are most limited, and traditional methods of allocating water rights are not conducive to satisfying the water demands of large, new users without impacting existing uses.

In the eastern part of the country (east of the 100th meridian) the impact on water resources should be smaller because there are still large water supplies available for new uses. However, there could be restrictions in some areas.

In the west, there are arguments as to whether there will be actual physical shortages of water for energy development, or whether the primary restriction is an institutional one. In the western states the principle of "first-in-time, first-in-right" applies to most water rights allocation. It is possible for water rights to be overallocated. That is, priorities are established for use of quantities greater than the average water flow in a stream. In addition, there is a current debate over federal reserved rights. The debate centers around whether the federal government can use reserved water rights for purposes not explicitly contemplated at the time the reservation was made (Dickson et al, 1976).

Restrictions on water uses within a state are also brought about by interstate compacts which guarantee the flow of water to neighboring states. Treaties with other countries can restrict water use, as in the case of the treaty with Mexico which guarantees limits on the salinity of the Colorado River.

The federal government also influences the uses of water through the construction of water projects, its veto power over interstate compacts, through its ability to declare rivers "wild and scenic," and so on.

The thrust of these considerations is that the allocation of water rights is likely to pose limitations on fossil energy development long before the total depletion of water resources becomes a serious issue. Other complicating factors include the availability and allocation of groundwater (this area has just recently begun to be addressed), the question of Indian water rights, the availability of federal reserved rights, and restrictions on interbasin transfers.

Probable Solutions

The availability of water for fossil energy conversion in the west has a large institutional component (involving constitutional protection of property rights in water) that is really not amenable to technical solution. However, to the extent that water consumption can be reduced, problems of allocation can be mitigated somewhat.

There are a number of approaches that can be taken to reduce water consumption by fossil energy technologies, some of which are already being pursued. The single most effective measure that could be taken for coal-fired power generation is the use of dry cooling. Although this technology is somewhat more expensive than evaporative cooling, and power plant efficiency is reduced, it is technically feasible. Pacific Power and Light Company will employ dry cooling on a 330 MW power plant in Wyoming.

In coal gasification and liquefaction, dry cooling would also save considerable amounts of water. However, because large quantities of wastewater are generated in the conversion process, this water can be a supply source for evaporative cooling if it is purified and recycled. Several companies planning to build coal gasification plants in the west have included in their plans the recycling of wastewater in this fashion, and the evaporation to extinction of any water that becomes too contaminated for cooling purposes. Such plans have the advantage that no wastewater is discharged to the environment.

Similar considerations apply to oil shale, although the potential use of *in situ* retorting will probably have the most pronounced effect on reduction of water use.

Even with the methods cited above, water availability will continue to plague fossil energy development in the west. The only remaining alternative (with the exception of oil shale) is to site the facilities away from the resources and closer to available water supplies. This can be done at the expense of having to transport the coal. This would effectively double the cost of coal and add 10 to 20 percent to the cost of synthetic fuels.

Legislative/Regulatory Background

The use of water for fossil energy conversion (or any other purpose) is currently governed by a host of state and federal laws, as well as court decisions, interstate compacts, treaties, and so on. It is safe to say that there is no clearcut set of rules that will apply to the use of water from a stream or river for a particular purpose at some particular time in the future. Legal systems for allocating water to new uses, especially on federal lands, are in a state of flux that is likely to continue for the near future. Ultimately, the conflicting demands for new water resources for energy development, agriculture and population growth will force resolution of the issue through the courts and legislation, or through buyouts of established prior rights.

The federal government has been reluctant to interfere in water issues within and between states. However, should the question of water availability be seen as a strong constraint on energy development, the federal government may attempt to help solve the disputes.

The most significant federal legislative action dealing with water resources was the Water Resources Planning Act of 1964. This act established the Water Resources Council and River Basin Commissions which are to study the water requirements of the nation and to coordinate planning efforts for developing water resources. The language of the Act is clear in stating that nothing in the act shall be construed "to expand or diminish either federal or state jurisdiction, responsibility, or rights in the field of water resource planning, development or control . . ." The federal government has, by and large, retained this attitude, and has been reluctant to interfere in the states' water allocation policies.

In June 1978, President Carter delivered a major water policy message to Congress, which followed a comprehensive review of federal water policy by the Water Resources Council, Office of Management and Budget, and Council on Environmental Quality. The emphasis of the President's message was on a set of initiatives that would: (1) improve the planning and implementation of federal water projects; (2) promote water conservation as a national goal; (3) improve federal and state cooperation in water resource management; and (4) increase environmental protection activities, especially in maintaining instream flows and protecting groundwater supplies.

The message was a major statement of federal water policy and is likely to set the stage for federal water policy for some years. Like the Water Resources Planning Act, it emphasized the primacy of state control over water allocation. However, by calling for more stringent cost/benefit and environmental criteria in planning federal water projects and by emphasizing conservation of water resources, the availability of water for certain uses, especially in the West, could be substantially affected. State water policies could also be affected by quantification of federal reserved and Indian Water rights, actions that are called for in the message. Finally, states that implement policies to protect instream flows and groundwater supplies should find support at the federal level.

Ultimately, the availability of water for energy development will be affected more by actions at the state level than at the federal level. Particularly important will be state policies toward the protection of instream flows and the allocation of water for traditional uses, such as agriculture, as opposed to new industrial demands. As an example of such state actions, consider Montana. In 1973, the Montana legislature passed a law that allows any political subdivision (state or federal agency, municipality, county agency, etc.) to apply for water reservations. These reservations must be approved by the Board of Natural Resources (appointed by the governor) after an EIS has been filed and a series of hearings has taken place. Although the water reservations are not to impinge on existing water rights, they could remove water from future allocations. In addition, water reservations will take preference over other allocations applied for since March 1974 (when a temporary water moratorium was instituted) during dry periods.

The largest application for a water reservation has been from the state Department of Fish and Game, which has asked for 8.2 million acre-feet per year at the mouth of the Yellowstone River. Although the virgin flow is 12 million acre-feet, existing appropriations reduce this amount to 8.5 million acre-feet. Thus, granting the Department of Fish and Game's application would effectively preclude further appropriations from the Yellowstone for industrial development. Furthermore, there would be little allowance for unclaimed federal reserved rights, Indian rights, and so forth. Even if the Board of Natural Resources grants a lower amount than requested by the Department of Fish and Game (the Department of Natural Resources has recommended that 4.5 million acre-feet be granted), there is certain to be litigation by energy industries and other industrial users challenging the constitutionality of the preference system governing water reservations.

In California, both the Department of Fish and Game and California Trout, Inc., a private organization, have gone to court seeking minimum instream flows to be granted from the California Water Resources Control Board for the purpose of protecting fish. Although these cases are still in litigation, the court's decision will probably center on whether water can be appropriated without physical control.

The two issues cited above represent examples of the types of actions that will strongly affect the availability of water for energy projects. Future state actions to protect instream flows, water rights moratoria, and court battles to obtain water appropriations can be expected. In addition, actions affecting the availability of groundwater, which has barely been addressed, can also be expected.

Other actions to resolve conflicts over water availability are also possible, including allowing the sale or exchange of water rights, constructing additonal impoundments to mitigate seasonal variations, and promoting inter-basin transfers.

Possible Future Regulatory Actions and Their Impacts

Future regulatory actions in the area of water use will probably originate at the state level, although some federal actions are likely. Federal actions could become dominant if the states fail to act in certain crucial areas. Major actions likely to be undertaken by water-poor states facing large-scale fossil energy development are as follows:

- Definition of the level of instream flows required to maintain the aquatic environment in rivers and streams, thus restricting the withdrawal of water for other purposes.
- Definition of priorities of water allocation for beneficial uses, placing restrictions on the purchase of water rights by industrial users.

- Restrictions on the use of water for evaporative cooling, forcing the use of dry cooling or waste water recycling in coal and oil shale conversion facilities.

- Extension of the SDWA to protect the quality of domestic water supplies (surface and groundwater) from degradation through excess withdrawal.

- Development of more detailed legal systems of groundwater allocation; certain uses could be prohibited or restricted.

- Prohibition of surface coal extraction where it would disrupt groundwater supplies.

- Requiring the use of recycled municipal, irrigation, and industrial waste-water.

The most likely impacts from these future regulatory actions are on the costs and siting of fossil energy conversion facilities. The construction of facilities to minimize water use will increase the cost of conversion, as will the shipment of coal if facilities must be sited closer to more abundant water supplies (east of the 100th meridian). Such increased costs could make the use of eastern coal more attractive, resulting in a lower rate of development of western coal. Because institutional considerations will probably dominate the western water supply picture, delays in construction of facilities could result if the allocation of physically available water is not addressed by the states in a timely manner. These could be avoided in part by buying out prior rights (however, large scale buyouts, though legal, would no doubt trigger partial retaliation). Finally, the availability of coal could be restricted in some areas where extraction of coal seams would disrupt important aquifers.

Time Frame For Future Regulatory Action

It seems certain that some actions will take place in the key western energy-producing states by 1985 that will limit the availability of water for energy development. More activity will occur in the late 1980's and early 1990's as water availability problems become more apparent and traditional users (e.g., agriculture) and public interest groups place increasing pressure on state legislatures and agencies.

4.3 Siting of Coal Conversion Facilities

Description of Issue

This issue arises not so much as a result of any particular environmental or regulatory problem as it does from a host of regulations, physical factors, and public attitudes. These factors can combine in a way that may severely limit the siting of coal conversion facilities. These limitations can, in turn, inhibit the implementation of new conversion technologies and result in substantial additional costs. All the conversion technologies could be subject to siting limitations.

There is probably no single impact that would prohibit the siting of a conversion facility in a particular location, although in some cases single impacts may dominate the siting problem (e.g., PSD). There are, however, a range of impacts likely to be important in siting considerations and several together may effectively prohibit or delay siting. These include impacts on air quality, water quality, land use, public health, water availability, and local socioeconomic conditions. Impacts in these areas will be dealt with by federal and state laws, regulations and procedures which, when taken together, could severely restrict the choice of sites.

Probable Solutions

There are no particular technical solutions to the problem of facility siting except, perhaps, in some cases in which additional controls could ameliorate a problem of primary importance in a particular location. An example is the use of additional controls on NO_x emissions in an area with high potential for photochemical smog formation. Important also to facility siting would be regional land use analyses coupled with land inventories and explicit cost/benefit studies. The selection and analysis of alternative sites early in the planning process will be an important step in dealing with the problem of siting restrictions.

Legislative Regulatory Background

There are no particular federal regulations dealing with facility siting, per se. However, several states have implemented policies toward siting. These state and local zoning laws are the primary constraint on facility siting. In addition, some federal laws will affect siting indirectly by effectively eliminating some sites from consideration. These include:

CAA Amendments of 1977 These place restrictions on siting plants in nonattainment and certain PSD areas.

Endangered Species Act of 1973 Limits siting in areas where endangered species would be futher imperiled.

Fish and Wildlife Coordination Act of 1934, as amended Affects the development of water resources for energy conversion.

FWPCA of 1972, as amended Limits areas in which wastewater can be discharged.

RCRA of 1976 The availability of sites for the diposal of solid wastes from energy conversion facilities could be limited by this act.

Federal Land Policy and Management Act of 1976 Provides for the protection of publicly-owned lands; requires the development of land use plans.

The Migratory Bird Conservation Act of 1929 Provides for the establishment of bird sanctuaries.

The National Historical Preservation Act of 1966 Requires the consideration of important historical or archeological sites that could be affected by federally-assisted actions.

At present, few states have laws that specifically regulate the siting of coal conversion facilities. A few states, such as Wyoming, have industrial siting acts. Wyoming's act specifically considers energy conversion facilities and requires permit applicants to: 1) assess the availability of water versus their proposed consumption; 2) supply an inventory of estimated discharges and emissions; 3) state why the proposed location was judged superior over other locations and 4) present plans for alleviating adverse social and environmental impacts on the affected area. Although most states have no comparable act, some states have strict air, water and waste disposal laws that indirectly affect siting. For instance, a coal conversion facility wishing to locate in an area where these state air quality standards are being exceeded might be unable to find sufficient emission offsets. Hence, the conversion facility would be forced to locate elsewhere.

Other, states have passed laws that set forth specific procedures for the siting of energy conversion facilities and establish siting authorities through which all siting procedures must be carried out. The intent of many of these laws is to streamline the siting process, to eliminate unnecessary delays, and to ensure that any adverse impacts have been addressed before construction begins. Thus, the problem lies not so much with the siting process itself as with the complex array of regulations dealing with air and water pollution, solid waste, and land use that must be dealt with for each facility that must be sited. Additionally, there are multiple levels of government entities that must be dealt with, ranging from municipalities to the federal government, each having its own set of regulations to be met and permits to be acquired.

Possible Future Regulatory Actions and Their Impacts

It seems likely that many of the states affected by energy resource development will establish policies toward the siting of conversion facilities, if they have not already done so. In addition, many states that are not in primary resource areas may also establish such policies. The thrust of these policies will be to minimize the impact of energy conversion facilities on population, agriculture, water resources, recreation and scenic values. These policies, in conjunction with federal laws that affect siting indirectly, will significantly limit the number of possible sites for location of such facilities. Many of the new laws will apply to development of all kinds, and will not be directed specifically toward energy facilities. The types of laws that could arise include those dealing with preservation of agricultural lands, establishment of state land use plans, the protection of marshes, deserts, and other unique ecosystems, and the promulgation of state and federal guidelines on cost/benefit analysis. Another important point is that Congress, through federal energy facility siting bills, could potentially preempt state land use laws and thus effectively remove state participation in the siting of energy facilities. In addition to the provisions of specific laws, the uncoordinated proliferation of laws and regulations affecting siting could result in long delays and dislocations because of the complicated regulatory picture.

The main impacts from the types of regulations discussed above will be delays in implementation and increased costs. The additional costs can result from the delays themselves, as well as from strict design requirements to comply with siting provisions, and from the necessity of siting in uneconomical locations.

The impacts will probably be felt most strongly in western resource areas because of their relatively pristine environments and traditional dependence on a nonindustrial economic base. However, some areas of the east could be affected as well.

Time Frame for Future Regulatory Action

The estimation of a time frame for this issue is difficult because of the complexity and multifaceted nature of the factors that affect siting of energy conversion facilities. Moreover, the situation is a dynamic one with new issues that affect siting developing at a rapid rate. Perhaps the only aspects of siting that can be dealt with in a reasonable fashion are costs and delay time, which represent the net result of the factors that contribute to siting problems.

Substantial increases in the costs and delay time (relative to the present) due to siting problems are likely to occur by 1985, continuing through by 1990. However, after that time it is possible that the costs and delays related to siting will decrease due to industry pressure for streamlined administrative siting procedures and the resulting legislative implementation of such procedures. A backlash by industry is bound to occur under almost any circumstances due to the frustrations that will be incurred in the siting of new facilities. The result of siting difficulties will be increased energy costs at best and, at worst, supply shortages in some of the high demand regions such as the Northeast, the Midwest, and the West Coast.

To the extent that siting procedures can be made more efficient through more responsive administrative procedures, Congress and the state legislatures will be under substantial pressure to carry out administrative reforms. Such pressures are evident in the area of nuclear power, and the government has instituted new procedures for accelerating the siting process.

4.4 The Carbon Dioxide Greenhouse Effect

Description of Issue

The combustion of fossil fuels necessarily results in the release of large amounts of carbon dioxide to the atmosphere. This has become an issue of concern, for the CO_2 concentration is now observed to be increasing throughout the troposphere. This increase may cause climatic changes by affecting the surface temperature of the earth.

The concentration of atmospheric CO_2 during the nineteenth century was about 290 ppm (mole fraction). The current value (1977) is about 332 ppm (NAS, 1977). The rate of increase averaged 0.7 ppm per year during 1959-1968 and 1.3 ppm per year during 1969-1973, while the fossil fuel input of CO_2 averaged 1.4 ppm per year and 2.0 ppm per year, respectively, during the same periods (NAS, 1977). Thus, the increasing rate of accumulation of CO_2 in the atmosphere is apparently correlated with the increasing rate of fossil fuel combustion.

Carbon dioxide is formed by oxidation and combustion processes, both natural and manmade. Human activities may contribute to the increasing CO_2 concentration as follows: by clearing land, thus decreasing the available plants that utilize CO_2, and increasing the decomposition of plant material; by burning fossil fuels; and by converting limestone into cements. The amount of CO_2 accumulated in the atmosphere each year is roughly half the estimated emission from anthropogenic sources. The portion of the anthropogenic CO_2 that is not accounted for by any increase in atmospheric CO_2 has been taken up by ocean water and possibly by land plants. Approximately one-third of the anthropogenic CO_2 emissions have been contributed by the United States.

Carbon dioxide is nearly transparent to visible light but is a strong absorber of infrared radiation, especially at wavelengths between 12 and 18 microns (10^{-6} meter). This gas effectively behaves as a one-way filter, allowing incoming visible light to pass through in one direction, but preventing the outgoing infrared radiation from passing in the opposite direction -- the so-called greenhouse effect. Hence, any increase in its concentration would presumably raise the temperature of the atmosphere by reducing the amount of terrestrial radiation lost to space. Manabe and Wetherald (1975) have recently predicted that an average rise of 2.5°C in air temperature in the lower atmosphere would result from a doubling of atmospheric CO_2 from 300 to 600 ppm. It has been suggested that average temperature increases of this magnitude could lead to increased melting of ice caps and glaciers, which would increase the average depth of all oceans by 200 to 250 feet. This would put many coastal areas under water. It might also move present agricultural areas toward the poles, with great attendant socioeconomic difficulties.

The worldwide average temperature increased by 0.6°C between 1885 and 1940 (Mitchell, 1970). However, a decline of 0.2 to 0.35°C has been recorded since then (Mitchell, 1970; Gwynne,1975). This decline may be explained by the increased cloud cover or increased atmospheric particulate concentration. Damon and Kunen (1976) have shown that there has been a warming trend in the southern hemisphere since 1964 that may, at least partially, be due to the CO_2 greenhouse effect. Hence, the northern and southern hemispheres have experienced opposite changes in surface air temperature in the last three decades. Carbon dioxide and particulate matter, the two major pollutants that may affect current climate trends, are mostly emitted in the northern hemisphere. Carbon dioxide can be latitudinally mixed relatively fast, whereas particulate matter is unlikely to become thoroughly mixed because of its short residence time. Thus, the observed warming of the southern hemisphere could be an indication that as the CO_2 concentration increases, there may eventually be a global warming trend because of the CO_2 greenhouse effect. It would be unwise to discount the possible atmospheric changes caused by the continued burning of fossil fuels.

Probable Solutions

The atmospheric CO_2 concentration may be controlled by either reducing the magnitude of burning fossil fuels or increasing the earth's biomass. Photosynthesis has a global CO_2 exchange rate of 6×10^{10} metric tons per year, which is about five times the combustion rate (1.2×10^{10} metric tons per year) (NAS, 1977; Plass, 1971). There is obviously a large potential for this natural process to take up large portions of the atmospheric CO_2. Actually, the rate of increase of CO_2 concentration may partially be attributed to the recent depletion of plants, especially the extreme cutting of tropical forests. Agricultural practices that expose humus or other organic matter also increase the release of CO_2.

Legislative/Regulatory Background

The scientific community began to show interest in the CO_2-greenhouse effect in the early 1950's. The Mauna Loa Observatory and the station at the South Pole started to record ambient CO_2 concentrations in 1957. The steady increase in the annual average atmospheric CO_2 concentrations was well recognized in the 1960's. Intensive research on the storage and exchange mechanisms, mathematical modeling, and the possible effects of CO_2 was initiated immediately after this finding. The U.S. Government has shown a marked interest in the CO_2 issue since 1972. Major government and institutionally-funded research projects have been conducted since then. Currently there is no regulation of CO_2 emissions. The only remotely related legislative action is the National Climate bill (1978) which has proposed the coordination of federal climate research including research on CO_2 effects.

At the present time, there are great uncertainties involved in the following major aspects of the problem associated with the CO_2-greenhouse effect:

- The causes of the steady increase of atmospheric CO_2.
- The storage and exchange mechanisms of oceans, forests and humus that can affect the atmospheric CO_2 concentration in the future.
- The impacts of other factors such as ambient particulate matter and cloud cover on global temperature.
- The possible effects of a global warming trend.

Because fossil fuel is the largest single energy source used by humanity at the present time and combustion of fossil fuel necessarily results in CO_2 emission, it is not likely there will be any regulation of CO_2 emission until enough information has been accumulated to resolve these uncertainties.

In the past few years, many studies were made in this field; the general conclusions that can be drawn are:

- The United States contributed 28 percent of the world's carbon dioxide from fossil fuel combustion in 1973, and predictions indicate a 19-28 percent U.S. contribution by 2025. Hence, the United States alone cannot solve the potential problem by unilaterally decreasing or eliminating carbon dioxide emissions. An international effort will be required.
- The consequences of climatic change are likely to become noticeable by the end of the century. The level of carbon dioxide in the atmosphere will increase to 400 ppm by the year 2000 and to 800 ppm by 2040.
- Ambient carbon dioxide concentrations of 500-1000 ppm are frequently found in urban areas. The environmental effects due to an increasing carbon dioxide concentration are expected to occur on a meso scale or synoptic scale before they happen globally.
- Removal of carbon dioxide from flue gases does not appear feasible. Possible measures to reduce carbon dioxide emission may include: (1) shifting to nonfossil energy sources, (2) energy conservation and more efficient use of fossil energy, and (3) eliminating the forest depletion process.

Possible Future Regulatory Actions and Their Impacts

Although the probability of harm is now unresolved, the magnitude of possible harm is so great that the CO_2 greenhouse effect will probably become a major issue in dealing with fossil fuel energy development. Although CO_2 emissions are not currently regulated, scientists will perhaps establish a sufficiently strong causal connection to bring agricultural and other economic interests into an alliance with environmental interests in opposing continued consumption of fossil fuels.

Should there be enough information accumulated to show that CO_2 emissions from fossil fuel combustion could cause climatic changes, there might be regulatory action on CO_2 emissions. Possible actions include: the requirement of more efficient use of fossil fuel; the requirement to reestablish forests to help balance CO_2 sources and sinks; the simple limitation of coal combustion/conversion as a source of energy; international agreements on long range policy and goals for the use of fossil fuels; increased emphasis on alternatives to fossil fuels in the NEPA process; and global controls or "levies" on fossil fuel use to offset predicted long term impacts.

All of the possible regulatory actions would slow down the growth rate of fossil fuel and limit the development of fossil fuel energy technologies. Should there be enough information accumulated that shows adverse effects of CO_2 emissions, large non-CO_2-generating energy sources will be required. This requirement could instigate intensive efforts toward the development of nonfossil energy sources such as fusion, solar, and geothermal. Biomass would be especially favored as a source of liquid and gaseous fuels since its conversion and use does not disrupt the CO_2 content of the atmosphere.

Time Frame for Regulatory Action

The consequences of climatic change are likely to become noticeable by the year 2000. Research results should be available to predict the possible consequences before they become noticeable. However, major legislation or international agreements on limiting CO_2 emission would be difficult to achieve without noticeable evidence of adverse impacts. Therefore, the chance of having any of the aforementioned actions would be small before 1990, but they could possibly take place by the year 2000.

4.5 Emission of Polycyclic Organic Matter (POM)

Description of the Issue

The relationship of POM to carcinogenesis is one of the most important of possible occupational and environmental impacts attributed to fossil fuel technologies. POM contains two classes of compounds that are known animal carcinogens: the polycyclic aromatic hydrocarbons (PAHs) and their neutral nitrogen analogues, the aza-arenes (i.e, indoles and carbazoles). Various types of POM exists in urban air, such as pyrene, anthanthrene, benz[a]anthracene, benzo flouranthenes, dibenzanthracenes, chrysene, phenylenepyrene, benzoperylene, coronene, flouranthene, and alkyl derivatives of these compounds, as well as benzo[a]pyrene.

The primary sources of airborne PAHs are combustion, coal coking, and petroleum catalytic cracking. Transportation and processing of petroleum are the primary PAH contributors to water contamination, while occupational carcinogenesis is attributed to those technologies involving contact with petroleum and coal "residuals" (i.e., coal tars) and by inhalation in heavily PAH-contaminated environments, such as coking. Coal and oil shale conversion will constitute a new source of PAHs.

The components and degradation products of fossil fuels resulting from burning, refining, distilling or cracking have been demonstrated to have a close association with a high incidence of skin cancer affecting the scrotum and heavily exposed skin areas. A high incidence of skin cancer has been observed among workers in coal-tar industries and gas plants (particularly in operations in oil and shale refineries). Lung cancer has been associated with coal processing operations such as coking and the manufacturing of illuminating gas. Substantial increases in lung cancer mortality rates over that of the general population have been noted in gas generator workers, coke oven workers and gas retort workers. Benzo[a]pyrene was identified in most cases as the airborne contaminant (NAS, 1972).

In summary, there is evidence that airborne POM found in occupational settings, especially in relation to the products of burning, refining, and distilling, are responsible for lung and skin cancer, nonallergic contact dermatitis, photosensitization reactions, hyperpigmentation of the skin, folliculitis, and acne. In concentrations usually found in the atmosphere, POM does not appear to cause any of the above-mentioned skin effects; similarly, there is no evidence to suggest that such materials as benzo[a]-pyrene in polluted air directly influence the pathogenesis of bronchitis and emphysema. However, statistics have shown the incidence of lung cancer to be twice as high in areas where fossil fuel products from industrial use are highly concentrated in the air (NAS, 1972).

There has been no information found to indicate that PAHs affect vegetation. However, absorption of POM by roots from contaminated solutions, by foliage from polluted atmospheres, and by aquatic plants from contaminated water has served to increase the traces of the compounds already produced metabolically (NAS, 1972).

Probable Solutions

Since much of coal-derived oil is expected to be consumed by combustion, it appears as if the efficiency will be a determining factor with respect to PAH emissions. It has been well documented that combustion efficiency is more important than is the aromaticity of the fuel in determining final PAH emissions. With respect to petroleum catalytic cracking, it is the regeneration of the catalyst, through the combustion of coke on the catalyst surface, in which benzo[a]pyrene and other POM are formed. These emissions can be controlled by passage to a carbon monoxide waste-heat boiler, which functions as a direct-flame afterburner and removes all the POM from the effluent being emitted to the atmosphere (Guerin, 1977). Further research is needed to assess the PAHs emitted as a result of coking.

Reductions in emissions of POM to the atmosphere from transportation (i.e., automobiles) can be projected through the 1980-1990 period, with the advent of a greater proportion of vehicles equipped with advanced emission control systems. The emissions from heavier vehicles, such as diesel-powered trucks and buses, have recently been linked with cancer as a result of the PAHs found in the soot emitted from tailpipes.

Legislative/Regulatory Background

Comprehensive regulations governing POM have not been enacted because of the difficulty in quantifying the various constituents. However, many federal laws exist that could act as enabling legislation, so that if evidence accumulates concerning the adverse effects of POM, controls can be established.

The CAA was enacted in 1963 with major amendments in 1967, 1970, and 1977. The 1970 amendments gave the Administrator of EPA authority to establish a list of hazardous air pollutants and to set national emission standards. In 1977, the Administrator was required to review all relevant information to determine whether emission of POM into the ambient air would cause or contribute to air pollution which might endanger public health. If an affirmative determination with respect to any POM was made, the Administrator would set air quality criteria or emission standards. The FWPCA (1972), as amended by the Clean Water Act of 1977, authorizes the Administrator of EPA to regulate the discharge of any hazardous material which might present an imminent and substantial danger to public health and welfare. As of 1977, toxic pollutants are required to apply BATEA. If data accumulates indicating that POM are toxic, the requirement would apply.

SDWA (1974) may regulate the discharge of POM into aquifers. More than likely, these regulations would require that some kind of control technology be applied to reduce POM concentrations in the discharges.
TSCA (1976) regulates commercial products containing chemical substances and mixtures which may be hazardous to public health and the environment. Various constituents of POM have been determined to be hazardous (carcinogenic); thus

it is quite likely that products containing these will have their circulation terminated or severely curtailed.

RCRA (1976) regulates the management of hazardous wastes. Standards have been set for hazardous waste generators and for transporters, owners and operators of hazardous waste treatment, storage and disposal facilities. Regulations identify hazardous wastes, and setting standards for its management were to take effect by October, 1978. If certain types of POM are identified as hazardous, RCRA standards will apply.

OSHA (1970) established a requirement for occupational safety and health standards for toxic and hazardous substances. If POM is found in the work area in concentrations that will affect the health or safety of workers, then appropriate standards may be promulgated. Presently, POM that is benzene soluble, as well as coke oven and coal tar emissions, are regulated.

Possible Future Regulatory Actions and Their Impacts

Further research into the effects of fuel composition and of advanced emission control devices will be continued. Coal-related POM emissions will be fairly well restricted by more efficient combustion processes, substitution of alternative fuels and the discontinuance of coal-refuse storage practices. Emissions associated with coke production require additional research on controls and source analysis. Conversion technologies will continue to remain a potential occupational and local environmental health threat until an efficient method of containing the hazardous constituents on a commercial scale can be devised. Future regulatory actions will impose emission standards to protect the air, water, land and human exposure.

Atmospheric emissions may be controlled by the following:

- NESHAPs (National Emission Standards for Hazardous Air Pollutants)
- NSPS - Although POM is not specifically dealt with, particulate emissions standards have been established which will indirectly affect POM emissions.

- PSD - Presently, particulates are regulated under this act. Thus POM is included, indirectly.

- Ambient air quality standards can be anticipated for POM. POM emitted into water will be covered by these regulations:

- FWPCA - which establishes effluent guidelines for toxic substances. Application of BATEA (best available technology economically achievable) to POM is expected in the later 1980s or early 1990s. NPDES (National Pollutant Discharge Elimination System) requiring a permit for any discharge may be applied to POM.

- SDWA - will prevent contamination of drinking water. Underground monitoring of contaminants such as POM may lead to concentration standards for groundwaters. These standards will lead to the regulation of underground injection of POM-containing wastes.

Protection of the land and water will be regulated through RCRA. This act deals with the existence of POM in solid wastes. If the existence of POM causes the waste to be declared hazardous, then strict RCRA requirements for hazardous solid waste disposal must be followed.

Occupational exposure to POM will be regulated by OSHA, which could establish ambient air quality standards for the work place. This also applies for a high POM concentration in waters near industrial sites, should this condition exist.

TSCA will affect POM if it is shown to exist in commercial products in concentration levels that might pose a risk of injury to public health or the environment. Testing of conversion products containing POM and use restrictions on those products may be required.

Time Frame for Future Regulatory Action

Presently, there is no legislation dealing specifically with POM. However, as more information accumulates, the likelihood of future regulatory action is fairly certain.

It is highly likely that POM will specifically be regulated under the CAA by 1985. Presently, the Administrator of EPA is in the process of determining

the effects of POM emissions on public health. It is speculated, based upon various epidemiological and animal studies, that within the next five years some types of POM will be regulated, most probably in the form of NESHAP limitations.
POM is presently being evaluated for any potential danger to public health and welfare it may represent as a contaminant in water discharges. There is a good chance that by 1985 some types will be classified as toxic pollutants and will be subject to the regulations as prescribed in the FWPCA.

To date, little information has been gathered concerning POM as a contaminant of aquifers. However, there is a good chance that by 1990 this information will be known, and that regulations that require that some kind of control technology will be implemented to reduce POM concentrations in such discharges.

It is highly likely that wastes containing significant quantities of POM will be identified as hazardous, RCRA standards should apply by 1985.

In a publication of the U.S. Department of Labor entitled "News" a proposal for regulating all work-place cancer-causing substances discussed the possibility that OSHA would regulate all chemicals contained in Category 1 "Confirmed Carcinogens". Various types of POM appeared on this list such as benzo(a)pyrene, 7,12-dimethylbenze(a)antracene, and 3-methylcholanthrene. One can predict with near certainty that by 1985 POM will be strictly regulated by OSHA.

4.6 Impacts of Outer Continental Shelf (OCS) Oil Development

Description of the Issue

There are various issues associated with OCS drilling. In the early stages, acquisition of an OCS lease is a necessary first step. The responsibility beyond the 3-mile limit for selecting, analyzing and leasing tracts for oil exploration lies entirely within the U.S. Department of the Interior. A second issue associated with OCS drilling is the release of oil into the water, either controlled, such as cleaning and ballasting operations, or by accidental release (blowout). Water/oil contamination also results from refinery and petrochemical plants, industrial machinery waste oil, leaks or breaks in pipelines, and tanker accidents. A third issue, air pollution, arises from spills and emissions from various sectors of the operations. Hydrocarbon emissions arise from gas and oil production, evaporation of gas and oil, and from the exhaust emissions of diesel engines, gas turbines, and gas burners. The sources of nitrogen oxide emissions include gas burners, gas turbines, and diesel exhaust. Diesel and gas turbine exhaust provide the only sources of carbon monoxide. Particulates will be present in the exhaust of the gas burners, gas turbines and diesel engines. Leaks, which occur as part of the production of gas, provide the only source of hydrogen sulfide (H_2S). Sulfur dioxide emissions arise from diesel exhaust, gas burner exhaust, gas turbine exhaust, and sulfur recovery operations. Blowouts accompanied by fire will emit NO_x, SO_x, and hydrocarbons into the atmosphere. A fourth issue, aesthetics, results from the location of OCS drilling sites off recreational and residential areas, thereby impacting the aesthetic quality of the locale. A fifth and final set of issues is socioeconomic, and results from the need for onshore facilitites for receiving, processing and transporting the oil.

Water/oil spills affect marine life (behavior change, change in nutrients smothering-type metabolic disorders, decreased photosynthesis as a result of decreased light, etc.), pose a hazard to navigation and fishing, especially downcurrent, and result in biota degradation which yields toxic end-products. Oil on beaches creates a hazard for animal life (i.e., birds losing their insulation and buoyancy). Further, there is the possibility of oil contamination of the food chain via fish to man, and environmental and occupational hazards as a result of a blowout. Necessary onshore facilities create socioeconomic as well as additional environmental problems.

Probable Solutions

Accidental spillage can be reduced through additional training in prevention practices. The passage of the FWPCA and the Coastal Dumping Law placed stricter controls on industrial and municipal waste disposal and effluent release. Various sorbents, booms, skimmers, oil/water separators, and chemical dispersants have been used to clean up water/oil spills. Solutions to these issues, especially oil spills, are very site-specific. Problems related to necessary onshore facilities can be ameliorated by careful location, design, and planning.

Legislative/Regulatory Background

The Outer Continental Shelf (OSC) Lands Act of 1953 , as amended in 1975, authorizes the Secretary of the Interior to lease submerged lands of the Continental Shelf for the exploration and production of oil, gas, and other minerals. Under the Act, regulations concerning the prevention of waste and conservation of natural resources are to be promulgated. Oil and gas operators are to utilize the best available technology by well-trained personnel to achieve the safest possible operations in OCS development.

The FWPCA (1972) as amended by the Clean Water Act of 1977, contains provisions relating to the effluents from extraction of offshore petroleum and natural gas. Oil or hazardous substances are forbidden from being discharged (in any quantity which the President determines will endanger public health or welfare, fish/wildlife, shores, and beaches) into or upon the navigable waters or adjoining shorelines of the U.S. Facilities that have discharged or could reasonably be expected to discharge oil in harmful quantities must prepare a Spill Prevention Control and Countermeasure Plan (SPCC plan). The Plan should include a list of prevention equipment and a written commitment of manpower, equipment, and materials that will be used to control and remove a potential spill.

The Coastal Zone Management Act of 1972 was enacted to establish a national policy and to develop a national program for the management, beneficial use, protection, and development of the land and water resources of the Nation's own costal zone management programs. The management program for each coastal state must identify the boundaries of the coastal zone and define permissible land uses within that zone. Any federal agency conducting or supporting activities directly affecting the coastal zone, such as OCS leasing, should comply with the approved state management program. Any applicant for an OCS permit must provide in the application a certification that any proposed activity will be conducted in a manner consistent with the state program. Some of the conditions that must be met before a development permit can be granted are defined for the State of California and, in most cases, applicable to all other states. These conditions include: (1) consolidation of new and expanded facilities to the maximum extent feasible in order to reduce the number of producing wells, support facilities, etc.; (2) development consistent with the geologic conditions of the well site; and (3) the use of environmentally safe and feasible subsea completions when drilling platforms or islands would substantially degrade coastal visual qualities.

The OCS Lands Act Amendment of 1978 requires separate filing of exploration and development plans, each with an EIS. This, in conjunction with the Coastal Zone Management Act of 1972 (which requires operators filing exploration and development plans in each case to certify that the activity is consistent with the State Coastal Zone Mangement Act), and the Marine Protection Research, and Sanctuaries Act of 1972, as amended (setting aside sections of the ocean as marine sanctuaries) represents legislation which will add to the already strong lobby for environmentalists.

Under Sections 301 and 304 of FWPCA relating to the effluents from extraction of offshore petroleum and natural gas, EPA has developed two sets of uniform effluent guidelines: the first set describes the best practicable control technology currently available (BPCT) to be applied by 1977, and the second set consists of the best available technology (BAT) to be applied by 1983. The guidelines were developed for two areas offshore; the near-offshore (state waters usually within 3 miles), and the far-offshore (federal waters usually beyond 3 miles, also termed the outer continental shelf). The following regulations for pollution as a result of far-offshore oil and gas production were proposed by the EPA: 72 ppm of oil for BPCT and 48 ppm for BAT. The zero discharge alternative goal for 1983 has been abandoned by EPA for the far-offshore area as it was considered excessively restrictive and economically impractical (NAS, 1977). The near-offshore area is regulated by the BAT requirements of zero discharge.

U.S. Coast Guard regulations through the U.S. Ratification of International Maritime Consultative Organization Treaty Conventions act to reduce accidential spillage through additional training in prevention practices. The FWPCA, the Ocean Dumping Act, and the Coastal Zone Management Act of 1972 provide for stricter controls on industrial and municipal waste disposal and effluent release.

The Department of the Interior, specifically the Bureau of Land Management and the U.S. Geological Survey, can impose conditions on the leases themselves. Other measures affecting leases are in the Code of Federal Regulations and are based mainly on provisions contained in the Geneva Convention on the continental shelf, the OCS Lands Act, and NEPA. The OCS Lands Act defines the relationship between the federal government and various coastal states regarding jursidiction over the outer continental shelf beyond the 3-mile limit. The Geneva Convention on the continental shelf defines the jurisdictional rights of nations on the continental shelves.

NEPA requires consideration of air quality and water quality impacts prior to OCS leasing.

Other acts that could affect OCS operations are:

- The Clean Air Act, as amended
- The Ports and Waterways Safety Act, as amended
- The Endangered Species Act
- The Occupational Health and Safety Act

The states have jurisdication of OCS oil development within 3 miles of their shores. Although the majority of OCS land is in federal control, much of the OCS activity is indirectly regulated by the states because they control the onshore support facilities. Many coastal states have neither OCS oil development nor a definitive coastal zone policy. However, California and New Jersey have well-defined coastal zone plans. Both states allow industrial development in coastal zones only when no reasonable alternative locations exist and when adverse environmental effects are mitigated to the maximum extent feasible. Most states with coastal zone plans follow this basic California and New Jersey format.

California specifically addresses oil and gas development in coastal zones. Some of the conditions that must be met in California before a development permit will be granted include: (1) consolidation of new and expanded facilities to the maximum extent feasible in order to reduce the number of producing wells, support facilities, etc.; (2) development consistant with the geologic conditions of the well site and; (3) the use of environmentally safe and feasible subsea completions when drilling platforms or islands would substantially degrade coastal visual qualitites. California also has provisions governing tanker terminals that could impact on OCS oil development. These provisions encourage multicompany use of existing and new tanker facilities, except where such use would result in increased tanker operations and associated onshore development incompatible with the land use and environmental goals for the area. Also encouraged is the siting of new tanker terminals sufficiently offshore as to avoid risk to environmentally sensitive areas.

Although the coastal states have varying policies regarding OCS oil development, they recognize that offshore oil is an important component of the nation's energy supply. Hence, OCS oil development will be permitted, and sometimes encouraged, but with reasonable environmental constraints.

Possible Future Regulatory Actions and Their Impacts

OCS leasing will be the major issue in the future. The Bureau of Land Management has the authority to impose conditions on OCS leases. Thus, the potential for future regulatory action is present. However, the extent to which these regulations may be applied retroactively to existing leases is not known.

In addition to complying with present regulations, possible future regulatory action may require that industry utilize alternative drilling technologies to demonstrate methods of avoiding environmental and human health impacts before an OCS lease is granted.

Prior to the granting of an OCS lease, it could become increasingly necessary to develop a thorough environmental impact statement which evaluates the location and design of total offshore drilling (including crude oil/gas transport to shore) as well as onshore facilities. Other future regulatory actions may include: federal and state guidelines on public participation and cost/benefit analysis, increased emphasis on the NEPA process involving indirect effects (onshore developments), as well as alternatives and preparedness requirements for emergency measures.

In addition, there is an ongoing controversy over whether the granting of an exploratory lease should automatically entitle the leasee to a developmental lease. The debate centers around the possibility of discovering that the leased area is environmentally much more sensitive than believed prior to the exploratory lease (UCLA, 1976).

Time Frame for Future Regulatory Action

The acquisition of an OCS lease will still be the major factor upon which future legislative/regulatory action will depend. Presently, OCS is well regulated; thus there is little likelihood that it will be subject to any further legislative action in the foreseeable future. The Bureau of Land Management has the authority to impose conditions on OCS leases, thus indicating the ever present potential for future regulatory action. However, any future regulations will be largely dependent upon economic trends.

4.7 Emission of Trace Elements

Description of Issue

The magnitude of 20 to 50 trace element emissions and the accompanying effects on man and the environment will increase as more coal-fired power plants and new commercial coal gasification and liquefaction facilities come onstream. Currently, the elements of major concern are beryllium, flourine, arsenic, selenium, cadmium, lead, mercury, nickel, and chromium (Yeh et al., 1976).

The issue of trace element emissions originates mainly as a result of the extraction and conversion process modules within the coal technologies. Direct coal combustion currently emits trace elements, and coal gasification and liquefaction commercial facilitites could contribute significant trace element emissions by the year 2000.

During resource extraction, the trace element discharges result from acid mine and alkaline mine drainage in the eastern and western regions of the U.S., respectively. Some trace elements dissolve under acid conditions and escape into surface waters during runoff. Also, trace elements can leach into the soil beneath extraction areas and escape into the groundwater supply. The number of elements involved, the chemical form in which they exist, and the mechanism by which they migrate into the water supply systems are not entirely understood at this time.

The source and route of the trace element emissions within the conversion module for direct coal combustion is better understood; however, there are information gaps in this area as well. The sources of trace element emissions for direct combustion are bottom ash, fly ash, and vapors in the flue gas (Radian Corporation, 1975). The less volatile trace elements remain with the bottom ash which is generally disposed of by sluicing to ponds, direct burial, or landfill. Fly ash collected by emission control devices (cyclones, baghouse filters, electrostatic precipitators, and scrubbers) is usually combined with bottom ash; however, small amounts of fly ash containing trace elements escape as airborne particulates. The elements Be, As, Se, Cd, Pb, Ni, and Cr appear both in fly ash and bottom ash (Attari, 1973). Also, some trace elements (Hg, Se, F) vaporize completely and escape directly with the flue gas (Sather et al., 1975). The sludge disposal of absorbents (e.g, lime/limestone) used in scrubbers contributes significantly to the trace element problem. The route for trace element emissions is either directly into the atmosphere via the flue gas or indirectly into the soil, surface or groundwaters via solid waste disposal. The chemical forms of the trace elements and the migration mechanisms from ash ponds or landfill through the soil and into the groundwater are not fully understood.

Coal gasification and liquefaction conversion processes will emit trace elements from gasifier slag and ash, filtrate sludges, and downstream gaseous and aqueous processing effluents. Since there are numerous gasification and liquefaction processes under consideration, each system will undoubtedly undergo scrutiny of its individual trace element emission sources.

Trace element emissions affect air and water quality which, in turn, affect human health and animal and plant life, both terrestrial and aquatic. The majority of trace element emissions will eventually reside in ground and surface waters and in the soil. The main concerns about trace element residuals involve plant uptake and contamination of drinking water (both surface and groundwater). The daily human intake of Cd, Hg, and Pb are already approaching dangerous levels, and these elements could pose health hazards, and carcinogenicity in some cases, with increasing coal utilization (Heit, 1977). Very little is known of the synergistic effects between trace elements and other organic and inorganic compounds in the atmosphere and water, or of their combined effects on human health.

Probable Solutions

Technical solutions exist today which can reduce the impact of trace elements on the environment and human health. The recent Surface Mining Control and Reclamation Act of 1977 should affect levels of mine drainage and strengthen reclamation practices for existing and new mines. Clay-lining in ash ponds will serve as an impervious layer to reduce trace element migration into soils and subsequently into surface and groundwaters. Certain emission control systems (such as baghouse filters) may increase element retention on fly ash and reduce vaporized elemental air emissions (Yeh et al., 1976). Boiler configuration and firing practices affect fly ash and bottom ash distribution. The possible use of bottom and fly ash in cinder blocks or highway construction would greatly reduce the potential impact of trace elements. The above practices treat the problem after the coal has been combusted, gasified or liquefied. Perhaps there will be future pretreatment methods which could selectively remove or reduce trace elements before and during utilization.

Legislative/Regulatory Background

There has been limited specific federal legislation concerning trace element pollution. There is, however, legislation which indirectly affects trace elements.

The CAA of 1970 and its amendments of 1977 provide a basis for regulating trace elements emissions through NESHAPS. There are already standards for beryllium and mercury air emission from certain stationary sources. However, coal-fired power plants are not currently one of the stationary sources regulated by NESHAPS.

RCRA (1976) has provided the basis for future regulation concerning those elements in solid waste. This Act would establish guidelines for the collection, transport, separation, and disposal of hazardous wastes. Proposed guidelines for the identification of hazardous waste include a toxicant extraction procedure that specifically addresses trace elements regulated under SDWA.

TSCA (1977) provides a basis for future trace element regulatory action in that all products and by-products (including waste) are subject to review. This review may include testing requirements to identify possible hazardous substances in products and by-products. Also, the disposal of potentially harmful chemical substances or mixtures is subject to review under TSCA.

The Federal Mine Safety and Health Amendments of 1977 makes provision in Section 101(a) that the Department of Health, Education, and Welfare should perform special research on potentially toxic substances on a continuing basis as input to the standard-setting procedure. This provides a basis for regulations concerning trace elements exposure to coal miners.

Under Section 1910.1000 of OSHA, worker exposure to some trace elements and their compounds is regulated.

There are water quality criteria establishing limits for 10 to 15 trace element concentrations for both surface and irrigation water which could be incorporated into the FWPCA (See Table 4-1).

Section 141.11 of the SDWA establishes maximum contaminant levels for inorganic chemicals which include arsenic, barium, cadmium, chromium, lead, mercury, selenium, and flouride (See Table 4-2).
The Surface Mining Control and Reclamation Act indirectly affects trace element water emissions by strengthening regulations involving acid and alkaline mine drainage.

Many states have set maximum water concentrations for various trace elements. These limitations often exceed any federal criteria and standards. Montana has different acceptable concentration levels for different waterways, such as the Clark Fork River (mainstream) from the confluence of Warm Springs Creek to the confluence with Cottonwood Creek. North Dakota is divided into three water quality classes. Each class sets specific limits for trace element concentrations. The most stringent class sets the same limitations as the federal SDWA. Additional state limitations are set on boron and copper. West Virginia has set more stingent standards on arsenic (0.01 mg/l) and barium (0.50 mg/l) than has the SDWA.

Arizona has established trace element standards for cold and warm water fisheries. These are the most stringent standards of all the states surveyed and are shown in Table 4-3. Illinois has trace elements standards for public and food processing water supplies, as well as effluent standards for water discharges.
Kentucky, Ohio and Virginia have trace element standards for public water supplies. In addition, Ohio has established standards for Lake Erie.

Many states have no air quality standards for trace elements because not enough sources emit trace elements in sufficient quantity to require regulation. However, several states have begun to address the problem. The state of Colorado has listed in its regulations the value set by the 35th Annual Meeting of the American Conference of Governmental Hygienists. These values are shown in Table 4-4.

TABLE 4-1. WATER QUALITY CRITERIA

Element	Surface Water (mg/l)	Irrigation Water (mg/l)
As	0.05	1.0
Ba	1.0	-
B	1.0	0.75
Cd	0.01	0.005
Cr	0.05	5.0
Pb	0.05	5.0
Mn	0.05	2.0
Mo	-	0.005
Ni	-	0.5
Se	0.01	0.05
V	-	10.0
Zn	5.0	5.0
Cu	1.0	0.2

TABLE 4-2. SAFE DRINKING WATER LEVELS

Element	Maximum Level (mg/l)
As	0.05
Ba	1.0
Cd	0.01
Cr	0.05
Pb	0.05
Hg	0.002
Se	0.01
F*	2.4 - 1.4

*Dependent upon air temperature over water supply (54-91°F)

TABLE 4-3. ARIZONA TRACE ELEMENT STANDARDS FOR COLD AND WARM WATER FISHERIES

Element	Limiting Concentrations (mg/l)
Arsenic	0.05
Barium	0.50
Cadmium	0.01
Chromium (Hexavalent)	0.05
Copper	0.05
Cyanide	0.10
Lead	0.05
Mercury	0.005
Selenium	0.01
Silver	0.05
Zinc	0.50

TABLE 4-4. COLORADO AMBIENT AIR QUALITY STANDARDS FOR TRACE ELEMENTS

Element	ppm	mg/m^3
Arsenic	-	0.5
Barium	-	0.5
Beryllium	-	0.002
Bromine	0.1	0.7
Cadmium	-	0.05
Copper fumes	-	0.2
Copper dusts & mists	-	1
Fluorine	1	2
Hafnium	-	0.5
Iodine	0.1	1
Lead	-	0.15
Mangense	-	5
Mercury (alkyl compounds)	-	0.01
Mercury (all other compounds)	-	0.05
Molybdenum (soluble compounds)	-	5
Molybdenum (insoluble compounds)	-	10
Nickel	-	1
Selenium	-	0.2
Silicon	-	10
Silver	-	0.1
Tellurium	-	0.1
Thallium	-	0.1
Tin	-	0.1
Tungsten (soluble compounds)	-	1
Tungsten (insoluble compounds)	-	5
Uranium	-	0.2
Vanadium dust	-	0.5
Vanadium fume	-	0.05
Yttrium	-	1
Zirconium	-	5

Montana now lists ambient air quality standards for lead and beryllium. Beryllium will probably be dropped from the list and arsenic added. Pennsylvania, in setting its regulation, attempts to identify the waste source before setting standards. Thirty-day standards have been set for lead (5 ug/m^3).

Texas has a 24-hour ambient air quality standard of 0.01 ug/m^3 for beryllium. New Mexico and Kentucky have also adopted this standard, except that the averaging period is 30 days. In addition, Kentucky has established emission standards for beryllium and mercury of 10 grams and 3200 grams per 24-hour period, respectively, from any source.

Possible Future Regulatory Actions and Their Impacts

Future NESHAPs standards could include beryllium, mercury, cadmium, arsenic, and other trace trace element air emissions from coal-fired power plants and coal gasification and liquefaction plants. OSHA standards for worker exposure to trace elements and their compounds would apply to future coal gasification and liquefaction plants, and these standards may be altered depending upon further investigation. Also, NAAQS for some trace elements could evolve, and the standards could be more stringent than the OSHA standards.

The present criteria for trace element concentrations in irrigation and surface water could be promulgated under the FWPCA. Also the current list of elements under the SDWA could be lengthened to include other possibly harmful trace elements. RCRA could eventually classify coal ash as a hazardous substance, thereby regulating the waste disposal procedures for this material and indirectly affecting trace element discharges to surface and groundwaters. TSCA may eventually affect both the coal ash waste by-product and the final saleable product because of trace element content in these materials. Since the National Energy Plan stresses increased coal utilization via existing and new coal technologies, there will be a significant increase in the release of trace elements into the environment. Detailed field and laboratory studies should shed knowledge on the chemical forms, the hydrologic and atmospheric pathways, and the human health and environmental effects of these trace elements.

Time Frame for Future Regulatory Action

Although there is much enabling legislation for future regulations, there are many questions concerning air, water, and solid forms of trace element pollutants. Areas which will require major research efforts include trace element chemical forms, mechanisms and pathways into the environment, and their health and welfare effects. Also, other than direct coal combustion, the fossil fuel energy technologies (principally coal and oil shale) which would emit trace element pollution are not yet commercially developed. Much information concerning various trace elements forms and sources of pollution will be obtained from pilot plant operations of these emerging technologies.

It is probable that the earliest regulation of trace elements would come from the CAA in the form of NESHAPS or the FWPCA for the direct combustion of coal. A proposed NESHAP for arsenic will be forthcoming from EPA. Also, there may be NSPS for cadmium. With the increased use of coal called for in the National Energy Plan, direct combustion will emit all forms of trace element pollution in increasing amounts. Under the FWPCA Amendments of 1977, EPA can establish effluent limitations based on best available technology (BAT) or effluent standards for 65 classes of toxic pollutants. Within these 65 toxics are 12 trace elements which include arsenic, beryllium, cadmium, lead, mercury, nickel, thorium, antimony, copper, selenium, silver, and zinc. An effluent limitation based on BAT must be met by July 1, 1984, and these limitations may be different for different industries. An effluent standard would apply to all categories of discharges designated by EPA, and compliance with these standards would be required one to three years after final promulgation. Given these two strong legislative bases and increased coal consumption, it is likely that some action may occur by 1985 concerning trace element pollution for direct coal combustion.

As new fossil fuel technologies develop, existing regulations and amendments to legislation should address all forms of trace element pollution. Coal liquefaction and gasification and oil shale retorting will be the most likely technologies to develop commercially before the year 2000. The rate of commercial development will influence the legislative/regulatory action for these technologies. Some regulatory action affecting coal gasification facilities should occur by 1985. Coal liquefaction will probably not be commercially developed before 1985; therefore, the likelihood of regulatory action before then is small. However, certain regulations now being considered could be applicable to new technologies. For example, if a NESHAP for arsenic is promulgated then it could be applicable to oil shale retorting as this technology becomes commercialized.

4.8 Groundwater Contamination

Description of Issue

The problem of groundwater contamination will become an important consideration in the commercialzation of in situ coal gasification and in situ and surface oil shale retorting. The principal degradation of water supplies results from the in situ process by-products and leaching of salts and trace elements into the exposed aquifers and surface waters.

The major pollutants from in situ coal gasification will be organic compounds, inorganic salts, and trace elements (Radian, 1977a). The organic pollutants are formed as condensates during the combustion and gasification process. Lighter, more volatile components rise to the surface with the gas, but heavier components such as phenolics, weak organic acids, and tar fractions (mainly pyridines, anilines, and quinolines) condense in the coal seam and exposed aquifers. The pathway for contamination by inorganic salts and trace elements is through dissolving and leaching of coal ash produced from the in situ gasification process. The inorganic salts contribute to a higher dissolved solids content in the groundwater. Some trace elements of concern are arsenic, cadmium, lead, nickel, and chromium (Massey et al., 1976).

The major pollutants associated with in situ and surface shale oil retorting are the organic compounds from in situ retorting, and the leached salts and trace elements from in situ and surface retorting. Organic condensation will occur for in situ shale oil retorting in the same manner as in situ coal gasification. The main organic pollutants will be phenolics and weak acids, but the individual contaminants will vary with shale quality and process conditions. The retorted shale, both above and below ground, will contain inorganic salts (mostly sulfates, carbonates, and chlorides of sodium, magnesium, and calcium) and trace elements which are released to the groundwater by leaching (Crawford et al., 1977). Snowfall and the resulting melt or heavy storms and runoff may leach the salts and trace elements from the exposed piles of surface retorted or processed shale (CSU, 1971). Should alkaline absorbent sludges and spent catalysts be disposed of in conjunction with the processed shale, there will be additional inorganic salts, organic contaminants, and trace elements which could leach into ground and surface waters.

The two major issues associated with these and other pollutant technologies are public drinking water contamination and increased salt and other pollutant loading of the local and regional water systems. These two issues span the range of impacts on resources, the environment, and human health.

The contamination of public drinking water with organic compounds and trace elements destroys a valuable resource and impacts on human health. The acids produced in the in situ coal gasification and in situ shale retorting lower the pH of the groundwater (Fleming, 1976). Water with low pH solubilizes some trace elements and increases their concentrations in the drinking water. The chemical forms of the trace elements and the mechanisms by which they leach into the groundwater are not well understood. Toxic organics and trace elements may enter the food chain through absorption by crops and aquatic systems. Some of these organics and trace elements are carcinogenic as well as harmful to local plant and aquatic life.

The salt loading of groundwater systems affects both resources and human welfare. The primary areas of known recoverable oil shale reserves are also areas of limited water resources. The Green River and Unita Basins of Utah, Wyoming, and Colorado contain the richest, most accessible oil shale deposits, and the Green, Whits, and Upper Colorado River systems drain from these areas. The increased salt loadings due to groundwater leaching and surface runoff from processed oil shale will directly affect the water availability for downstream uses such as crop irrigation. Crops have different salinity tolerances, and an increase in salt loadings could reduce or enven eliminate certain agriculture products. This crop shortage or nonavailability could indirectly affect human welfare, causing increased product prices and water allocation problems (White et al., 1977).

Probable Solutions

The basis for solving or reducing the problems of groundwater contamination via these coal and shale oil technologies is a more thorough understanding of the specific identity (chemical form), concentration, and transport mechanisms involved. Establishment of baseline conditions and constant monitoring of changes in water quality will help in identifying the individual contaminants and their concentrations. Monitoring changes in flow patterns or rates of groundwater flows due to subsidence or interconnection of aquifers will further aid in understanding how these contaminants are transported. Knowledge of the sorptive properties of porous media, including the coal and oil shale themselves, will help form a basis of understanding concerning the pollution of groundwater. Higher recovery efficiencies of organic condensates produced by in situ gasification and in situ retorting will reduce the level of these pollutants. Erosion control measures including compaction, revegetation, drainage systems, and impoundments will reduce leaching and runoff from processed oil shale.

Legislative/Regulatory Background

The two major acts that have dealt with groundwater contamination are the SDWA of 1974 and the FWPCA of 1972 and its subsequent amendments (1977). Section 141.11 of the SDWA established maximum contaminant levels for inorganic chemicals which include arsenic, barium, cadmium, chromium, lead, mercury, selenium, and flouride. This act also established maximum contaminant levels for some organic compounds which include endrin, lindane, methoxycholor, toxaphene, and two cholorphenoxy compounds. In February 1978, three other organic compounds were proposed for interim primary drinking water regulation. The three compounds were the trihalomethanes: chloroform, bromoform, and dibromochloromethane. The maximum contaminant level (MCL) for all three compounds was set at 0.10 mg/l(100 parts per billion). This set of proposed regulations also requires a treatment technique using granular activated carbon (GAC) for further control of synthetic organic chemicals associated with industrial pollution and urban and agricultural runoff which could contaminate drinking water. The SDWA also provides that underground sources of drinking water be protected by establishing minimum requirements for state programs to prevent waste disposal via underground injection.

Presently, there are water quality criteria establishing limits for 13 trace element concentrations of both surface and irrigation water which could be regulated under the FWPCA. Also, in July 1976 there were 65 classes of toxic compounds which could also be included for water quality criteria under the FWPCA. These toxics include several trace elements (beryllium, mercury, thallium, antimony, and silver) and organic compound (phenols, nitrophenols, benzene) which are known pollutants associated with in situ coal and oil shale technologies. Standards for these 65 toxics may take the form of effluent limitations for particular industries under the NPDES.

Another important act that could indirectly affect groundwater is RCRA of 1976. This act, in requiring standards for the disposal of hazardous solid wastes, would protect groundwater from contamination through leaching.

Most states have regulations which allow water discharge into a well only when it does not impair the quality of the receiving aquifer. The procedures and standards set forth in the federal SDWA are generally more stringent than state standards.

New Mexico has established standards for groundwater that set limits on the concentration of trace elements, radioactivity, phenols, sulfate, and total dissolved solids.

Possible Future Regulatory Actions and Their Impacts

In order to prevent or reduce groundwater and subsequent surface water contamination, there will be various future regulatory actions by both the federal and state governments.

Spent catalysts, scrubber sludges and processed oil shale may eventually be regulated as hazardous substances under the RCRA. This act will regulate the methods of disposal and handling of such hazardous materials in the solid waste so as to prevent groundwater contamination.

The proposed list of trace element pollutants in irrigation and surface water under the FWPCA will be promulgated and additional elements may be included as these technologies develop.

Future treatment techniques and standards for organics (such as phenols and anilines) in drinking water could be promulgated under SDWA. The *in situ* coal and oil shale processes could be regulated similar to deep injection wells under SDWA in order to protect groundwater, and abandoned *in situ* sites might have to undergo a stringent closing-off process.

Use allocations for groundwater co-located with coal or oil shale activities could be decided under the Water Resources Planning Act. This allocation could alter the extent of coal and oil shale technologies in certain regions.

New mining laws might be enacted to permit subsurface burning which occurs in the in situ coal and oil shale processes. These laws may require stringent procedures for closing or sealing off in situ sites.

These future regulations could impact the economics and the extent of commercialization regulations, and strict disposal practices could alter the future growth of these technologies.

Time Frame for Future Regulatory Action

The basis for future regulations concerning groundwater contamination via in situ coal and oil shale technologies lies within the framework of SDWA and the FWPCA and its amendments. Trace elements and organic compounds are recognized as harmful surface and drinking water pollutants, and some of these are currently regulated under these acts. For in situ coal gasification, one of the major pollutants is phenols, and this family of compounds is listed as one of the 65 toxics in the FWPCA. It is possible that regulations concerning trace elements and organics will be developed for these technologies by 1985, but further pilot plant testing is required to determine the various specific pollutants and their pathways into aquifers and groundwater systems.

The spent catalysts, scrubber sludges, and processed oil shale from these technologies may eventually be regulated as hazardous wastes under RCRA. This act will regulate the methods of disposal and handling of hazardous materials in the solid waste. Due to the numerous unknowns associated with the specific wastes from these technologies and the lack of specific regulations within these acts, it is unlikely that specific action will occur before 1985.

Entirely new legislation may be required concerning subsidence, subsurface burning, and sealing off unproductive in situ coal and oil shale production sites. The background for this legislation would require much more knowledge, via pilot tests of _in situ_ processes, so that there may not be regulatory action before 1990.

4.9 Liquefied Natural Gas (LNG)

Description of Issue

Relatively small amounts of LNG are now imported into the U.S., but with growing energy requirements and air quality concerns, the demand for this clean-burning fuel will increase. The safety and environmental issues concerning LNG relate to the transportation, storage, and regasification before distribution and end use. Natural gas is liquefied by a refrigeration (-260°F) cycle at atmospheric pressure. The LNG is then transported via huge, specially designed and insulated tankers to a receiving terminal. These terminals consist of an off-loading pier or pipeline system, an onshore storage facility, and a regasification plant. The off-loading system consists of a berthing place for the tanker and a trestle or pier which supports a pipeline network to the storage area. The storage facility usually consists of a tank farm of specially designed and insulated tanks to store the gas in its liquid state until regasification. The regasification plant usually uses either treated ocean water, river water, or fired heaters to vaporize the liquid gas before pipeline transmission to end use (Research and Education Association, 1975).

The major impacts associated with LNG are plant siting and operation, transportation, and fire hazards. These items affect the environment and human health and welfare. The problems associated with terminal and plant siting are numerous and complex. Important factors include population densities of nearby communities, existing land uses, local geologic stability, local weather conditions, and effects on the marine environment (O'Neil, 1978). Onsite construction would involve dredging certain areas for pier and pipeline rights of way. Also, the air quality of the areas would be temporarily degraded due to regasification plant and storage tank construction. The operation of the regasification facility could possibly affect the air quality and marine environment, depending on how the gas is vaporized. If sea or river water is used to transfer heat to the liquefied gas, huge (several feet in diameter) intake lines would pump water to the plant. Special screening systems (as yet unperfected) would be needed to protect marine life. Also, the water would re-enter the ocean or river several degrees cooler, which could affect local biota or marine organisms. Should fired heaters be used in heat transfer, there would be accompanying air quality problems with NO_x, SO_x, hydrocarbons, and particulates. Increased water traffic and air pollution emissions from tankers would accompany the transportation of the LNG to specific ports. The ever-present possibility of a major fire, either with transportation or at the site itself, is a major safety concern. The possibility of an LNG explosion is presently under investigation; however, it is highly unlikely that LNG will explode under any circumstances (Aulf, 1978).

Probable Solutions

There are numerous ways to minimize the impact of an LNG facility. Coordination and proper scheduling of ship traffic for a local area will eliminate collision risks and prevent delays at the terminal. Alternative forms of vaporization, using solar technology, could eliminate or reduce the marine and air quality impacts. Proper venting and recirculation of natural vapor losses will prevent fugitive emissions and possible fire hazards. Careful studies and prudent judgements as to proper siting of the facility will reduce socioeconomic problems.

Legislative/Regulatory Background

There is no current specific federal legislation regarding LNG import quotas or terminal siting. The Department of Energy Organization Act of 1977 delegates authority to the Federal Energy Regulatory Commission concerning environmental safety issues for siting LNG facilities, but there are no specific regulations involved.

Indirectly the design, safety equipment requirements, and the traffic control of LNG tankers is regulated under Sections 101 and 201 of the Ports and Waterways Safety Act of 1972. This act allows the U.S. Coast Guard to carry out its traffic and safety regulations.

The Coastal Zone Management Act of 1972 provides that coastal states establish a program for the energy-efficient use of the land and water resources of the nation's coastal zones and also the protection of the land and marine resources of these areas. The transportation, conversion, treatment, transfer, and storage of LNG is considered a coastal energy activity under this act. There are several sections (including 304, 305, and 306) which are applicable to individual coastal states and their respective coastal management programs.

The Natural Gas Pipeline Safety Act of 1978 applies to LNG after the it has been regasified and is ready for transport via pipeline. This act provides for federal safety standards for interstate pipelines which transport natural gas. Intrastate pipeline transportation is exempt from this act.

The Natural Gas Act is a much broader act which would indirectly affect LNG. This act proposes that interstate pipeline transportation of natural gas has a special status much like that of a separate business entity or utility, and thus it is subject to various permits and certification procedures regarding transportation and end use.

The Fish and Wildlife Coordination Act of 1934, as amended, would apply to any dredging operations associated with building an LNG terminal. An estimation of the wildlife and aquatic life benefits or losses associated with the new project should be reported to Congress.

The Coastal Zone Management Act of 1972 would also apply to any future LNG coastal sitings. This act provides that economic and environmental studies be coordinated before commercial or industrial use of these areas commences. Also, the Endangered Species Act would apply to any fish or wildlife species which may be endangered by a future LNG site. This current legislation would affect the possible siting and operation of any future LNG facility.

In 1977, the California Legislature passed the LNG Terminal Act. This act grants to the state Public Utilities Commission (PUC) the exclusive authority to issue a single permit concerning the location, construction, and operation of an LNG terminal. The bill requires the California Coastal Commission to identify, evaluate and rank potential sites for an LNG terminal. Due to the uncertainties about the safety of LNG, the Coastal Commission cannot consider sites near populated areas. The Act requires the terminal to be located in an area where there are no more than 10 persons per square mile within 1 mile of the facility and 60 persons per square mile within 4 miles of the facility. After the Coastal Commission has ranked sites, the PUC, if it approves a site, must approve the highest ranked site unless the PUC determines that higher ranked sites could not commence operations in sufficient time to prevent significant curtailment of high priority requirements for natural gas, and that approval of a lower ranked site will significantly reduce such curtailment. If a site is approved, various safety and environmental considerations will have to be followed. These considerations will be enforced as permit conditions.

Possible Future Regulatory Actions and Their Impacts

Recent proposed legislation would require the President to decide the amount of LNG imports for the next 10 years. The proposed LNG Safety and Siting Act (S2273) would develop minimum standards for siting, design, construction, and operation of LNG transportation, storage, and regasification facilities. These standards are similar in nature to those of the Deepwater Port Act.

As is currently being demonstrated in southern California, the siting of an LNG terminal and regasification facility is a complex, controversial, and multifaceted issue. The implementation of increased LNG technology within the U.S. will be influenced by several factors. The projected energy demands for a certain region and the nation will impact LNG imports, and the multitude of environmental and safety concerns for terminal siting will affect the location of individual LNG facilities. These combined concerns for future energy and a safe environment point out the need for federal legislation dealing with LNG imports and the resulting terminals and regasification facilities. This federal legislation, along with specific future state legislation, could significantly affect future levels of LNG imports.

Recently, the Department of Transportation adopted the 1972 edition of the National Fire Protection Association Standard No. 59A, "Standards for the Production, Storage, and Handling of LNG," as part of an interim federal regulation. In April 1977, a draft regulation, "LNG Facilities: Federal Safety Standards," was submitted for public comment by the Material Transportation Bureau's Office of Pipeline Safety Operations. Industry reaction to this proposed regulation was very critical, and it is suspected that the revisions will take some time. In conjunction with these standards, a safety analysis report would be submitted to an appropriate federal agency (DOT or DOE) for final federal approval of any LNG project. This report would contain a description of the nature of the plant, description of plant operations, and safety evaluations and testing that have been performed to protect the public health and welfare.

Time Frame for Future Regulatory Action

It appears likely that all of the proposed legislation and actions discussed above will be take place by 1980. Already, the need for clean-burning natural gas for residential and industrial use is evident on both the East and West Coasts. The Department of Transportation has issued advanced notices of proposed rulemaking regarding LNG siting and safety. Currently, Massachusetts and Maryland have LNG regasification facilities, and there are plans for facilities in the Southern California and Gulf Coast areas. State legislation regarding siting of LNG facilities exists in certain states and could be forthcoming in others.

4.10 Undergound Coal Mining

Description of Issue

Underground or deep coal mining is the method used to extract coal from seams that are relatively distant from the surface (more than 300 feet). It has been called "the most hazardous occupation in the country from standpoint of accidental death, injury, and occupational disease such as coal worker's pneumonconeosis (black lung)" (Hammond et al., 1973).

Coal mining hazards must be a consideration when discussing the impacts of any of the coal conversion technologies since coal obviously must first be mined in order to be used in the technology.

The techniques used in deep mining are the source of numerous health and safety hazards. Mining techniques involve a machine and crew who work several underground rooms at one time, leaving pillars of coal to support the roof. Operations performed by the crew are cutting, drilling, blasting, building roof supports, and loading and hauling the coal and using shuttle cars. The hazards of the occupation result mainly from roof collapses or cave-ins, explosions and fires from coal dust and methane gas, and exposure of workers to toxic materials while they are working underground.

The health hazards associated with roof falls and cave-ins are obvious; severe injury or death involving large numbers of workers may occur. The National Safety Council found the coal mining accident fatality rate higher than for any other occupation examined. There were approximately 0.5 deaths for every million tons of deep-mined coal in 1971.

The major health problem which can be attributed to worker exposure to coal dust is coal worker's pneumonconeosis (CWP), or black lung. Pneumoconeosis is a generic term applied to a group of occupational diseases of the lung caused by inhalation of irritating material. CWP is the response of lung tissue to chronic retention of coal dust generated during extraction. CWP may cause the development of fibrotic tissue around bronchioles and small blood vessels, leading to permanent compression and occlusion of the bronchioles. The prevalence of CWP among working miners is about 10 percent (Penman, 1971).

Decreased pulmonary function and increased chronic bronchitis, emphysema, and lung cancer also occur among coal workers, although environmental factors and smoking habits complicate these figures somewhat. Respiratory diseases are 5 times more prevelant for coal workers than for the general population.

Numerous miscellaneous diseases or afflictions occur among mine workers: (1) dermatoses due to the abrasive nature of coal are common, (2) "beat hand" and "beat knee" occur due to inflammation of the synovial membrane of joints after the trauma of squatting or working in awkward positions, (3) increased incidence of rhematoid diseases occurs due to awkward working positions, (4) more orthopedic diseases (particularly of the spine) are observed, (5) more allergies occur, and (6) Weil's disease, a spirochettal infection spread by the urine of rats in coal mines, is quite common.

Aside from known hazards, the coal workers may be exposed to some toxic materials whose effects are unknown. Raw coal is known to contain uranium and thorium, as well as trace metals. The degree or worker exposure to radioactivity is not known but may be a potential health problem. Trace elements and organics in coal may be volatilized by the heat of extraction machinery and be made available for inhalation by workers. Some trace elements and organics are known to be carcinogens and may also exert other toxic effects.

Probable Solutions

Solutions to coal mining safety hazards deal mainly with adherence to safe work practices set down by the 1977 Federal Mine Health and Safety Act. Dust control and ventilation (to control methane and coal dust, thus reducing explosion hazards) are safety measures of major importance. Improvements in equipment maintenance, roof bolting procedures and supervising of mining operations also contribute to a safer workplace.

Prevention of worker exposure to toxic materials in coal mines is more difficult. Respirators are effective in excluding coal dust, but because they are hot, uncomfortable, and difficult to breath through, they are usually not used as recommended. Also, their usefulness in preventing exposure to radioactive materials and other toxic compounds in coal is probably quite minimal.

Limiting the concentration of respirable dust in the mine atmosphere is probably the best solution for preventing coal-related health problems. The Federal Mine Health and Safety Act has set a mandatory interim health standard of 2.0 mg/m^3 of respirable dust in the mine atmosphere averaged over each shift during which a miner is exposed. The 2 mg/m^3 may not be adequate protection, however, and the standard will probably be made more stringent. The presence of radioactive substances such as 222Rn in the mine atmosphere is most effectively controlled through adequate ventilation.

Legislative/Regulatory Background

The Federal Coal Mine Health and Safety Act of 1969 was the first federal legislation addressing both the health and safety hazards of coal mining. Prior to 1969, all laws related to coal mining dealt with safety measures and failed to emphasize the health hazards associated with the occupation.

The 1969 Act endeavored to protect the health and safety of persons working in the coal mining industry by (1) establishing interim health and safety standards and directing the Secretaries of the Interior and HEW to develop and promulgate improved health and safety standards, (2) requiring that coal mine operators and coal miners comply with such standards, (3) cooperating with and providing assistance to the States in development and enforcement of effective state coal mine health and safety programs, and (4) improving and expanding research and development and training programs aimed at preventing coal mine accidents and occupationally caused diseases in the industry.

The Coal Mine Health and Safety Act may have been the prototype for the Occupational Safety and Health Act (OSHA) of 1970, a general health and safety law extending to all industries, including the mining industry. The purpose of OSHA was to develop occupational safety and health standards for various industries.

In 1977, the Federal Mine Safety and Health Act was enacted. The Act addressed the same topics as the 1969 Federal Coal Mine Health and Safety Act but many of its health and safety standards were revised. The mandatory safety standards cover such topics as roof support, ventilation, electrical equipment, fire protection, explosives, and emergencies but are much more comprehensive than in the 1969 Act. The mandatory health standards deal with noise, medical examinations, use of respiratory equipment, dust containing quartz, and respirable coal dust. Most of these standards were revised and made more stringent or comprehensive. However, the 1969 interim repirable dust standard of 2.0 milligrams/m^3 of air in the mine atmosphere during each work shift was left unchanged in the 1977 Act and is now considered final.

OSHA (1970) covers health and safety aspects of all industries in general. Coal mining practices are therefore required to comply with safe work practices described by this act. Specific OSHA regulations for coal dust are:

Coal dust (respirable fraction 5% SiO_2) - 2.4 mg/m^3

Coal dust (respirable fraction 5% SiO_2) - 10 mg/m^3

Pennsylvania, West Virgina and other states with underground coal mining have comprehensive mining laws. These laws have an exhaustive list of mining health and safety regulations. Included in the list are provisions for roof support, dust control, ventillation and handling of explosives. These state laws are used in conjuction with federal law to regulate the health and safety of underground coal mining.

Possible Future Regulatory Actions and Their Impacts

The health and safety impacts of deep coal mining are large and must be addressed before any great expansion of the industry can occur. As the demand for coal for new technologies increases, the environmentalists and miners' unions may join forces to obtain legislation more protective of the environment and of miners' health and safety. The interim health and safety standards set by the 1977 Mine Health and Safety Act will probably be followed eventually with regulations which are much more strict; the 2 mg/m^3 respirable dust standard could be revised by as much as an order of magnitude. Miners likely will also insist on shorter working hours, higher pay, and possibly very expensive technological solutions to their health problems.

The impact of these regulatory actions on the coal industry may include: increased coal costs; bias toward development of in situ coal and shale oil conversion; bias toward development of eastern and western coal reserves which can be surface mined (there will be restrictions on western surface mining also, however, because of environmental problems and water scarcity problems); and delays in expanding underground coal supplies with a resultant delay in the development of new technologies that use the coal.

Time Frame for Future Regulatory Action

It is unlikely that the health and safety standards set by the 1977 Federal Mine Health and Safety Act will be followed by more stringent health and safety standards before 1985. It is more likely that this will occur by 1990. The revision of the standards will probably involve the 2 mg/m^3 respirable coal dust standard which may be tightened considerably.

Any revisions of this standard are to be based on epidemiologic and feasibility studies which take a long time to complete. Also, NIOSH is currently conducting a chest and x-ray monitoring program of coal miners which will be completed in 3 years; unsatisfactory findings from these x-rays would be cause for revision of the coal dust standard as well.

There is already some speculation from individuals in the occupational health professions and within the federal Mine Safety and Health Administration as to the adequacy of the coal dust standard for preventing long term health effects. It is thought that it will be 8-15 years before enough information is accumulated to set a final health standard. If the standard is changed at that time, it could well be revised downward, possibly by as much as an order of magnitude.

Other candidates for future regulation are radiation and numerous potentially toxic substances present in the mine atmosphere. Radiation is not at present considered a problem in coal mines. However, it is likely that the allowable radiation levels in all working environments will be lowered as time goes on, and this may lead to specific regulations for coal mines. NIOSH is preparing criteria documents on some of these compounds, the results of which may lead to further regulation of them. Of particular concern are certain trace elements and oxides of nitrogen from the diesel exhaust of mine equipment.

4.11 Fugitive Emissions From Coal Gasification and Liquefaction

Description of Issue

Coal gasification and liquefaction processes involve the formation of numerous chemical compounds in each of the process steps. High temperatures and pressures used in the processes make it likely for fugitive emissions or leaks to occur from plant equipment. The high temperatures and pressures are themselves a safety hazard to workers, and some of the chemicals released to the work environment may present a health hazard.

The liquefaction and gasification conversion technologies are similar in their emissions and potential hazards. Gaseous emissions in both processes may occur from flanges, valves, ducts, pumps, and seals of high pressure equipment and may include sulfur compounds (SO_2, H_2S, COS, CS_2, thiophenes, mercaptans), nitrogen compounds (NO_x, NH_3, HCN, heterocyclic nitrogen compounds, nitrosamines), trace elements, CO, and aliphatic and aromatic hydrocarbons (including PAHs). Low-Btu gasification may produce more nitrogen compounds (NH_3, HCN, NO_x) than either high Btu gasification or liquefaction because of the use of air in the gasifier rather than oxygen. Low Btu gas also has CO as a major component, and CO could thus be given off in substantial quantities due to fugitive emissions. High-Btu gasification has a methanation step using a nickel catalyst and nickel carbonyl emissions may therefore result (Radian Corporation, 1977b).

Physical safety hazards are basically the same for both liquefaction and gasification processes. Leakage of flammable or toxic liquids, gases or vapors could reach explosive limits quite easily. Also, pressure vessels could fail or pipes rupture due to the abrasive nature of coal, resulting in explosion, fire, or other rapid release of toxic gaseous or liquid products.

Conveyor belts, crushers, high voltage electrical circuits, high working platforms, and numerous other features could result in physical hazards to workers in coal conversion plants.

The health impacts resulting from operation of equipment used in coal conversion plants are obviously physical injury or death. The probability of such accidents occurring is probably somewhat higher than in other industries because of the high temperatures and pressures, and corrosive materials used.

Health hazards related to toxic emissions are more difficult to assess. First of all, there is uncertainty concerning exactly what compounds will be released. Since coal conversion plants are, for the most part, not yet commercialized, little actual monitoring of emissions has been conducted. There is the potential for a variety of compounds to be formed. Emissions will probably vary from plant to plant, and even within plants depending upon the nature of the coal and the conditions at the plant. Emissions of all of the compounds mentioned in the previous sections should be anticipated; however, and their possible effects considered in process design and operational guidelines.

Sulfur oxides may be present in emissions from gasification and liquefaction process streams, and the concentration will vary depending upon the sulfur content of the coal used. SO_2 is an irritant of the respiratory tract and can be oxidized in the ambient air to form sulfuric acid and sulfates.

H_2S may be formed in high concentrations in the immediate vicinity of H_2S-rich process streams and is an acute poison at concentrations above 400 ppm; it is also an eye and respiratory irritant at 10 to 100 ppm and is a nervous system poison which induces respiratory failure. Mercaptans and other thiols have similar effects, as do carbon disulfide and carbonyl sulfide.

Nitrogen compounds produced at coal conversion facilitites include NO_x from high combustion temperatures, nitrosamines, ammonia, hydrogen cyanide, and various heterocyclics. Exposure to nitrogen oxides may cause delayed pulmonary edema; there may also be an association with carcinogenesis. Nitrosamines may be formed from the reactions between nitrogen oxides and amines and are potent carcinogens. Heterocyclic nitrogen compounds may be potentiators of carcinogenesis, as well as being strong irritants and narcotics. Hydrogen cyanide is acutely toxic by asphyxiation at low concentrations. Ammonia is such an intense irritant that acutely toxic doses cannot be voluntarily inhaled.

Trace elements (the main ones being As, Be, Cd, Pb, Mn, Hg, Se, and V) may cause a wide variety of health problems ranging from metabolic disorders to carcinogenesis and mutagenesis. Trace elements may be volatilized due to high temperatures and thus may occur in gas streams in low concentrations.

Carbon monoxide is present in the gas streams of coal gasification and liquefaction plants, and is found in particularly large quantities in low-Btu gasificaton plants. It is a chemical asphyxiant which may produce chronic effects.

Aliphatic hydrocarbons will probably be found at below toxic levels, but may potentiate carcinogenic effects of other compounds. Aromatic hydrocarbons (e.g., benzene, toluene, xylene, etc.) may have narcotic, acute toxicity, or carcinogenic effects. Most PAHs (e.g., benzanthracene, benzo[a]pyrene, etc.) are established skin carcinogens, and less well established respiratory or general carcinogens.

The multifactorial toxic hazards of the above compunds must also be considered. Since they exhibit dissimilar effects, a simple additive toxicity would not be valid. Synergisms may occur as well as antagonisms. Because the probability of occurrence of the various compounds is already uncertain, any prediction of their total effect would also be questionable (NIOSH, 1978).

Probable Solutions

The safety hazards from coal conversion plants can be minimized by adherence to safe work practices, such as isolation or enclosure of dangerous processes, frequent maintenance of equipment, proper personal protective equipment, etc. Continous monitoring of the environment for flammable gaseous emissions may prevent explosion hazards and also may prevent worker exposure to toxic materials. The uncertainties involved in occupational exposure to potential multifactorial emissions make it difficult to suggest solutions to the problem. Environmental monitoring should certainly be conducted at coal conversion plants to determine exactly what compounds are released. At the same time, a well-designed industrial hygiene program should be implemented which can be updated and revised to cover any particularly hazardous emissions that are bound to occur. An industrial hygiene program for coal conversion plants would include engineering controls for hazardous processes, workplace air sampling, and personal hygiene and protection procedures.

Legislative/Regulatory Background

OSHA was passed by Congress and signed into law in 1970 in response to a variety of national issues concerning occupational injury and disease; the rapid rate of appearance in the workplace of new chemicals, processes and forms of stress; and the changing character and demands of the workforce itself. By means of a general duty clause, the act requires that employers in the private sector provide for their employees' "employment and a place of employment which are free from recognized hazards that are likely to cause death or serious physical harm." Furthermore, OSHA was established under the Act as a regulatory agency which promulgates and enforces health and safety regulations and standards; and the National Institute for Occupational Safety and Health (NIOSH) was established as a research agency to develop and recommend standards to OSHA, to publish a list of known toxic substances and the concentrations at which these substances exert their toxic effects, and, as it pertains to achieving these ends, to conduct research and initiate experimental programs.

Under the act, OSHA promulgated in May 1971 a number of general industry health and safety regulations. Many of these general industry standards were based on existing good practice or national concensus standards. New standards are added as promulgated, and standards may be revised or revoked by OSHA.

Portions of these general industry standards are relevant to specific conditions of the working environment within a coal conversion plant and must be complied with. These regulations may be the subject of OSHA inspections, and employers may be cited for failure to comply. In addition, employers may be cited under the general duty clause for other conditions deemed to pose "recognized hazards that are likely to cause death or serious physical harm."

Exposure limits for approximately 40 air contaminants, many of which were adopted by OSHA from national concensus standards, have been issued as part of the general industry standards (29 CFR 1910.1000). Many of the substances which are expected to be present in coal conversion processes are covered by these exposure limits. In addition; OSHA has developed and promulgated permanent standards for 14 carcinogens (29 CFR 1910.1003 - 1017). These carcinogens include 4-nitrobiphenyl, a-naphthylamine, b-naphthylamine, benzidine, 4-aminodiphenyl, ethyleneimine, and N-nitrosodimethylamine.

The Division of Criteria Documentation and Standards Development of NIOSH has responsibility for the preparation of criteria documents on industrial processes and individual substances to which workers may be occupationally exposed. Each criteria document, when completed, is forwarded to OSHA as a recommended standard. OSHA may then review the recommended standard and may revise or promulgate NIOSH's recommendations as a permanent standard. To date, NIOSH has prepared approximately 80 criteria documents, including documents covering many of the substances that would be encountered in a coal conversion plant. At present they remain recommended standards only, since OSHA has not acted on them. Several of these recommended standards are listed below (NIOSH, 1978).

- Sulfur dioxide - OSHA standard is 5 ppm time-weighted average (TWA); NIOSH recommends .5 ppm TWA.

- Hydrogen sulfide - OSHA standard is 20 ppm ceiling, 50 ppm/10 minute peak; NIOSH recommends 10 ppm/10 minute ceiling.
- Carbon disulfide - OSHA standard is 20 ppm TWA, 30 ppm ceiling, 100 ppm/30 minute peak; NIOSH recommends 1 ppm TWA, 10 ppm/15 minute ceiling.
- Hydrogen cyanide - OSHA standard is 10ppm TWA; NIOSH recommends 5ppm/10 minute ceiling.
- Ammonia - OSHA standard is 50 ppm TWA; NIOSH recommends 5 ppm/10 minute ceiling.
- Heterocyclic Nitrogen Compounds (pyridine) - OSHA standard is 5 ppm TWA.
- Carbon monoxide - OSHA standard is 50 ppm TWA; NIOSH recommends 35 ppm TWA, 200 ppm ceiling.
- Aromatic Hydrocarbons:

  Benzene - OSHA standard is 10 ppm TWA; NIOSH recommends 1 ppm ceiling

  Toluene - OSHA standard is 200 ppm TWA; NIOSH recommends 100 ppm

  Xylene - OSHA standard is 100 ppm TWA

  Styrene - OSHA standard is 100 ppm TWA

Two of the documents just completed by NIOSH are directly concerned with coal conversion processes. The first, issued in January 1978 is "Recommended Health and Safety Guidelines for Coal Gasification Pilot Plants" (DHEW (NIOSH) Publication No. 78-120). This document identifies specific potential hazards and recommends work practices, engineering controls, industrial hygiene procedures, air sampling strategies, medical monitoring and safety procedures for reducing and characterizing exposures in coal gasification pilot plants. This document has been forwarded to the Department of Energy, and in at least one of DOE's gasificationn pilot plants, the document's recommendations have been applied in full.

The second coal conversion document prepared by NIOSH recommends health and safety guidelines for commercial scale gasification plants. While the pilot plant document stressed work practices and industrial hygiene monitoring, the

commercial plant document is reported to emphasize use of engineering controls, backed by personal hygiene measures, for controlling worker exposure to process constituents. This document was forwarded to OSHA during the latter part of August 1978.
Personnel at OSHA's Health Standards Office indicate that OSHA probably will not begin work on the NIOSH commercial coal gasification document. Accordingly, OSHA's approach in selecting subjects for standard-setting is slightly different from that of NIOSH, in that OSHA is looking at individual substances or classes of substances, rather than at a specific industrial process. Consequently, should OSHA perceive a need to examine coal gasification for possible standard-setting action it is felt that such concern would probably focus on a specific substance present in the gasification process rather than on the process itself. In addition, it was noted that OSHA standards currently exist for a number of substances anticipated to be of potential occupational health concern in a coal gasification facility (29 CFR 1910.1000).

NIOSH has begun preparation of a similar criteria document on coal liquefaction plants. Personal communication with NIOSH indicated that the project was initiated several months ago and is presently in literature search phases. The document is scheduled for completion in June 1979.

NIOSH is engaged in several other research activities directed toward coal gasification and liquefaction processes. Several two-year studies attempting an industrial hygiene characterization of liquefaction and gasification plants have been initiated, and an engineering control assessment of conversion plants is also underway. Study findings may influence the recommended health and safety criteria outlined in the commercial gasification plant document and the liquefaction document now in progress.

Under the Clean Air Act and Amendment, a number of air standards have been promulgated by EPA which would apply to fugitive emissions anticipated from coal conversion plants. NAAQS which have been promulgated for SO_2, CO, NO_x, and particulate matter will apply to coal conversion plants as it is anticipated that fugitive emissions from coal conversion will include these categories of substances.

NSPS have not been set for coal gasification plants. Such action was under consideration at EPA until it became apparent that insufficient information was available on which to base a NSPS. In lieu of NSPS, EPA issued a document evaluating recommended emission control system for sulfur compounds and nonmethane hydrocarbons. This document was forwarded to the states as an aid to environmental personnel in determining BACT for Lurgi coal gasification plants. Coal gasification plants are in the list of new sources to be considered for NSPS and such standards for gasification plants will be issued probably within the next five years. NSPS (for SO_2 emissions) have been issued for fossil-fueled steam generators, a component of coal conversion plants.

Emission standards may be promulgated for substances deemed to be hazardous under Section 112 of the Clean Air Act. Benzene was listed as a hazardous air pollutant in June 1977. A number of possible regulations are being considered, and a proposed rulemaking is expected in the near future.

Most states do not have fugitive emission standards for coal gasification and liquefaction facilities. However, Illinois and Kentucky are in the process of writing guidelines for fugitive emission levels from coal gasification and liquefaction plants. Kentucky will opt for technological control and ambient air quality standards to control fugitive emissions.

Possible Future Regulatory Actions and Their Impacts

Fugitive emissions from coal liquefaction and gasification plants will no doubt be a problem facing the workforce, but the extent of the emissions is not yet known. The main concern at present seems to be over numerous potential carcinogens emitted in coal conversion. There are no standards for many of these, since knowledge of their properties is very limited.

More and more information on the health implications of working in coal conversion plants will soon be emerging from research, development and demonstration programs. This new information will probably lead to regulation of presently nonregulated pollutants and possibly to more stringent regulations for pollutants which currently have standards. New standards would most likely take the form of TWA exposure limits under OSHA or NSPS for coal conversion plants under the CAA. Also under the CAA are NESHAPs which may cover some coal conversion emissions in the future. New regulations will probably ban certain carcinogens (zero emissions allowed). Stringent application of the lowest acheivable emission rate (LAER) can also be expected.

As the nation becomes more dependent on coal, environmentalists will demand greater environmental protection and unions will demand better health and safety protection, improved work practices, and greater pay for greater risk. There may be resistance on the part of the labor force to accept jobs in the coal conversion industries because of potentially dangerous emissions. All of these trends will result in higher wages, higher costs of coal products, and delay in the commercialization of coal technologies.

Time Frame for Future Regulatory Action

Promulgation of new standards and revisions of existing standards will continue to take place within OSHA as new information on specific substances is reported according to OSHA's priorities. Some of these substances may be present in fugitive emissions from coal conversion plants. Specific OSHA interest in the conversion process would be more likely to focus on specific substances encountered in work areas which would appear to pose a health hazard and which are not already adequately regulated. Such activity may result from a number of research projects now in progress concerning the coal conversion process. Since these are 2-year studies, the regulatory process takes up to several years itself, and since coal gasification and liquefaction are not yet commercial technologies, there is only a small probability that such regulatory activity will occur prior to 1985. After that time, there is a greater probability that this type of regulatory activity may occur since coal gasification plants will have been in operation for several years by then, and the occupational health history of conversion plant workers will have begun to accumulate.

It is highly unlikely that a criteria document specifically concerning the conversion plant process will be adopted as a standard by OSHA. An alternative would include use of the NIOSH documents as recommended health and safety guidelines.

OSHA is certain that a final carcinogen policy will be promulgated shortly. Personal communications with personnel in OSHA's Health Standards Office indicated that OSHA may begin issuing standards under this new policy as early as 1979. Some substances encountered in the coal conversion process (e.g. benzene, some polynuclear aromatic compounds - benzo(a)pyrene, benz(a)-anthracene, etc.) appear on a tentative OSHA list of "confirmed carcinogens." It is very likely that some of these substances may be regulated under this carcinogen policy within the next few years, and that other substances may be added as they are identified.

OSHA is currently in the process of revising selected portions of the general industry standards. A final rulemaking is expected shortly. It is likely that the general industry standards will continue to be revised and updated from time to time. On the whole, such revisions would apply to all employments covered under the Occupational Safety and Health Act. Subpart R of the general industry standards is entitled "Special Industries," and should specific regulations pertaining solely to coal conversion plants be promulgated, it is likely they would appear here. The likelihood of such regulatory action should increase as operating experience in commercial conversion plants increases and specific hazards or problems are identified.

As results of current research activities are reported and as commercial plants begin operation, a more complete analysis of fugitive emissions should emerge. It is possible that some components of conversion plant emissions, especially certain trace elements, possible carcinogens, or other extremely toxic substances, may be listed by EPA as hazardous air pollutants and consequently be regulated through promulgation of a NESHAP. It is more likely that states with a number of conversion facilities would be taking action on this issue. Such actions may be expected throughout the 1980's.

4.12 Boomtown Effects

Description of Issue

Construction and operation of a energy project can provide many benefits to nearby communities. The economic base may be expanded to provide new employment opportunities for local people, the energy supply may be improved, and the tax base may be strengthened. All too often, however, benefits are long range and regional, while negative impacts are immediate and local. The severity of the impacts on communities depends on several factors: population size, rate of growth, and level of planning. The rate of growth is probably the best indicator of the severity of impacts to be expected. In its study of energy impacts, the Denver Research Institute (1975) concluded: "An annual growth rate of 10 percent strains local service capabilities. Above 15 percent seems to cause breakdowns in local and regional institutions."

Proposed energy projects which are likely to have socioeconomic effects on areas in which they locate are coal mines, coal-fired electric generating plants, coal gasification and liquefaction plants, oil shale processing facilities, in situ gasification and oil shale facilities, support facilities for offshore oil and gas, oil refineries, and LNG terminals, regasification plants, geothermal facilities, biomass conversion plants, and a host of projects associated with the nulcear fuel cycle. Many parts of the U.S. will be affected by these proposed projects, with the most predominant being:

Rocky Mountain and Northern Great Plains states - coal and oil shale facilities (including mines, in situ processes, conversion processes, etc.), geothermal, and nuclear fuel cycle plants.

Appalachia - coal mines and associated processes.

Coastal zones - offshore oil and gas facilities and associated processes, and geothermal.

The impacts expected due to rapid growth of energy projects are likely to be on employment and population, land use and housing, community life (health, local services), and community tax revenues.

Construction activities on fossil energy projects can bring up to several thousand temporary workers into a community. The population will increase still more as workers' families follow them. Several years later, when construction is finished, there will be an exodus of workers since the number needed to operate the energy project is generally less than the construction force.

One of the first impacts felt as a result of the project is on housing. The few vacant houses will be quickly occupied by temporary residents. When all available standard housing has been taken up, workers and their families will probably turn to mobile homes. If there are not enough spaces within the existing community, the units will tend to scatter across the landscape. Inadequate planning and lack of control over siting may therefore result in an eyesore for the community and an aesthetically unpleasant living arrangement for temporary residents.

Unemployment will be another problem and will result from completion of various tasks during the construction of the project. Some unemployed construction workers will no doubt seek employment in other jobs within the community, thus competing with local residents.

Community life may also change as the fast rate of growth produces symptoms of urbanization such as an increased pace of life, congestion, inflation, increased traffic, and scarcity of amenities such as shopping facilities.

A major problem in local services is likely to be medical care; more doctors and hospitals will be needed for the increased population. Other services such as fire protection, law enforcement, social services, and schools will be taxed by the increased population. Large demands will also be put on utilities such as gas, electricity, water and sewer systems.

Revenues from energy developments are usually sufficient in the long run and at the regional level to offset induced costs. For the local community, however, there may be problems of timing and geographic distribution of revenues. The taxing imposed on an energy project occurs after the project is completed and so are of little help to a city or county attempting to solve the immediate problems created by the project. Tax revenues usually go to the county and state while the towns may get no taxes; the towns are often where the major impacts occur and therefore where added revenues are required to cover costs. Also, if an energy project is located in one county and workers live across a county or state line, tax revenues will go to the county or state in which the project is located and the area that is impacted will receive little help (U.S. HUD, 1976).

Probable Solutions

Mitigation of the adverse effects of boomtown development must involve advanced planning, proper institutional arrangements for the implementation of plans, and the provision of adequate financing prior to the onset of the project.

The advanced planning should be conducted in the areas of basic public services such as school facilities, sewers, roads, utilities, manpower training, and continuing educational opportunities. Public environmental services such as parks, recreational areas, landscaping and community centers should also be planned for in advance. Large amounts of front-end money will obviously be needed for these tasks and the federal government could possibly make available moderate interest loans to communitites and counties likely to be impacted by energy projects.

Advanced planning agencies should be aware of the impossibility of anticipating and preventing impacts and conflicts of interest. Probably the best preventative measure is judicious site selection. An attempt should be made to situate a new town to serve several mining operations, if possible. Local attitudes, local government competence and labor force statistics should also play a part in site selection. Planners should be aware that a trade-off exists between the advantages of securing capital investment in community development and the risk of burdening communities with excessive bonded indebtedness if population growth projections turn out to be incorrect.

In areas where it is difficult and costly to establish a permanent community, an alternative might be a temporary new town--either a planned mobile home community or a barracks-type living arrangement with longer work days and extended leave to allow workers to be with their families over long weekends. A ferry service using buses or aircraft might be set up in this sort of situation (Montana Academy of Sciences, 1975; Newitt, 1977).

Legislative/Regulatory Background

To date, there have been no federal laws that specifically address the adverse effects of rapid growth from energy development. However, the Carter Administration has proposed a 5-year energy program to assist states, communities, and Indian tribes in planning for and mitigating the effects of boomtowns. The intention of the program is to provide a total of $675 million in grants to states and Indian tribes and up to $1.5 billion in loans guaranteed by the federal government. Congress has already tentatively approved a similar energy impact assistance program under Section 306 of the Coal Conversion bill (part of the proposed National Energy Act) which would establish a planning and housing impact assistance program under the Department of Agriculture. The Carter Administration proposal would provide broader assistance, however.

The Energy Impact Assistance bill (S1493) which failed passage by Congress would have incorporated the President's proposed 5-year program. The bill, endorsed by the Western Regional Governors Conference, was approved by the Environmental and Public Works Committee. There was considerable debate over 2 provisions of the bill, one of which would have given state governors the right to veto federal approval of energy projects and one which would allow a state governor, local official, or assessment team to force an industry contribution to the impact aid program by withholding permits or licenses. Representatives of the coal industry believed these provisions would give states unfair control over energy project siting.

Some western states such as North Dakota and Wyoming already have siting laws which are aimed at alleviating the adverse effects of boomtowns. Both state laws were passed in 1975 and require any proposed large scale facility to assess and present plans for alleviating socioeconomic or environmental impacts on the surrounding area.

North Dakota's siting law requires a study of the socioeconomic impacts that large scale construction would have on the surrounding area. In order to help monitor and project socioeconomic impacts, a computerized model was developed. Raw data is updated every 30 days. The intent of this project is that the computer model will predict potential adverse impacts so that steps can be taken to mitigate the impacts before they occur.

Adverse effects from boomtowns are regulated through the use of permit conditions. Recently, three large energy facilities located near Beaulah in Mercer County. Every facility has special conditions attached to its construction permit. The special conditions require the energy development companies to assist local communities in such impact areas as: 1) law enforcement; (2) school systems and educational programs; 3) governmental services and facilities; 4) general and mental health care facilities; 5) temporary and permanent housing; 6) recreational facilities and programs; and 7) utility services. Generally, the permit conditions are written in an open-ended manner so that unforeseen impacts can be mitigated through existing permit conditions. A "catch-all" condition is in every permit in case the other permit conditions fail to address the unforeseen impact.

The "catch-all" could require the developing company to manage at its own expense any adverse socioeconomic impacts arising as a result of the new facility. However, the developing company is given an opportunity to demonstrate that the adverse impacts are at an acceptable minimum and that it should not have to pay for impact management.

Wyoming's Industrial Development Information and Siting Act requires applications for permits to contain preliminary evaluations of or plans and proposals for alleviating socioeconomic or environmental impacts upon local communities. The plans should cover the following:

1) Scenic resources
2) Recreational resources
3) Archeological and historical resources
4) Land use patterns
5) Economic base
6) Housing
7) Transportation
8) Anticipated growth of satellite industries
9) Sewer and water facilities
10) Solid waste facilities
11) Police and fire facilities
12) Educational facilities
13) Health and hospital facilities
14) Water supply

Both North Dakota and Wyoming hope that these policies will alleviate many of the adverse impacts associated with boomtowns. Other states with potential boomtowns may use the North Dakota and Wyoming policies as models.

Possible Future Regulatory Actions and Their Impacts

Boomtowns resulting from energy projects are a serious problem and will continue to increase in importance as more energy projects locate in sparsely-populated areas which cannot handle huge influxes of workers nor provide the necessary workers from the present labor force.

The governors of the Rocky Mountain states, which will be severely impacted by this problem due to their large energy reserves, have banded together to form the Western Governors' Regional Energy Policy Office. The purpose of this office is to identify energy needs and, at the same time, protect the quality of life in the western states from undue social, economic and environmental disruptions. They are asking for federal loans to states, and other federal support and legislation to help alleviate rapid growth impacts. This trend will no doubt continue since local communitites cannot solve these problems without help.

Other areas of the U.S. likely to be severely impacted by the appearance of boomtowns are the coastal zones, since the location of offshore oil and gas facilities in these areas will bring in large numbers of workers and associated onshore facilities. There is much concern at present over preservation of the fragile coastal environment, and population increases in these areas will certainly be environmentally disruptive.

The desire to protect coastal and other undeveloped areas in the western states may lead to enactment of regulation by these states which attempt to restrict or slow down coal development or to restrict the use of coal to export. Western states may also demand legislation promising federal support and aid to states affected by rapid growth problems from energy development. Major programs aimed at improving quality of life aspects of boomtowns may be developed under pressure from unions and environmentalists and would lead to higher costs and possible time lags in developing some of the energy technologies. Advanced planning studies and other similar programs attempting to improve the quality of boomtown developments might also impose siting restrictions on fossil fuel facilities, again resulting in higher costs and delays in commercialization. Federal guidelines on revenue sharing and subsidies will have a major impact in the future. State laws and local ordinances may be estalished to maintain stable growth.

Time Frame for Future Regulatory Action

Federal legislation dealing with boomtown effects will probably be passed within the next few years. Environmental groups and the Western Regional Governors Conference are lobbying for passage of energy impact assistance legislation, and although the coal industry was opposed to certain provisions of the recent bill, it will quite probably be passed in at least one form or another. If it is not passed, its defeat could act as a catalyst for impacted states to pass their own legislation, using North Dakota and Wyoming as examples. By 1985, most impacted states will probably have developed advance planning studies and programs aimed at improving the quality of life of boomtowns. By 1990, states that have large coal reserves will probably feel the effect of rapid growth impacts and will probably be forced to draft some form of energy impact legislation. Even if federal legislation has passed by that time, states will still have to develop an energy impact program; federal funding will be available for only a few years (5 years under Carter's proposal). After that time, states and tribes will be expected to have developed the necessary institutions and funding sources to alleviate further adverse effects and to continue aid to communities with or without federal help.

4.13 Emission of Fine Particulates From Coal, Oil, and Oil Shale Technologies

Description of Issue

Fine particulates are generally defined as particles with a size less than 5 um in diameter. Fine particulates can be primary or secondary. Primary particulates are the direct products of an emitter such as a fuel conversion technology. Secondary particulates are products of the complex transformation and transport processes occurring in the atmosphere between gases and between particulates and gases. The main ingredients in their formation are sunlight and such chemicals as SO_2, NO_x, NH_3, and hydrocarbons. A major part of the fine particulate problem is probably due to secondary fine particulates. Fine particulates can have a variety of impacts ranging from environmental effects such as weather modification, to human health and ecological effects.

Primary fine particulates may be emitted in different processes of fossil fuel technologies. The major particulate emissions from oil-related technologies come from oil refineries and oil burning power plants. Coal technolgies generate air emissions of particulates from the extraction or mining process and from direct combustion of coal. The coal conversion technologies such as gasification and liquefaction are enclosed processes and will not result in substantial particulate emissions; process heater and boilers in these conversion plants will be coal-fired, however, and will therefore emit large quantities of particulates. Oil shale technologies will also emit particulates from mining and retorting operations and from process heaters and boilers. The upgrading steps in oil and shale processing are enclosed steps and probably will not contribute significantly to particulate emissions. The end product of some of the fossil fuel technologies is transportation fuel, and particulate emissions from automobiles are substantial and primarily in the fine particulate category. Large particulates can be removed by using existing technologies before emitting to the ambient air. However, fine particulates usually can escape electrostatic precipitators and most other emission control devices.

Oxidants formed during the process of photochemical reaction between NO_x and reactive hydrocarbons under strong solar radiation contribute significantly to the formation of secondary fine particulates. Primary pollutants, including NO_x, SO_x, and organic compounds, can be oxidized by these compounds to form acid mists such as nitric acid, sulfuric acid and oxidized organic compounds. These compounds are then neutralized by ammonia and alkaline material in the ambient air to form secondary and fine particulates--nitrates, sulfates and organic aerosols.

The most significant impact resulting from fine particulates is on human health. Health impacts of fine particulates depend upon the size and chemical nature of the particulate. Particulates less than 5 um in size are particularly hazardous in terms of human health because they are of respirable size. Since few current standards covering particulates take into account particle size or composition, it is possible that effects on human health may occur even when existing emission and ambient air quality standards are met. Since fine particulates are not a single pollutant but a large category of pollutants which includes sulfates, nitrates, and numerous other compounds; the toxicity of all these compunds must be evaluated when considering particulate health effects.

Most particulates smaller than 5 um are deposited in the tracheobronchial or alveolar compartments of the lungs. Toxic effects that occur after deposition are dependent on size and density of the particulates, retention time in the lungs, and host factors. Direct attack on the respiratory system may occur, causing short term irritant effects or longer term damage such as silicosis, asbestosis, chronic brochitis, and emphysema. A second mechanism causing adverse health effects involves the respiratory system indirectly as a route of entry for nonrespiratory toxicants; particulates which are deposited in the respiratory system are translocated to the gastrointestinal system by ciliary action and are swallowed. They may exert a primary toxic effect or be absorbed and translocated to other tissues to exert adverse effects.

Particulates can also act as vehicles into the lungs for substances such as PAHs, asbestos, SO_2, and trace elements. PAHs are preferentially carried on small particles and their respiratory potency as carcinogens is enhanced by adsorption on certain materials such as sulfates (Radian Corporation, 1977b). Particulates can be synergistic with certain compounds. For example, the effects of sulfur oxides may be intensified when associated with particulates. Also, particulates, SO_2 and certain hydrocarbons have been suggested as possible cocarcinogens, although this is not an established fact.

Particulates may cause environmental problems as well as health problems. They are responsible for visibility reduction since they have light scattering and light absorption properties. They may also cause weather and climate changes. As they are effective for nuclei condensation and ice formation, they can affect the physical processes of condensation and precipitation. Since they redirect or scatter solar radiation, they decrease the amount of heat reaching the earth's surface, possibly causing long term climatic changes (Fennelly, 1976).

Probable Solutions

Control devices for fine particulates include the use of electrostatic precipitators, cyclones, scrubbers, or baghouses during stack gas or product gas cleaning. The range of applicability of these devices is limited, however. Some of them have the capability to remove only larger particulates. The electrostatic preciptator, although capable of removing small particulates, is only effective in a narrow range of electric resistivity; at both high and low resistivities, control effciency drops off. Most low sulfur coals produce high resistivity fly ash, so particulates (especially fine particulates) are still a control problem (Burchard, 1974). Control of the gaseous precursors of secondary particulates should be given consideration when discussing control strategies for fine particulates. Production of secondary particulates can be controlled through the control of SO_2, HC, NO_x and O_x, as well as the cationic species which participate with them.

Legislative/Regulatory Background

Particulates are currently regulated primarily by EPA under the CAA (1970) and Amendments (1977). Respirable size coal dust in occupational environments is regulated by OSHA under the Occupational Safety and Health Act (1970), and specifically in coal mines under the Federal Mine Safety and Health Act (1977).

Particulates are regulated through NAAQS, PSD increments, standards of performance and emission offset limitations. First promulgated in 1971, the NAAQS is currently scheduled for review, with the revised criteria document expected in December 1980. New health and other pertinent criteria will be evaluated and, if necessary, the standard may be revised. The current particulates standard is not specific to fine particulates but includes all size ranges of particulate matter. As with all NAAQS, the particulate standard must be reviewed every 5 years. Final PSD regulations for total suspended particulates were issued in 1978.
Standards of performance for particulates are currently in effect for oil-fired and gas-fired steam generation, coal preparation plants and petroleum refineries. Performance standards for coal and oil-fired boilers were promulgated in 1971 and were scheduled for revision beginning in August 1978. Particulate emission standards for catalytic crackers of petroleum refineries were issued in 1974. Standards for coal preparation plants were promulgated in 1976. Coal conversion plants appear on the list of major stationary sources for which the EPA must promulgate NSPS within 4 years. Emission offset regulations, issued in 1976 and reinforced by the 1977 Amendments to the Clean Air Act, do not allow new sources emitting more than

100 tons year of particulates to locate in nonattainment areas unless existing sources reduce their emissions by an equivalent amount. Where only the secondary NAAQS is exceeded, no major source will be allowed unless the state can demonstrate eventual compliance with the standards despite the new source.

Consideration of fine particulates as an environmental health issue is not directly applicable to evaluation of particulates as an occupational health issue. Primary particulates from oil, oil shale, and coal energy technologies are released to the ambient air and are thus an air quality and public health, rather than an occupational health, concern. Secondary particulates are formed as a result of atmospheric conditions and interactions which would not be expected to occur in the workplace environment. In the environmental area, particulate matter, although composed of many different species of chemical substances, has been categorized as a single class because of common physical characteristics; and under Federal and state air quality standards, particulates or total suspended particulates are regulated as a single category of pollutant.

Particulate matter, as a single category of pollutant, has not been identified in the occupational setting. Specific types of dust (coal dust, silica, nuisance dust) and specific chemical substances which may occur in particulate form (acid mists, nitrates, sulfates, metallic species, trace element compounds, organic matter, etc.) have been identified as occupational health hazards associated with specific industrial processes. Occupational exposure limits for many of these dusts and particulates have been issued by OSHA (for example: nitric acid, sulfuric acid, particulate polycyclic organic matter, some trace elemental compounds, metallic oxides and metallic salts, etc.). OSHA has also issued exposure limits for the respirable fraction of coal dust and inert or nuisance dust (29 CFR 19100.1000).

Coal dust from coal storage and pretreatment operations is the major particulate of industrial health concern to coal-based energy technologies. Particulate polycyclic organic matter is discussed in Section 4.5.

Many states enforce ambient air quality standards for particulate matter which are identical to the federal standards. Some states (North Carolina, New Mexico, Arizona) have issued AAQS which are more stringent than the federal standard. Indiana has issued an AAQS for respirable dust (50)ug/m3 ground level concentration for a 60-minute period for a particulate size of 0.5-6.0 microns).

Possible Future Regulatory Actions and Their Impacts

Future development of fossil energy technologies will cause an increase in primary fine particulate emissions and in the formation of secondary particulates. Due to the limitations of current control strategies, a major proportion of these will be fine particualtes. Although the current state of knowledge relating to fine particulates is inadequate, it does suggest that fine particulates exhibit very different properties and effects from larger particulates and the effects vary depending upon the chemical composition of the particulates. Research is currenty being conducted in the areas of health and welfare effects and characterization of fine particulates. It is highly probable that, based on the results of this research future regulation of fine particulates may occur. The regulations are likely to take the form of: NAAQS for specific sizes and species of fine particulates (e.g., sulfates); NESHAPs which take into account size and chemical form of particulates; NSPS for cationic species emitted from coal conversion plants and associated with secondary particulate formation; revised NSPS for pollutants (e.g, SO_2, NO_x, HC, NH_3) that participate in atmospheric formation of secondary particulates; and relative location prescriptions for sources of the various precursors necessary to the production of toxic fine particulates.

Time Frame for Future Regulatory Action

As with all NAAQS, the particulate standard is subject to review at least every 5 years. At present the revised criteria document is scheduled for December 1980. EPA's Pollutant Strategies Division indicates that there is little likelihood of a primary NAAQs for fine particulates with the next 5 years. It is more likely that a secondary standard for fine particulates will be promulgated in the future. Such a standard would probably be related to the protection of visibility. Although it is possible that a secondary fine particulate standard may be promulgated in 1980, it is thought that such a standard more likely will be issued in 1985 when the NAAQS is revised for the third time.

It is possible that the present NAAQS may be revised to reflect particle size. EPA is considering shifting the current NAAQS to apply only to particulates 15 um in diameter or smaller. Such a standard would encompass the fine particulates (less than 5 um diameter) but would also include many large particles. Such a standard has a medium probability for the 1980 revision of the particulate NAAQS.

At present, there are no plans to revise the particulate standard to reflect any specific component. It may be concluded that concern for a specific particulate would be reflected in a separate standard, and that total particulates will remain a class of pollutant regulated by a separate NAAQS.

NSPS exist for particulates in general, and there are no plans at present for promulgating NSPS strictly for fine particulates. Should existing particulate NSPS be revised to allow fewer emissions, an increment of control would be achieved within the fine particulate size range, due to the characteristics of particulate control devices.

PSD Class I areas in the West may become important areas from a regulatory viewpoint under the protection of visibility clause of the CAA amendments of 1977. More stringent PSD regulations in the western Class I areas are a possibilite standard to reflect any specific component. It may be concluded that concern for a specific particulate would be reflected in a separate standard, and that total particulates will remain a class of pollutant regulated by a separate NAAQS.

NSPS exist for particulates in general, and there are no plans at present for promulgating NSPS strictly for fine particulates. Should existing particulate NSPS be revised to allow fewer emissions, an increment of control would be achieved within the fine particulate size range, due to the characteristics of particulate control devices.

PSD Class I areas in the West may become important areas from a regulatory viewpoint under the protection of visibility clause of the CAA amendments. More stringent PSD regulations in the western Class I areas are a possibility, although precise time frame cannot yet be estimated.

A number of specific constituents of suspended particulate matter are receiving attention. EPA is in the process of promulgating a NAAQS for fine particulate lead. Sulfates have received much attention in recent years, and some states (e.g. California) have promulgated AAQS for sulfate. The adequacy of existing information relating to health effects of sulfates has been debated, and a national sulfate standard has not yet been considered by EPA. EPA has indicated that it is doubtful that a sulfate standard will be promulgated in the near future. The organic fraction of particulate matter, particularly the polycyclics, are receiving increasing attention. The sources of interest for these emissions are coke ovens. The particulates arsenic and cadmium are also causing some concern at present; however, the emission sources for these pollutants (smelting operations and municipal incinerators) do not concern the energy technologies at issue here. In summary, it appears certain that a lead standard will be promulgated before 1985. It does not appear that other fine particulates under consideration (from the energy technologies) offer more than a slight possibility of becoming the subject of regulatory action before this time. As more information is accumulated, the chances of regulatory action also will change. Indentification of additional specific components of fine particulates and determination of their health effects, should result in additional regulation of these components in the 1985-2000 time frame.

Through the protection of visibility clause, EPA may direct the control of fine particulates to include the control of some secondary particulate precursors. In particular, regulation of particulate emissions in areas where suspended fine particulates are comprised primarily (30-50%) of suspended sulfates may be expanded to include control of primary sulfur emissions as well as primary particulates. However, definite plans for such types of regulations cannot be predicted at this time.

4.14 Emissions of Radioactivity From the Mining and Conversion of Coal

Description of Issue

The natural radioactivity which is present in coal may result in individual and population exposures that are greater than exposures resulting from the normal operation of conventional nuclear reactors (Eisenbud and Petrow, 1964; Martin and Howard, 1969). Exposures are a direct function of the level of natural radioactivity present in coal and the conditions under which it is mined, used, and disposed of.

Much of the natural radioactivity present in coal and the earth's crust is attributed to members of the radioactive decay series of the parent radionuclides 238U and 232Th (National Council on Radiation Protection, 1975). Uranium and thorium appear to be lognormally distributed in coal, as are many other trace contaminants. An analysis of 799 coal samples by the U.S. Geological Survey indicates average concentrations of 1.8 ppm for uranium and 4.7 ppm for thorium (Swanson et al., 1976). It is not unusual, however, to find coal burned in power plants with greater than 10 ppm uranium (Farmer et al., 1977).

Uranium concentrations tend to be vertically stratified in veins as well as significantly different between veins. Above-average uranium concentration in coal tends to be dependent on local geological history with uranium most likely deposited through epigenetic processes whereby the pryrite and organic matter in coal tends to reduce the soluble hexavalent uranium in groundwater to the relatively insoluble tetravalent state in the seam.

Ionizing radiation produces cancer and mutation effects and is assumed by most knowledgeable authorities to have no threshold concentration for effects. (NAS, 1972; Cohen, 1976; ICRP, 1977) Major candidate issues for potential future regulatory action center around radon emanation in undergound mining; emissions of alpha-emitting particulates from conventional combustion (e.g, 238U, 234U, 239Th, 226Ra, 210Po, 232Th, 228Th), 222Rn emanation from 226Ra with progency buildup (210Po, 210Pb), and groundwater contamination from ash and residue disposal from coal conversion activites. For the gasification of low rank uraniferous lignites there may be some concern for the pass-through of 222Rn into the product gas.

The impacts upon which protection criteria are developed for ionizing radiation are carcinogenic and mutagenic biolgical effects. The effects are considered carcinogenic if they are manifested in the exposed individual (such as malignant carcinomas) and mutagenic if they affect his descendants (such as congential defects in offspring). Low-dose exposures of tissue are generally considered to have no threshold effects. For these reasons the International Commission on Radiological Protection (ICRP) recommends that all exposures be kept as low as reasonably achievable, economic and social factors being taken into account (ICRP, 1977).

The ICRP recommendations, as well as those of other recommending bodies (e.g, the National Council on Radiation Protection), have resulted in exposure limits for occupational and the general public's protection based upon annual dose limitations of 5 rem/year, and 0.5 rem/year, respectively.* In actual practice, it is found that when discounted for natural background, the eventual risk to the general population is approximately one-tenth of this value (50 mrem per year), because the above limits are intended to protect the maximally exposed individual or group.

Risk factors that show a cause-effect relationship between irradiated tissues and manifestations are based upon the estimated likelihood of producing fatal malignant diseases, nonthreshold changes, or substantial genetic defects expressed in live-born descendants. Table 4-5 shows estimates of the quantification of such risks for certain tissues for which quantitative estimates are available (ICRP, 1977).

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*rem - a common scale unit for quantifying the dose equivalent to a medium (biological tissue), taking into account the energy absorbed in the medium, quality factor of the radiation type, distribution factor, and other factors.

TABLE 4-5. ESTIMATES OF RISK FOR IRRADIATED TISSUES

Tissue	Risk Manifestation	(Effect/Dose)*
Gonads	Hereditary abnormality	.01/100 rem
Red bone marrow	Leukemia	.002/100 rem
Bone	Bone cancer	.005/100 rem
Lung	Lung cancer	.002/100 rem
Pulmonary lymphoid	Lung cancer	.002/100 rem
Thyroid	Cancer	.0005/100 rem
Other tissues	Cancer	.005/100 rem
Total risk (whole body)	Cancer	.01/100 rem

*The number of abnormal manifestations in the population per dose equivalent (rem) to the population.

Generally, fatality risks on the order of $1x10^{-5}$ to $1x10^{-6}$ are considered acceptable; they are crudely on the order of 100 mrem whole-body exposure per year to members of the general population.

Probable Solutions

For undergound mining of uranium-bearing coal, controls would most likely take the form of ventilation to achieve appropriate working levels of radon and its daughter products (U.S. Congress, 1967).

For controls on coal conversion and ash/residue disposal, three solutions are feasible, the most obvious being preferential utilization of coal-bearing low levels of radioactivity. Otherwise direct removal of the contaminants from coal or ash, or prevention of environmental emissions, would be warranted. Pre- or post-combustion control systems might be feasible for direct removal of radioactivity. In some configurations one can conceive of the econommical recovery of uranium; however, major attention should also be devoted to direct removal of thorium, polonium, and in the case of radon, emanation from ash ponds, its parent radium. For controls taking the form of prevention of environmental emissions, advanced particulate control systems for stack emissions (e.g, baghouses) and ash disposal in buried and stabilized geological formations would be required.

Legislative/Regulatory Background

To date, there are no regulations that apply to the release of radioactive pollutants from coal conversion facilities. However, under its authority to regulate hazardous pollutants, established under the Clean Air Act and subsequent amendments, EPA could establish. In the 1977 amendments to the Clean Air Act, radioactive pollutants were specifically addressed. The administrator of EPA is required to determine within 2 years of enactment whether NSPS, NAAQS or NESHAPS should be established for radioactive pollutants (along with several other pollutant categories).

The authority for licensing and regulating nuclear power plants and their associated fuel cycles was transferred to the Nuclear Regulatory Commission (NRC) under the Energy Reorganization Act of 1974. These activities had previously been assigned to the Atomic Energy Commission (AEC) under the Atomic Energy Act of 1954, as amended. Other responsibilities for nuclear safety were assigned to the AEC by NEPA (1969) and the FWPA as amended (1970). The NRC does not have any statutory authority to regulate radioactive emissions that result from fossil fuel activities. However, the CAA amendments of 1977 specify that the Administrator of EPA must consult with the NRC in establishing jurisdiction over facilities which may come under regulation.

Some responsibilities for radiation protectin were transferred to EPA from the AEC under Reorganization Plan No. 3 of 1970, including the authority to establish standards for protection of the environment from radiation and radioactive materials. EPA was given further standard-setting and surveillance responsibilities for radiation protection, other than those already assigned, such as for drinking water standards. Enforcement is generally carried out by NRC.

The maximum ambient concentrations allowable for facilities licensed by the U.S. Nuclear Regulatory Commission (NRC) are presented in Table 4-6. Occupational standards are approximately 40 times greater. NRC-licensed facilities involve those of the nuclear fuels cycle. Where federal regulations may not now be applicable to radioactivity emissions from coal utilization, state regulations may. Many state health departments have authority for health and safety relative to radioactive materials that are not covered by federal regulations (for example, California Health and Safety Code, Sections 25800-25876).

There are also federal drinking water standards on radioactivity for community water supplies (41 FR 28402). These are listed in Table 4-7.

TABLE 4-6 U.S. NUCLEAR REGULATORY COMMISSION
MAXIMUM PERMISSIBLE CONCENTRATIONS

<u>Maximum Permissible Concentration (uCi/m^3)*</u>

RADIONUCLIDE	AIR	WATER
238U	3×10^{-10}	4×10^{-5}
234U	4×10^{-12}	3×10^{-5}
234Th	1×10^{-9}	2×10^{-5}
232Th	1×10^{-12}	2×10^{-6}
230Th	8×10^{-14}	2×10^{-6}
228Th	2×10^{-13}	7×10^{-6}
228Ra	1×10^{-12}	3×10^{-5}
226Ra	2×10^{-12}	3×10^{-8}
224Ra	2×10^{-11}	2×10^{-6}
222Rn	3×10^{-9}	---
210Po	7×10^{-12}	7×10^{-7}
210Bi	2×10^{-10}	4×10^{-5}
210Pb	4×10^{-12}	1×10^{-7}
U - natural	2×10^{-12}	2×10^{-5}
Th - natural	1×10^{-12}	1×10^{-6}

*10 CFR (Appendix B). The lowest level for soluble or insoluble form is included.

TABLE 4-7 MAXIMUM RADIOACTIVITY LEVELS ALLOWABLE IN COMMUNITY WATER SUPPLIES

Radioactivity	Regulation
Radium 226 & 228	5 pCi/liter
Gross alpha (excluding Rn and U)	15 pCi/liter
Beta and gamma	Average annual concentration from manmade radionuclides shall not produce 4 mrem/year to total body or any internal organ.

The states have few, if any, regulations on the radioactivity levels in the air. Most states do have radioactivity standards for water. Some of these states' standards are listed below. Standards more stringent than Federal requirements are followed by an asterisk.

- Montana - The following radiological criteria shall apply to all waters except those classified as A-Closed. The average dissolved concentrations (including the naturally-occurring or background contributions) of ^{131}I, ^{226}Ra, ^{89}Sr, ^{90}Sr, and ^{3}H are not to exceed the following concentration limits:

^{131}I	5 pCi/L
^{226}Ra	1 pCi/L*
^{89}Sr	100 pCi/L
^{90}Sr	10 pCi/L
^{3}H,	3,000 pCi/L

  For all other radionuclides, the average dissolved concentration limits are to be 1/150 of the corresponding maximum permissible concentration in water (MPC) for continuous occupational exposure as recommended by the National Committee on Radiation Protection (National Bureau of Standards Handbook 69 or subsequent revisions).

- North Dakota - Same as Montana

- Pennsylvania

  alpha emitters maximum 3 pCi/L*
  beta emitters maximum 1,000 pCi/L

- Utah - Radioactive substances shall not exceed 1/30 of the MPCW values given for continuous occupational exposure in the National bureau of Standards Handbook 69.

- West Virginia

  Gross alpha activity: 3 pCi/L*
  Gross beta activity: 1,000 pCi/L

- Wyoming - All controls which are physically and economically feasible.

^{226}Ra	3 pCi/L*
^{90}Sr	10 pCi/L

Possible Future Regulatory Actions and Their Impacts

Possible candidate future regulations are described below:

Nuclide	Type of Standard
222Rn	Ambient Air/Emission Standard
222Rn	Gasification Product Gas Standard
226Ra	Solid Residue (ash)/Ambient Air Standard
238U/234U	Ambient Air/Emission Standard
210Po	Ambient Air/Emission Standard
210Pb	Ambient Air/Emission Standard
alpha activity	Surface/Groundwater Standard

Coal is critical in the country's energy plans and regulations of radioactivity emissions from coal could have mostly negative economic impacts depending on the form and level of the regulations. Solutions are available as previously discussed, but the application of these solutions will take time and effort. For example, the 5 pCi/g - 226Ra classification of radiological wastes under RCRA could force preferential development of coal resources with 238U levels below approximately 2 ppm in order to avoid the ash disposal licensing requirements which such an ash would require. However, the requlation may also foster the development of innovative control technologies to fix radium (e.g., $RaSO_4$) and recover uranium from the ash for coal containing higher than normal uranium concentrations. In general, the impact of future radiological regulations on coal emissions could be offset in that control technology is, in general, available. However, resulting control cost, siting restrictions, etc., could lead to large end-product cost increases, and to development of alternative nonradioactive sources such as cleaner coals or shale.

Time Frame for Future Regulatory Action

EPA is responsible for studies of the radionuclide content of fossil fuels and of population exposures due to extraction and conversion activities. Included in these studies are analyses of the bioaccumulation of radionuclides such as 210Pb. It has been shown that the expanded use of coal should not result in significant population exposures on a nationwide basis. However, for individual sites and for particular types of coal, exposures could be significant, particularly if there were substantial bioaccumulation of radionuclides.

It seems unlikely that there will be strong public pressure in the next few years to establish radioactivity standards for fossil energy (particularly coal) facilities, or that sufficient data will be available for the EPA administrator to establish regulations by 1979. However, the increased use of coal, increasing public concern over all forms of radiation exposure, and accumulating evidence on the radiological effects of coal use (especially higher uranium- and thorium-content western coals) over the next 5 to 10 years support the likelihood that radioactivity standards, most likely in the form of NESHAPS, will be established by 1985.

4.15 Emissions of Nitrogen Oxides

Description of Issue

Both natural and anthropogenic sources contribute to current atmospheric levels of nitrogen oxides. Fossil fuel combustion in stationary and mobile sources is the major source of anthropogenic NO_x. While the NO_x formed within the combustion device is discharged to the atmosphere largely as NO, it is thereafter slowly converted into NO_2. Oxides of nitrogen are formed both by thermal fixation of atmospheric nitrogen (thermal NO_x) and by oxidation of organic nitrogen compounds present in the fuel (fuel NO_x). Hence the quantity of NO_x emitted is closely related to the nitrogen content in the fuel, the temperature of combustion, and the fuel to air ratio in the combustion device.

Different technologies may cause different levels of NO_x emission. Gas turbines, using natural gas or syngas derived from coal gasification as fuels, are usually kept at higher operating temperatures than most coal and oil-fueled steam turbines, therefore much larger quantities of NO_x would be emitted from gas turbines. The high combustion temperature (4,500-5,000°F) used in open-cycle MHD could produce up to 10 times the nitrogen oxide emissions produced in conventional coal combustion. (Bienstock et al., 1971) Nitrogen content in retorted shale oil is high, around 1.8 percent. Large amounts of fuel-derived NO_x would be emitted as the result of burning shale oil if no pretreatment of fuel is applied.

The most significant environmental effect of NO_x emissions may be the role NO_x plays in photochemical smog formation. Nitrogen oxides, together with hydrocarbons, contribute to the formation of high concentrations of oxidants in the ambient air. These oxidants include ozone and peroxyacyl nitrates (PANs). PANs are potent eye irritants, whereas ozone has been speculated to accelerate the aging of lung tissue and to cause respiratory irritation. The presence of NO_x in the atmosphere leads to plant injury and damage. The effects of NO_x to man are not a serious problem at present levels. Both NO and NO_2 are potential health hazards at high concentrations, however. They can also corrode metals, crack rubber, indirectly cause eutrophication and contaminate drinking water.

Oxidants formed during the process of photochemical smog formation play a major role in the formation of secondary fine particulates, or secondary aerosols. NO_x, SO_x, and organic compounds are oxidized by these oxidants to form nitric acid, sulfuric acid and organic acid/carbonyl compounds. These compounds then react with ammonia and other alkaline particulates in the ambient air to form nitrate, sulfate and organic aerosols. Fine particulates in the atmosphere may function as the reaction media for these oxidation processes. These secondary fine particulates impose additional environmental problems.

The hygroscopicity of these secondary particulate nitrates, sulfates, and other aerosols significantly increases their light-scattering ability. The size of these fine particulates falls in the exact range for maximum scattering of visible light. Therefore, NO_x emissions can indirectly reduce the prevailing visibility by forming secondary fine particulate matter. Nitrogen dioxide absorbs some light over the entire visible spectrum, but primarily in the short wave lengths, i.e, violet, blue and green. Hence, visibility reduction is also enhanced by atmospheric NO_x which effectvely reduces the brightness and contrast of distant objects.

As the photochemical smog matures, the concentration of fine particulates rises markedly. These particulates are especially hazardous in terms of human health effects because they are of respirable size. The potential hazard of sulfuric acid mist and sulfate salt are well known. Sulfate salt with a wide spectrum of cations may impose a new set of problems to human health. Results of studies involving the exposure of human volunteers to particulate sulfate aerosols suggest that sulfate aerosols produce infrequent changes in pulmonary function, although there is considerable controversy remaining.

The sulfuric acid and nitric acid formed in the oxidation process in the ambient air may contribute significantly to the formation of acid precipitation. It has been estimated that the contribution of sulfuric acid and nitric acid to the total acidity of precipitation in the northeastern U.S is approximately 60 and 34 percent, respectively (Grant, 1972). Precipitation in the northeastern U.S. has a mean pH of about 4.0, and rainfall with a pH as low as 2.1 has been reported in the same region. The acidity of the precipitation has been attributed to the combustion of fossil fuels.

In the presence of aerosols, amines may be nitrosated by NO, NO_2, or PANs to form nitrosamines. Amines are readily available in industrial air and automobile exhaust, and are also a result of fossil fuel combustion. Although there is no direct evidence that nitrosamines have produced cancer in humans, approximately 70 percent of all N-nitroso compounds studied were found to be carcinogenic and mutagenic in a wide range of animal species over a wide range of potency.

In summary, reacting with hydrocarbons under intense solar radiation, nitrogen oxides contribute to the formation of oxidants. These oxidants may react with NO_x, SO_x, and organic compounds to form secondary fine aerosols which cause visibility reduction, human health hazards, acid precipitation, and the formation on nitrosamines--a potential carcinogen. NO_x, thus plays a major role in the whole set of air pollution problems.

Probable Solutions

One difficulty in trying to control NO_x emissions is that some of the factors that tend to reduce other types of pollutants cause an increase in NO_x emissions. For example, enhancing combustion by increasing temperature or making combustion mixtures more oxygen-rich will decrease the emissions of hydrocarbons and CO. However, these same factors will increase the formation of NO_x. An alternative approach would be to maximize NO_x in the effluent to recover nitrogen products (e.g., fertilizer), but this approach has received little attention thus far.

There are two fundamentally different approaches to the control of NO_x emissions from stationary sources. These are combustion modification and flue gas treatment. Combustion modification includes techniques such as staged combustion and flue gas recirculation. Flue gas treatment includes techniques such as regulation of exhaust gas residence times in downstream components to enhance decomposition of NO_x and the use of catalysts to reduce the NO_x back to free N_2 and O_2. While combustion modification seems to be the near-term technology of choice for NO_x control, flue gas treatment has the potential for high NO_x removal efficiency. The control of NO_x emissions from mobile sources can be accomplished by exhaust gas recirculation or a catalyst system.

Legislative/Regulatory Background

The Clean Air Act of 1970 required the administrator of EPA to publish proposed regulations prescribing a national primary ambient air quality standard and a national secondary ambient air quality standard for nitrogen dioxide simultaneously with the issuance of air quality criteria for nitrogen dioxide. That Act also required the promulgation of emission standards for mobile and stationary sources emitting nitrogen oxides. These ambient air quality and emission standards were promulgated in 1971, and the emission standard for mobile sources have been modified frequently ever since. The 1977 amendments require the administrator of EPA to promulgate a national primary ambient air quality standard for NO_2 concentrations over a period of not more than 3 hours unless there is no significant evidence that such a standard for such a period is requisite to protect public health.

Another impact of the 1977 amendments results from the regulations concerning the Prevention of Significant Deterioration (PSD). These regulations authorize states to designate areas as one of three allowed growth categories and give states the option of imposing more stringent emission standards (than New Source Standards of Performance) on new or modified sources on a case-by-case, source-by-source basis. EPA is required by the 1977 amendments to conduct a study and to promulgate regulations that should become effective by 1980. The 1977 amendments does not require the PSD approach for NO_2 be the same as the present one for TSP and SO_2; it does require specific numerical measures against which permit applications can be evaluated, the stimulation of improved control technology, and an effectiveness at least as great as that of the increments approach.

The 1977 amendments add to the intent of the original Act by providing specific mechanisms and regulations designed to control NO_x emissions from stationary and mobile sources. The nonattainment plan provisions have immediate impacts on fossil fuel technologies. Under these provisions, revised State Implementation Plans (SIPs) governing these nonattainment areas must assure attainment of primary air quality standards (including NO_2) no later than December 31, 1982. Major source introduction or construction in these areas is regulated by "trade-off" policy and the requirement to apply lowest achievable emission rate (LAER) technology.

The 1977 amendments gives special attention to the control of long distance impacts, especially interstate impacts, of air pollution. A part of this phenomenon is the interaction of polluted air masses that have travelled a long distance. For example, air parcels with high NO_x concentrations may be transported a long distance to react with hydrocarbons emitted somewhere else. These long distance inter-AQCR transportaton dynamics will likely influence the emission, location, and site concentration requirements of NO_x-

emitting fossil fuel facilities. The Federal primary and secondary ambient air quality standards for NO_x are both 100 ug/m3 (0.05 ppm) annual arithmetic average. Most states have adopted this federal standard. California has a strict short-term standard of 470 ug/m3 (0.25 ppm) measured over 1 hour. North Dakota also has a short-term standards of 200 ug/m3 (0.10 ppm) maximum 1-hour concentration not to be exceeded over 1 percent of the time over any 3-month period. On the national level, emission standards for fossil fueled steam generating facilities are contained in the Standard of Performance for Fossil-Fuel Fired Steam Generators. The standard is 0.20 $lb/10^6$ Btu for gaseous fuel, 0.30 $lb/10^6$ Btu for liquid fuel and 0.7 $lb/10^6$ Btu for solid fuel. EPA has recently lowered the NSPS for coal-fired boilers to 0.6 $lb/10^6$ Btu for bituminous coal and 0.5 $lb/10^6$ Btu for subbituminous coal.

Possible Future Regulatory Actions and Their Impacts

As more and more evidence accumulates to relate emissions of nitrogen oxides to human health problems, visibility reduction, acid precipitation, formation of nitrosamines, and other effects, regulations on NO_x emissions will possibly become more stringent. The possible future regulations are:

- NAAQS for toxic NO_x species, emitted or secondary.
- NSPS for toxic NO_x species emitted, or for key NO_x precursors that can cause the formation of toxic/hazardous secondary nitrogen oxide species.
- Regulations on locations of sources on NO_x and other reactive pollutants (taking into consideration the density of emission, location, topography, meteorology, etc.) to avoid long-distance reactions. An example is the creation of buffer zones for Class I areas.
- PSD regulatory actions reflecting the synergistic effects of NO_x-hydrocarbons, SO_x-oxidants, SO_x-oxidants-particulates, etc.

PSD regulations may impose major restrictions on future development and commercialization of fossil fuel technologies. Possible impacts involve potential restrictions of facility siting and expansion, and the possibility of cost-prohibitive control requirements being required. Since NO_x control technology is not as well developed as that for other pollutants at the present time, PSD rulings will have major effects on NO_x control technology. Especially when facility expansion is desired, which is a major step toward commercialization, adequate air quality degradation increments may not be available. The uncertainty involved in the future development in NO_x control technology may seriously affect the implementation of BACT in the future. These possible future regulations of NO_x emissions are so stringent that precombustion cleaning or postcombustion reduction may be required.

Time Frame for Future Regulatory Action

Nitrogen oxides play a major role in the whole set of air pollution problems, and adequate relevant information is likely to be accumulated in the near future to strongly link the emission of nitrogen oxides to human health and other serious problems. There is a strong incentive to have more stringent regulations under the current regulatory climate. However, there are two major difficulties involved:

(1) NO_x is a photochemically reactive species in the ambient air. Its role as the precursor gas to other pollutants is not thoroughly understood. The potential impacts on ambient air quality of its emission reduction is not clear.

(2) The future of NO_x emission control technology is uncertain. Combustion modification seems to be the near-term solution, but it can achieve relatively less reduction. Flue gas treatment has the potential for high NO_x removal efficiency but technology is not that well developed and probably will cost more.

Hence, the likelihood of having additional regulations, under the current regulatory climate, really depends on the air quality predicting capability and the economical and technical feasibility of control measures. Hence, there are some uncertainties involved in having enough knowledge to predict air quality and having feasible control measures before 1985. However, such knowledge is likely to be available in the 1985-1990 time frame, resulting in additional regulatory action by 1990.

4.16 Land Disturbances From Surface Mining

Description of Issue

Coal is the single fossil fuel for which the U.S has a large enough supply not to be concerned about future availability and which can be obtained at a clearly competitive cost. Energy shortages have focused attention on the need for massive exploitation of the nation's coal resources as a substitute for oil and gas. Although 77 to 91 percent of the nation's coal reserves can be recovered only by deep mining, (University of Oklahoma, 1975), surface mining now contributes more than half of the coal mined in the U.S. (Westerstorm, 1975) The trend in recent years has been increasingly in the direction of surface mining. The major reasons for this trend are the lower extraction cost, higher resource recovery efficiency, and less health and safety problems for surface mining as compared to deep mining. Oil shale, another abundant fossil fuel resource in the U.S., can also be surface mined. However, reclamation of land after the resources have been removed is a critical environmental issue.

The principal environmental concerns associated with large-scale surface mining are the maintenance of original topography and high quality of water supply, and the preservation of local ecological and agricultural productivity. As surface-mined areas are laid bare, deep cuts are made and the wildlife habitat is totally destroyed in the process of removing the overburden. Groundwater supply may become questionable because of the indication that the coal beds themselves, or the zones immediately above, are the primary shallow groundwater aquifers. In the reclamation process, soil and subsoil materials are generally blended with other materials and usually turned upside down. This blend is no longer a soil in the agricultural sense but a mass of heterogeneous sterile material. Techniques usually used in agricultural soil frequently do not apply in backfilling. Therefore, there is too little moisture in the soil and stress conditions are high. Revegetation of spoils is difficult because the conditions necessary to reestablish the key species known to be important to the local ecosystem are usually unknown. Revegetation of shrubs and trees is seldom considered. It is often difficult to return the topography to pre-mining conditions.

After steeply-dipping seams are mined, the surface cannot be restored to the original contours. The pattern of surface drainage is usually changed after backfilling, the impacts of changes in surface and subsurface hydrology between mined and undisturbed lands are difficult to estimate, and the stability of backfills is often questionable.

Other possible environmental impacts away from the mining sites are: adverse effects on water supply, destruction of commercial and recreational fisheries, destruction of aquatic biota with its ultimate effect on the food chain, flooding, siltation of navigation channels, and reduction in storage capacities of reservoirs.

Probable Solutions

Technically, problems associated with land disturbances and reclamation caused by surface mining can be eased by detailed pre-mining planning. This would prohibit mining where damage is irreparable. The properties of spoils and overburden can be carefully analyzed and backfill plans can be delineated. Hydrological surveys can be conducted so that underground aquifers are avoided. Revegetation plans and landscape designs can also be delineated before mining.

While massive exploitation of coal resources is a necessary component of national energy policy, stringent regulations to protect the environment from damage by surface mining seem unavoidable. This situation could result in shifts toward alternative underground extraction methods (e.g., longwall mining) which have safety factors closely resembling surface mining, or in widespread enforcement problems, should surface mine operations actively resist the regulations.

Legislative/Regulatory Background

The Coal Mine Health and Safety Act of 1969 has had a major impact on underground mining and has been credited with aiding the shift to surface mining. Following the Arab oil embargo in 1973-74, Congress passed the Energy Supply and Environmental Coordination Act of 1974 (ESECA) which was enacted to give the Federal Energy Administration the authority to order certain oil and gas burning utilities and industries to convert their steam boilers to coal. The 1977 National Energy Plan recommended the increased use of coal to meet increasing need for energy. All these contributed to an increase in surface mining operations in the West.

The FWPCA Amendments of 1972 affect surface mining in two ways. First, Section 404 of FWPCA Amendments regulates the placement of dredge and fill materials and protects navigable channels from siltation. Second, through the authorization of NPDES, the FWPCA Amendments requires EPA to set effluent standards. The current limitations are set for pH, suspended solid, total iron, dissolved iron, acidity, alkalinity, and manganese in the mine discharge. The RCRA (1976) requires EPA to regulate the treatment, storage, transportation, and disposal of hazardous wastes. Special placement of hazardous wastes is required to protect groundwater. Because large amounts of overburden are involved in the surface mining process, it would have tremendous effect on surface mining should the overburden be found hazardous. Authorized by the National Environmental Policy Act (NEPA) of 1969 and the Coal Leasing Act Amendments of 1976, the Department of Interior and EPA both require detailed environmental impact analysis before federal coal land can be leased or mining permits can be issued.

The Surface Mining Control and Reclamation Act of 1977 probably will have the major impact on surface mining. It requires that a permit application include, among other things, a determination of the probable hydrological consequences of the mining and reclamation operation. It requires the land to be restored to a condition "capable of supporting the use which it was capable of supporting prior to any mining or higher or better uses." Additionally, all operators of coal mining operations must pay to the Secretary of the Interior a reclamation fee. The fund will be used to protect the public from adverse effects on coal mining operations and will also be used to restore the land and water resources and the environment previously degraded by adverse effects of coal mining practices. This Act can have major impact on surface mining in the near future.

Thirty-eight states have laws to regulate surface mining. Pennsylvania and Wyoming already have reclamation plans for surface mining operations. Pennsylvania has a comprehensive plan which includes: (1) a statement of highest and best use to which the land was put prior to commencement of surface mining; (2) the proposed use of the land following reclamation; (3) the manner in which the topsoil will be conserved and restored; (4) a complete planting program providing for the planting of trees, grasses, legumes or shrubs; and (5) a detailed timetable for the accomplishment of each major step in the reclamation plan, the operations estimate of the cost of each step, and the total cost of the plan. Wyoming's plan is similar to Pennsylvania's, but also pays attention to the social and economic value of the product mined and the technological availability or economic feasibility of reclaiming the affected area.

Possible Future Regulatory Actions and Their Impacts

Current legislation covers nearly all aspects of this issue. Possible future regulatory actions will involve extensions of the present legislation. The possible actions that could have major impacts on surface mining include:

(1) Extension of Surface Mining Control and Reclamation Act

- More stringent requirements for restoration
- Prohibition of surface mining in certain topographically, ecologically, or hydrologically sensitive regions
- Requirement for more efficient or complete recovery of coal from seams

(2) Extension of RCRA

- Requirement for special placement of overburden
- Requirement to have special mining and restoration technologies

(3) Extension of SDWA

- Requirement for detailed hydrological survey to avoid contaminating underground aquifers
- Restriction on mining and restoration practices to maintain the availability and quality of drinking water supply

(4) Extension of FWPCA

- Inclusion of major rivers, reservoirs, and even small, upstream waters in the 404 program.
- More complete effluent standards for surface mine discharges

The extended regulatory actions from the above four Acts will have direct, major impact on surface mining. More regulatory actions may derive from extensions of other legislation, including the Coal Leasing Act Amendments, the Fish and Wildlife Coordination Act, the Federal Land Policy and Management Act, and the Endangered Species Act.

All these possible actions will have major impacts on the future of surface mining. Technically, it is very difficult to reduce the toxic substances in the effluent and drainage and to clean the hazardous residuals from the overburden, yet these activities are likely to be regulated in the future.

Time Frame for Future Regulatory Action

Under the current regulatory climate, there is little likelihood of having any of the above major regulatory actions by 1985, mainly because of the demand for coal and the low level of exposure of the impacts to the general public. As the production of coal from surface mines increases, both in tonnage and in geographical extent, there is likely to be increased public and environmental interest group pressure for further regulation. This pressure will be alleviated to some extent if reclamation techniques are shown to be effective, especially in areas in which long-term reclamation will be difficult to achieve.

4.17 Effluent From Geothermal Facilities

Description of the Issue

Geothermal resources are classified into five major categories: dry steam fields (vapor-dominated systems); wet or hot-water fields (liquid-dominated systems); geopressured resources; impermeable dry rock; and magma systems. The most accessible geothermal resources are dry steam fields, which can be tapped by conventional steam thermal cycle technology; however, this particular geothermal resource is a rather rare geological occurrence. The greatest midterm potential involves wet steam fields which are more abundant than dry steam fields. Dry, hot rock geothermal sources may be the most abundant domestic geothermal resource, but they are economically prohibitive at the present time. Another source of geothermal energy representing an immense energy potential consists of hot porous sands saturated with high pressure, high temperature brine or hot water such as those along the gulf coast of U.S. However, the technology required to convert this thermal energy into electrical energy is not yet available.

Geothermal fluids withdrawn from the earth contain a variety of noxious substances, including significant amounts of mercury, hydrogen sulfide (H_2S), carbon dioxide (CO_2), silica, arsenic, salinity (sulfate, chloride and fluoride salts), and even radioactive materials which can be rejected into adjacent bodies of water or the atmosphere unless carefully controlled (Axtmann, 1975). The actual effluent depends upon the technology and the specific drilling site, as well as the fluid composition.

The concentrations of some of the major contaminants found in geothermal resources in different parts of the would are shown in Table 4-8. From this table it can be seen that the concentrations of the contaminants can vary by orders of magnitude from one resource area to the next. The amounts released to the environment will depend on the nature of the resource as well as the technology used to convert it to electricity. For example, the extraction of dry steam resource, (e.g., the Geysers) would result in the release of nearly

TABLE 4-8 CONCENTRATIONS OF SOME COMPOUNDS EMITTED FROM GEOTHERMAL WELLS (White, 1979)

COMPOUND	California Geysers	Idaho Raft River	Utah Roosevelt	California East Mesa	Mexico Cerro Prieto	N. Zealand Wairakei
Mercury						
NCG ug/l	1.8-5.8	0.04	--	2.3-3.6	0.3-0.4	--
CS ug/l	2.8-10.0	0.10	--	1.5-14.4	3.8-5.4	--
FB ug/l	--	.01-.04	--	.001-.003	.05	0.1
Arsenic						
NCG ug/l	0.003	--	--	--	0.016	--
CS mg/l	0.002-0.1	0.012	--	--	0.006	--
FB mg/l	--	0.025	--	--	0.5-2.3	2.7-4.8
Boron						
NCG ug/l	--	--	--	--	--	--
CS mg/l	6.4-76	0.1	--	0.1	0.006	--
FB mg/l	--	0.13	25-29	9.8	19	20-29
Ammonia						
NCG mg/l	--	--	--	108	17.8	8
CS mg/l	157-818	1.8	--	98	88-163	--
FB mg/l	--	0.27	1.0	65	127	0.2-1.0
Radon						
CS pCi/l	3,820-27,800	--	--	280-1262	--	--

KEY: NCG= Non-combustible gases
CS = Condensed steam
FB = Flashed brine

all the noncondensible gases such as ammonia, mercury, radon, and hydrogen sulfide, unless otherwise controlled. Similarly, the recovery of wet steam resources (e.g., Roosevelt) via a flashed steam process would result in the emission of nearly all the noncondensible gases. The use of a binary cycle, however, would result in the emission to the amir of very little if any of these gases. Any contaminants not released to the air remain in the condensed fluid phase which must ultimately be disposed of.

The major environmental issue is the disposal of these noxious substances. Discharging these mineralized fluids into streams and lakes would be generally unacceptable as would disposal to otherwise useable underground aquifers. Even discharge to the ocean might be unacceptable in view of the thermal load (Research and Education Association, 1975). The significance of the release of geothermal wastes to the environment is indicated in the following brief discussion of the environmental effects of arsenic, mercury, hydrogen sulfide, carbon dioxide,silica, highly saline fluids and radioactive materials.

- Arsenic. Compounds of arsenic (As) are ubiquitous in the environment and insoluble in water. Arsenic exists in the trivalent and pentavalent states and its compounds may be organic or inorganic. In general, naturally occurring arsenic is pentavalent, while that added to the environment is trivalent. Trivalent inorganic arsenicals are more toxic than the pentavalent forms to both mammals and aquatic species (U.S. EPA, 1976).

  Arsenic is normally present in sea water at concentrations of 2 to 3 ug/l, and tends to be accumulated by oysters and other molluscan shellfish (Sautet, et al., 1964; Lowman et al., 1971). In most drinking water supplies in the United States, the arsenic concentration ranges from a trace to approximately 0.1 mg/l (U.S. EPA, 1976). Arsenic is a cummulative poison demonstrating long-term chronic effects both aquatic organisms and on mammalian species. It may be accumulated; a succession of small doses may add up to a final lethal dose (Buchanan, 1962).

Arsenic has been a suspected carcinogen (Borgono and Greiber, 1972); however, substantial evidence from human experience and animal studies now supports the position that arsenicals are not tumorigenic at levels encountered in the environment (Kanisawa and Schroeder, 1967; Milner, 1969).

Compounds of arsenic are concentrated in aquatic organisms; however, they evidently do not progressively concentrate along a food chain (U.S. EPA, 1976). The data also indicate that freshwater fish--food organisms are adversely affected by concentrations of arsenic as low as 1.3 mg/l. Impaired mobility of the freshwater crustacean Daphnia is observed at a concentration as low as 4.3 mg/l (U.S. EPA, 1976).

- Mercury. Mercury (Hg) exists in three oxidation states: (1) zero (elemental mercury), (2) +1 (mercurous compounds) and (3) +2 (mercuric compounds). Mercury is widely distributed in the environment, and biologically is considered a nonessential or nonbeneficial element. Several forms of mercury, ranging from the element to dissolved inorganic and organic species are expected to occur in the environment.

In unpolluted U.S. rivers from thirty-one states where natural mercury deposits are unknown, the mercury content was determined to be less than 0.1 ug/l (Wershaw, 1970). Jenne (1972) also found that the majority of U.S. waters contained less than 0.1 ug/l of Hg (lower limit of detection). Marine waters have been shown to have concentrations of mercury ranging from a low of 0.03 ug/l to a high of 0.2 ug/l; however, most sea water falls within a range of 0.05 to 0.19 ug/l (U.S. EPA, 1976). Mining, agriculture and waste discharges contribute to the natural levels found.

A recent discovery by Jensen and Jernelov (1969) found that certain microorganisms have the ability to convert inorganic and organic forms of mercury to the highly toxic methyl or dimethylmercury, indicating that any form of mercury can be made potentially hazardous to the environment. Bisogni and Lawrence (1973) in studies on the biochemical kinetics of mercury methylation demonstrated that in water, under naturally occurring conditions of pH and temperature, inorganic mercury can be readily converted to methylmercury. Because of methylation and bioconcentration of the methylmercury, mercury limits must take into consideration the food chain transport path from aquatic organisms to man.

Aquatic organisms concentrate mercury in their bodies either directly from the water or via the food chain (Johels et al., 1967; Hannerz, 1968; Miettinen et al., 1970). In general, the mercury contained in the organisms eaten by fish increases at each trophic level of the food chain (Hamilton, 1971). The magnitude of the bioaccumulation of Hg is determined by the species, its exposure, feeding habits, metabolic rate, age and size, quality of the water and the degree of mercury in the water.

Excessive mercury residues in sediments are dissipated slowly. Lofroth (1970) estimated that aquatic habitats polluted with Hg continue to contaminate fish for as long as 10 to 100 years after pollution has stopped.

With respect to humans, mercury poisoning may be acute or chronic. Generally, mercurous salts are less soluble in the digestive tract than mercuric salts and, consequently, are less acutely toxic. Chronic poisoning from inorganic mercurials has been most often associated with industrial exposure, whereas organic derivatives of mercury have been the result of accidents or environmental contamination such as drinking contaminated water or eating contaminated fish.

Hydrogen Sulfide. Hydrogen sulfide (H_2S) is a poisonous gas, soluble in water (4,000 mg/l at 20°C and 1 atm), having a characteristic rotten egg odor. In solution, H_2S dissociates according to the following reactions H_2S --- HS^- + H^+; HS^- --- S^- + H^+. At pH 9, about 99% of the sulfide is in the form of HS^-; at pH 7 it is about equally divided between HS^- and H_2S; and at pH 5 about 99% is present as H_2S. Consequently, the toxicity of sulfides increases at lower pH because a greater proportion is in the undissociated form.

Most available data concerning the toxicity of H_2S to aquatic life have been based on extremely short exposure periods and have failed to provide adequate information on water quality, oxygen content and pH. As a result, early data have suggested that concentrations between 0.3 and 4.0 mg/l will permit fish to survive (Bonn and Follis, 1967; Theede et al., 1969). However, more recent data both in field situations and under controlled laboratory conditions demonstrated H_2S toxicity at lower concentrations. Because of the rotten egg odor, it is highly unlikely that human consumption of contaminated water will present a problem.

H_2S gas is acutely toxic at higher concentrations. However, at the low concentrations likely in the vicinity of geothermal power plants (below 1 ppm) the main problem is the distinctive "rotten egg" odor. Vegetation effects may also be observed at a concentration of several parts per million, including leaf lesions, defoliation and reduced growth. The effects of long-term exposure at concentrations under 1 ppm are not well known, and require further study.

- Carbon Dioxide. Carbon dioxide (CO_2) exists in two major forms in water. It may enter into the bicarbonate buffering system at various concentrations depending on the pH of the water, or it can also exist as "free" CO_2. The latter state of CO_2 affects the respiration of fish (Fry, 1957), and is considered the most significant to aquatic life because of these respiratory effects.

The concentration of CO_2, where oxygen-demanding wastes are not excessive is a function of pH, temperature and the atmospheric pressure of CO_2. An excess of "free" CO_2 may have adverse effects on aquatic life. Various studies have shown that fish are able to detect and respond to slight gradients in CO_2 concentration (Powers and Clark, 1943; Warren, 1971). Elevated CO_2 concentrations may interfere with the ability of fish to respire properly and thus may affect their dissolved O_2 uptake. In studies by Doudoroff and Katz (1950) and Doudoroff and Shumway (1970), it was reported that where elevated CO_2 levels are found, interference in the dissolved O_2-uptake occurs. However, the "free" CO_2 concentrations which appreciably affect this are higher than those found in polluted waters.

Basu (1959) found that for most fish species, CO_2 does have an affect on the fishes' ability to consume O_2 in a predicted manner. He further indicated that temperature affected CO_2 sensitivity, being less at higher water temperatures.

- Silica. At depth, hydrothermal waters are saturated with quartz, but as the fluid in the borehole rises, its temperature decreases resulting in a supersaturated solution. When steam at the wellhead is extracted, the volume of the water fraction decreases causing its temperature to fall even further. At this point, the silica concentration in the water exceeds the solubility of amorphous silica (550 ppm). If the supernatant steam comes in contact with water, the silica will begin to polymerize and then precipitate in the amorphous form. The discharge canals must be cleaned periodically with a pneumatic shovel, which is a dangerous and expensive operation (Axtmann, 1975).

This precipitation of silica is one of the most serious impediments to utilizing the heat in waste water and to reinjecting the fluid. With respect to the utilization of the heat in waste water, the problem is the fouling of heat-exchanger surfaces. In the second case (reinjection), the problems are clogging of the reinjection pipes and reduction of the receiving aquifer's permeability (Axtmann, 1975).

- High Salinity Fluids. The principle constituents of total dissolved solids in natural surface waters include carbonates, sulfates, chlorides, phosphates and nitrates. These anions occur in combination with such metallic cations as calcium (Ca), potassium (K), magnesium (Mg), and iron (Fe) to form ionizable salts (Reid, 1961).

The quantity and quality of dissolved solids are two of the major factors in determining the variety and abundance of plants and animals in an aquatic system. They can serve as nutrients in productivity or contribute to osmotic stress and direct toxicity. A major change in the quantity or composition of total dissolved solids changes the structure and function of aquatic ecosystems.

Fish and other aquatic life must be capable of tolerating a range in concentration of dissolved solids for survival under natural conditions. Studies performed in Saskatchewan have indicated that several common freshwater species of fish have survived a concentration of 10,000 mg/l, but only the Stickleback survived a 20,000 mg/l concentration of dissolved solids. Therefore, it was concluded that lakes containing dissolved solids in excess of 15,000 mg/l were unsuitable for fish (Rawson and Moore, 1944). Marine fish have also exhibited a variance in the ability to tolerate changes in salinity. In Laguna Madre off the Texas Coast, fishkills have occurred with salinities in the range of 75 to 100 parts per thousand (Rousefell and Everhart, 1953). Fish inhabiting estuaries are tolerant to salinity changes ranging from fresh to brackish to sea water. Likewise, anadromous species are tolerant although evidence indicates that the young cannot tolerate the change until the normal period of migration (Rousefell and Everhart, 1953).

An accidental release of geothermal fluid onto the soil will have an effect the osmotic pressure of the soil solution. This is one of the most important water quality considerations. In fields having an otherwise adequate water supply, plants have been observed to wilt. This was usually the result of high soil salinity creating a physiological drought condition. In addition, temperature and wind effects are especially important because of their direct effect on evapotranspiration. Periods of high temperature or other factors such as dry winds, which increase evapotranspiration rates, not only have the tendency to increase soil salinity but also to create a greater water stress in plants. Care must be taken to prevent the discharge of highly saline fluids to the surrounding soil especially where there is an abundance of vegetation.

- Radioactive Materials. Radioactive materials in the aquatic environment may be cycled through water, sediment and the biota. Each radioisotope tends to take a characteristic route and possesses its own rate of movement through various temporary reservoirs. When first introduced into fresh or marine water, a substantial part of the materials present in radioactive wastes become associated with solids that settle to the bottom, with many of the radioisotopes chemically binding to the sediments.

Plants and animals must accumulate the radioisotope, retain it, be eaten by another organism, and be digested for passage of radioisotopes through a food web in the aquatic environment to be of any significance. Radioisotopes may be passed through several trophic levels of a food web in which the concentration can either increase or decrease from one trophic level to the next, depending upon the radioisotope and the prey/ predator organisms. Radioisotopes with short half-lives are less likely to be highly concentrated at the higher trophic levels of the food chain because of the time required to move from water to plants, to herbivores, and eventually carnivores.

With respect to the production of geothermal power, radon-222 (222Rn) is the radioactive isotope of major concern. 222Rn is an inert radioactive gas which is produced through the decay of the naturally occurring isotope of uranium, 238U. Since 222Rn is a gas, it can diffuse from its point of origin through rock or soil. In addition, 222Rn is found in fluids from wells or mines that are drilled into rock formations containing 238U. This is apparently what occurs at the Geysers (Pacific Gas and Electric Co., 1975). Radon is inert; however, its daughters, polonium-218, lead-214 and bismuth-214 are all chemically active. In particular, when 222Rn decays, most of the newly created polonium-218 (solid) atoms are ionized and will attach almost immediately to any particulate matter in the atmosphere.

The principle release points for 222Rn carried into the power generating units of the Geyser Power Plant geothermal production steam are the gas ejector stacks (from 60 to 85 feet above local ground level, depending on the unit). The daughter product, lead-210 has been found in water samples (Pacific Gas and Electric, 1975).

Based on the above discussion, it can be concluded that at the local level the environmental impact of a geothermal power station may be quite significant (Axtmann, 1975).

It should also be stressed that technology exists which can greatly minimize the environmental impact of geothermal energy facilities. However, geothermal energy is not the benign and clean energy source it is frequently claimed to be and it will require a substantial effort to minimize its environmental impact.

Probable Solutions

The most commonly proposed solution to the problem of liquid waste disposal is to reinject the waste fluids back into the producing zone. This method is advantageous in that it provides a recharge and pressure maintenance to the geothermal reservoir. However, reinjection can be dangerous--the dangers primarily arising from spills, reinjection at the wrong level, reinjection at pressures that are too high, causing cracks in the surrounding rock, reinjecting in areas of sloping aquifers or those with lens-shaped caps, and the natural development of cracks in the disposal area. In a seismic area, reinjection poses another problem - the triggering of an earthquake or pipes broken by shifting strata. Another possible solution would be to evaporate wastes and recover minerals and salts of economic value. However, this would require a large area and impermeable ponds which would be expensive. Thus, this method is probably not very practical.

Currently, reinjection appears to be the only viable solution to the liquid waste disposal problem. However, further research is needed to evaluate more fully any additional solutions, including costs of disposal, and potential benefits.

The release of gaseous H_2S from geothermal energy production can be controlled by treating the noncondensible gas stream with commercially available H_2S removal system such as the Stretford or Claus process. These processes oxidize H_2S to elemental sulfur and can remove on the order of 90 percent of the H_2S from the gas system.

Legislative/Regulatory Background

The federal legislation concerning disposal of liquid geothermal wastes consists of the FWPCA of 1972, as amended, specifically section 402, which established the NPDES; the SDWA; of 1979, as amended, the National Environmental Policy Act of 1969 and the Geothermal Energy Research, Development, and Demonstration Act of 1974.

The FWPCA, specifically NPDES, regulates the discharge of pollutants from point sources into the waters of the United States. The effluent standards fall into several categories: (1) standards of performance for existing sources, (2) standards of performance for new sources, (3) water quality related effluent limitations, (4) effluent standards for toxic pollutants, and (5) pretreatment standards (effluent standards for sources discharging into treatment works rather than directly into water courses). The standards that are likely to be most applcable to geothermal effluents are described briefly below.

<u>New Source Performance Standards</u>. A list of categories of sources have been published by the EPA. This list may be periodically revised. Federal standards of performance have been established for sources listed within any of the categories. Any source that commences construction after the publication of a proposed regulation prescribing a standard of performance must comply with the prescribed standard. The standards are based on the greatest degree of effluent reduction achievable through the application of the best demonstrated control technology (BDCT). In establishing the standards, the cost of achieving such effluent reduction, and any non-water quality environmental impact and energy requirements must be considered.

<u>Water Quality Related Effluent Limitations</u>. If a point source meeting the required technology-based effluent limitations still interferes with the attainment or maintenance of a minimum water quality, that source must apply stricter effluent limitations which can reasonably be expected to contribute to the attainment or maintenance of that minimum water quality. Some factors considered when setting a minimum water quality standard are the protection of public water supplies, the propagation of a balanced population of fish and wildlife, and recreational activities in and on the water.

Toxic Pollutants. A list of toxic pollutants has been established. Prior to listing, a pollutant's toxicity, persistence, degradability, potential presence of the affected organisms in any waters, the importance of the affected organism, and the nature and extent of the effect of the toxic pollutant on such organism is considered. Every toxic pollutant listed is subject to the effluent limitations resulting from the application of the best available technology economically acheivable (BATEA). In order to determine BATEA, an identification of the effluent reduction attainable through the application of the best control measures and practices achievable must be made in terms of amounts of constituents and chemical, physical and biological characteristics of pollutants.

The SDWA under Section 1421 regulates the State Underground Injection Control Program. With regard to geothermal energy, this Act will regulate the underground injection associated with this technology. Geothermal energy may produce reinjected wastewater containing large amounts of dissolved solids (silicon, calcium carbonate, sodium chloride, and boron), which could contaminate aquifers if proper precautionary measures are not taken. However, the EPA draft Underground Injection Regulations under the SDWA says:

> "States could, but need not, treat geothermal aquifers as mineral producing aquifers, and thereby explicitly exempt them from classification under Section 146.05(d)." (Section 146.05(d) allows the states to exclude from the "potential drinking water" aquifer classification aquifers that are mineral, oil. or geothermal producing). Treatment would be left to the individual states.

The Geothermal Energy Research Development,and Demonstration Act of 1974, as amended Sec. 104, provides for a program with the purpose of resolving all major technical problems associated with the utilization of geothermal resources. The goals of the program which are most applicable to the problem of liquid waste disposal includes (1) the development of improved methods for converting geothermal resources and by-products to useful forms; (2) the development of improved methods for controlling emissions and wastes from geothermal utilization facilities, including new monitoring methods to any extent necessary; (3) the development and evaluation of waste disposal control technologies and the evaluation of surface and subsurface environmental effects of geothermal development; (4) the improvement of the technical capability to predict environmental impacts resulting from the development of geothermal resources, the preparation of environmental impact statements, and assuring of compliance with applicable standards and criteria. In addition, Sec. 301 of this act specifies that the environment and the safety of persons or property are effectively protected and Section 103(b)(4) provides that:

> "The Chairman [of the Interagency Geothermal Coordinating Council] shall make such recommendations for legislation or administrative regulations as may from time to time appear to be necessary to make federal leasing, environmental and taxing policy for geothermal resources consistent with known inventories of various resource types, with the current state of technologies for geothermal energy development, and with current evaluations of the environmental impacts of such development."

A number of states with the potential for producing geothermal energy have developed legislation that affects geothermal development. The legislation pertaining to geothermal energy for Idaho, California, and New Mexico is described below.

Idaho

The Idaho Geothermal Resources Act of 1972, was enacted for the purpose utilizing the state's geothermal energy potential for "enhancement of our economy and quality of life with a minimum of environmental degradation." (First adopted in 1972, revised in 1975 and again in 1978.)

The Geothermal policy of the state of Idaho as stated in section 42-4001, Idaho Code, is as follows:

> It is the policy and purpose of this state to maximize the benefits to the entire state which may be derived from the utilization of our geothermal resources, while minimizing the detriments and costs of all kinds which could result from their utilizaton. This policy and purpose is embodied in this Act which provides for the immediate regulation of geothermal resource exploration and development in the public interest."

California

The California Environmental Quality Act of 1970 requires the preparation of two Environmental Impact Reports (EIRs)--one for the geothermal exploration phase of development and one for power plant construction (production) phase of development. A minimum of ten state and three local agencies must review these two EIRs before permits on geothermal projects are approved (Bedrossion, 1978). In addition, a special geothermal task force, created with the passage of Assembly Bill No. 3590 in August 1976, has made a study of all aspects of the development of geothermal resources of the state.

The State of California has prohibited the discharge of waste fluids with high dissolved solids content into either surface waters or shallow aquifers. This is in reference particularly to the geothermal developm of the Imperial Valley where the salinity level of the Salton Sea and various shallow aquifers is already high (EPA; 1977).

With respect to the Geysers, Order No. 77-221 "Waste Discharge Requirements for Union Oil Company of Caifornia", is to be rescinded and the Union Oil Company of California shall comply with the following:

A. Discharge Specifications
   1. The discharge of waste of any nature to the waters of Big Sulphur Creek or its tributaries is prohibited.

2. The disposal of drilling muds, oils, and associated wastewater in any area not approved and classified by the Regional Board as a disposal site is prohibited.

3. Neither the treatment nor disposal of waste shall cause a nuisance or pollution.

B. Provisions

1. Drilling muds, oils, and associated wastewater shall only be disposed of at sites approved by the Regional Board as provided in Chapter 3, Title 23, Subchapter 15, of the California Administration Code, Waste Disposal to Land.

2. The discharge, in cooperation with Pacific Gas and Electric Company shall implement the plan submitted to the Regional Board for the control of geothermal condensate spills by providing retention barriers at all Geysers generating units to prevent accidental releases of condensate from discharging to surface water streams.

New Mexico

The State of New Mexico has various rules and regulations with regard to the production of geothermal energy. Several of only those rules and regulations specific to the problem of waste disposal and reinjection areas follows:

RULE 3. WASTE PROHIBITED

(a) The production or handling of geothermal resources of any type or in any form, or the handling or products thereof, in such a manner or under such conditions or in such an amount as to constitute or result in waste is hereby prohibited.

(b) All owners, operators, contractors, drillers, transporters, service companies, pipe pulling and salvage contractors, and other persons shall at all times conduct their operations in the drilling, equipping, operating, producing, and plugging and abandoning of geothermal resources wells in a manner that will prevent waste of geothermal resources, and shall not wastefully utilize geothermal resources, or allow leakage of such resources from a geothermal reservoir, or form wells, tanks, containers, or pipe, or other storage, conduit, or operating equipment.

RULE 106. DRILLING MUD AND MUD PITS

In order to assure an adequate supply of drilling fluid to confine all natural fluids to their respective native strata and to prevent blowouts, each operator shall, prior to commencing drilling operations, provide a pit of adequate size to hold such drilling fluid and to receive drill cuttings, and such pit shall be so constructed and maintained to prevent contaminants from overflowing on the surface of the ground and/or entering any water course.

RULE 116. DISPOSAL OF PRODUCED WATERS

The disposal of highly mineralized waters produced from geothermal resources wells shall be in such a manner as to not constitute a hazard to surface waters or underground supplies of useable water.

RULE 505. SURVEILLANCE

Surveillance of waste water disposal or injection projects is necessary on a continuing basis in order to establish to the satisfaction of the Commission that all water is confined to the intended zone of injection.

The regulation of air pollution from geothermal resource development is currently carried out at the state and local level. Both California and New

Mexico have ambient air standards for H_2S that must be met in the vicinity of geothermal development areas. California's one hour standard is 0.03 ppm, while New Mexico's is ten times lower--0.003 ppm, which is approximately the odor threshold for H_2S. In California, Lake County and Sonoma Country Air Pollution Control Districts regulate H_2S emissions at the Geysers. The Sonoma Country emission standard for new power plants is 0.4 lb H_2S per MW-hr, which requires approximately 90 percent reduction in H_2S emissions.

There are currently no federal NSPS or NESHAPs that would apply to geothermal energy development.

Possible Future Regulatory Actions and Their Impacts

At the federal level, the legislative basis for future regulation of air, water, and solid waste emissions from geothermal energy development is well established. EPA has declared its intention to develop regulatory standards for the geothermal industry and is likely to establish regulations in the following areas:

- Effluent guidelines, including National Standards of Performance, and water quality standards applicable to receiving waters, under the FWPCA

- Groundwater protection regulations under the SDWA applicable to subsurface disposal of spent geothermal fluids

- Regulations under RCRA applicable to subsurface brine and sludge impoundments at geothermal facilities, primarily to prevent infiltration of contaminants to groundwater

- NSPS under the CAA for emissions from geothermal facilities, primarily hydrogen sulfide emissions

Also likely to come under regulation are noise generation from geothermal wells (under the Noise Control Act of 1972) and radioactivity in fluid discharges. Until such time as formal regulations are established, EPA will regulate discharges through permits issued on a case-by-case basis.

Additional regulations may be established at the state and local level as well, as geothermal development becomes more widespread. In many cases, such regulations may be more stringent than those established by EPA. For example, EPA has suggested a NSPS for H_2S of 0.2 to 0.4 kg per MW-hr, roughly in line with the current Sonoma County, California, standard. However, that county is considering lowering its standard by as musch as a factor of 10 because of the large projected capacity expansion at the The Geysers. New Mexico also is likely to enforce emissions standards lower than EPA in order to insure compliance with its stringent H_2S ambient air standard.

The impact of these regulations will be to increase the cost of geothermal developments via stringent controls on fluid disposal and the addition of H_2S abatement technology at all conversion facilitites. Fluid reinjection, which is the most feasible method of effluent disposal, is particularly costly for hot water resources because of the large waste volumes involved. Environmental regulations may also force the development of some innovative waste fluid treatment techniques in areas where reinjection may not be practicable for one reason or another, such as seismicity problems or the possibility of contaminating nearby aquifers. The success of such techniques is ultimately dependent on economics, and it may be that within the future regulatory framework, some geothermal resources may simply prove to be uneconomical, and their development would be unlikely to take place.

Time Frame for Future Regulatory Action

Given that EPA has announced its intention to regulate geothermal energy and the pace of geothermal development, it is likely that at least some of the regulatory actions mentioned above will be carried out within the next five years. Particularly likely to be established in that time frame are regulations that result in the use of well established control techniques, e.g., H_2S emissions. As geothermal resources are developed through 1980's, it seems likely that regulatory activities will keep pace, and that a fairly complete regulatory framework will be established at the federal and state levels by 1990. Regulations dealing with some specific pollutants (e.g., arsenic and boron) for which further research is required on both effects of emissions and methods of control, may be delayed somewhat beyond that time.

4.18 Nuclear Waste Disposal

Description of the Issue

The disposal of wastes generated from the nuclear fuel cycle represents one of the major environmental issues associated with the use of nuclear power. Nuclear wastes possess both high and low-level radioactivity depending upon the stage of the fuel cycle in which they are generated. Obviously, the high-level radioactive wastes will present the greater disposal problem. The various stages of the fuel cycle and the wastes generated at each can be identified as discussed below (U.S. Atomic Energy Comm., 1974; NRC, 1976; California Energy Resources Conservation and Development Comm., 1977):

(1) Mining. Both underground and open pit techniques are used in the mining of raw uranium ore. The ore obtained from mines in this country averages 0.25% uranium oxide (U_3O_8). The solid waste consists primarily of barren rock and earth overburden, the bulk of which is used as backfill

(2) Milling. Milling is necessary to extract and concentrate uranium from the raw ore in the form of U_3O_8. Liquid and solid chemical and radiological wastes are discharged to the tailings retention pond. The tailings are composed primarily of sandstone and particles; however, they also contain 85% of the radioactive materials originally found in the ore (uranium-natural, radium-226 and thorium-230).

(3) Conversion. The U_3O_8 extracted from the ore must be converted to gaseous UF_6 for enrichment. The chemical solid wastes consist of iron, calcium, magnesium, copper and other nonvolatile fluorides. The radioactive components of the solid waste are: uranium-234, -235, and -238; thorium-230 and radium-226. These are contained in the ash residue which is packaged and consigned for burial, along with the chemical wastes, at a licensed commercial disposal site. In addition, other low activity solid wastes in insoluble form are also buried.

(4) Enrichment. Essentially all power reactors (with the exception of heavy-water reactors or the early gas-cooled, graphite moderated reactors) utilize enriched uranium, that is, uranium with higher than the natural 0.7% concentration of U-235 (at least in the initial core loading). The uranium-235 content for the current generation of reactors is 2 to 4 percent. The waste generated from the enrichment process is in the form of sludge. The sludge is a solid effluent that contains soil runoff from groundwater, small quantities of precipitated metals and other settlable solids. These solids accumulate in holding ponds before they are removed and buried.

(5) Fabrication. Following enrichment, the UF_6 is chemically converted to a solid ceramic such as UO_2 or UC. The resulting ceramic powder is compacted (and sintered) into small pellets which are then loaded into metallic tubes (cladding). The solid waste consists of CaF_2 solids which contain about 0.23 curie of uranium per annual fuel requirement for a 1,000 Mwe reactor, and are contained on site. Other solid wastes contaminated with low levels of uranium are sent to a licensed commercial burial ground. It is very likely that the bulk of these wastes are incinerated and thus the volume shipped is considered insignificant.

(6) Fuel Burnup in the Reactor Core. The fuel assemblies are loaded into the reactor core for fissioning. There is no waste disposal problem in this step.

(7) Spent Fuel Storage and Decay. After being irradiated in the reactor core, the fuel is intensely radioactive due to fission product build-up. The spent fuel is removed from the core and stored in water pools for several months to allow the short-lived products to decay out. Disposing of the spent fuel is the major waste disposal problem in the nuclear fuel cycle. (See reprocessing for further discussion.)

(8) Reprocessing. (optional) The spent fuel can be shipped to reprocessing facilities to reclaim unused uranium (which can be recycled back as UF_6) and plutonium. The wastes which are generated are high level liquid wastes containing more than 99 percent of the nonvolatile fission products. These wastes are concentrated for storage on site in specially built, contained, and monitored tanks for a maximum of 5 years. This is followed by conversion to an inert solid which, after a maximum on-site storage time of ten years, is eventually transfered to a federally designated disposal site. In addition to the fission product content, there will be approximately 3.5 kg of plutonium and 350 kg of uranium in the wastes from an annual fuel requirement. The total quantity of high-level waste from an annual fuel requirement can be converted to a solid weighing approximately 1.4 to 2.3 thousand tons. Wastes other than high-level consist of: the undissolved fuel element hulls, which contain trace quantities of uranium, plutonium, and fission products; other fuel element parts and discarded equipment; and laboratory wastes, small tools, gloves and clothing may be buried on-site or at a commercial burial ground. (Discarded equipment is decontaminated prior to disposal).

(9) Waste Disposal. Finally, the radioactive waste products remaining after reprocessing are converted into either liquid of solid forms for storage and are shipped to various depositories for burial (and surveillance).

(10) Decontamination and Decommissioning. This primarily occurs to retired facilities with high levels of radioactive contamination. The waste will be generated from equipment removal, removal of cell liners, removal of contaminated concrete, etc.

The major issue specific to waste disposal is one having to do with the mechanism by which wastes might be contacted by groundwater, be leached into solution, travel through aquifers, and eventually reach surface waters where they might enter food or drinking water supplies. In order to avoid this possibility, care should be exercised in choosing a burial site that will minimize the chance for groundwater contaminate (Cohen, 1977). Described below are suggested alternatives for the disposal of wastes.

Probable Solutions

According to DOE, "major aspects of safe disposal of radioactive waste have not been demonstrated and certain treatment procedures have not even been developed." Work is proceeding on a variety of solidification processes; those methods currently being investigated are (U.S. AEC, 1974a,b,c):

(1) Fluidized bed calcination - Liquid waste is sprayed into a heated bed where it is deposited on granular particles

(2) Spray solidification - A liquid spray is flack evaporated into solid oxide particles.

(3) Pot calcination - The liquid is boiled off to leave a solid residue.

(4) Phosphate glass solidification - Liquid waste and phosphoric acid are mixed and concentrated to a thick sludge which goes to a melter where the liquid is evaporated and molten material drops into a container and solidifies.

(5) Borosilicate glass solidification - Calcining followed by melting.

Of these, calcination has received the most attention but has certain drawbacks, e.g., it is more easily leached than the glass solids.

After solidification, the waste should be permanently buried. Some of the alternatives for the permanent burial of nuclear waste are:

Ocean Disposal. With respect to ocean disposal, work has focused on stable deep seabeds or large marine sediment deposits on the top of basaltic rock. Potential advantages of ocean disposal are: (1) slow advection of soluble material through sediments, (2) sediment ion exchange processes to trap any released waste, and (3) low tidal currents (Bishops and Hollister, 1974). However, currently there is insufficient information to evaluate the seabed alternative (Calif. Energy Res. Conserv. Develop. Comm., 1977).

Ice Disposal. Disposing of wastes beneath the ice caps would place a massive physical barrier between the waste and the biosphere. However, uncertainties exist concerning the movement of ice, especially under the influence of heat from the waste, the lack of information pertaining to the rock-ice interface, and the inability to predict the stability of the ice sheet over long periods during which several glaciations may occur (Calif. Energy Res. Conserv. Develop. Comm., 1977).

Shallow Burial in Arid Zones. Desert areas are generally hydrologically closed basins and lack effective transport to deep water tables (Winograd, 1974). This situation is ideal because of the number of large, remote, federally-owned areas with thick, unsaturated zones. The only major drawback is the possibility of climatic change making such a repository unsuitable for the long-lived actinides (Calif. Energy Res. Conserv. Develop. Comm., 1977).

Realistically, however, it appears that deep-earth-based alternatives are the only viable options. Deep geologic formations are presently being considered. The deep geologic formations receiving the most attention are: salt beds, granite, shales and clays. Of the three formations mentioned, the most work has been done with salt beds.

Salt Beds. Salt beds have been of interest as potential sites for waste disposal because of their existence through long periods of time (250 million years) indicating that water has not entered them (Cohen, 1977). Since circulating groundwater is the most likely agent for dispersal of radionuclides from deeply buried wastes, the interiors of salt deposits apparently represent stable, dry geologic formations which may be suitable for the long-term isolation of radioactive wastes. Additional advantages to the use of salt beds are (Calif. Energy Res. Conserv. and Develop. Comm., 1977):

(1) The tendency of salt to flow plastically under pressure and seal cracks;

(2) Occurrence of salt formations over widespread areas;

(3) The high thermal conductivity of salt which enhances heat transfer;

(4) High compressive strength and radiation shielding characteristics of salt; and

(5) Location of salt deposits are usually found in areas of low seismicity.

However, while burial in salt beds appears to be a feasible approach, more information concerning the effects of migration of the hot wastes through salts is needed.

Disposal in Granite, Shale or Clay. The disposal of high-level waste in these formations has been given less attention than the possibility of disposal in salt beds; however, such research is becoming more widespread. In these media, there are several barriers to prevent the escape of radioisotopes. These include [California Energy Res. Conserv. and Develop. Comm., 1977):

(1) Low permeability of the rock type in which the waste is located, and

(2) The impermeable layers of clay between the waste repository and the surface, and the ion exchange capacities of soil.

In general, granite clays and shales offer the following advantages:

- They are impermeable when not joined or fractured.
- They are insoluble,
- They are thought to have relatively high ion exchange capacities
- They exhibit significant plasticity.
- The retrievability of the waste, especially in granite.

The disadvantages include:

- The existence of moisture in such materials, both as fluids in the pores and as water of hydration in the clays which may be released by the waste decay heat, and

- Underground excavation is difficult to perform in these types of rocks (Blomeke et al., 1973).

While salt beds, granite, shale and clay represent feasible approaches to the problem of waste management, their use will be highly site specific. The particular geology, lithology and hydrology of an area would have to be thoroughly explored before it is chosen as a burial site (Cohen, 1977).

If groundwater should enter the geological formation in which the waste is buried, disaster is not imminent because of important time delays before the waste can reach the surface. The non-porous rock formation encasing the waste must first be leached before the waste enters the groundwater. In most circumstances, water moves rather slowly and must travel long distances before contacting surface waters. In addition, the radioactive materials are held up by ion exchange processes so that movement is slower than even that of water (Cohen, 1977).

In summary, with respect to burial in geologic formations, there are three independent variables to be considered--burial in a formation expected to be free of water, the leaching time for the surrounding material as well as for the waste itself, and the travel time should the waste dissolve in groundwater--any one of which would ordinarily be sufficient to prevent any appreciable fraction of the waste from reaching surface waters in the first few hundred years when the potential hazards are so great. From the discussion of Cohen (1977), one is lead to believe that even if the waste were contacted by groundwater and leached into solution, most of it would not reach man's environment for a million years or so.

The most controversial issue associated with the waste disposal problem has been concerned with the reprocessing of nuclear fuels. Reprocessing is a method of reclaiming unused uranium (which can be recycled back as UF_6) and plutonium. The principle fission products in aged or reprocessed high radioactive wastes are cesium-137 and strontium-90 (Bebbington, 1976). Such wastes also contain traces of uranium and plutonium; however, most of the uranium and plutonium will be recycled back into the reactor. These radioactive products associated with the nuclear fuel cycle represent the greatest waste disposal problem prior to reprocessing. Both cesium-137 and strontium-90 have half-lives of about 30 years, so that several centuries of storage are needed for them to decay to negligible levels (twenty half-lives, or a factor of a million are enough to leave most waste solutions innocuous). Plutonium, however, has a half-life of about 24,000 years, but since it is a valuable product, its loss in waste is kept to a minimum. Typical wastes contain less than 1 percent plutonium (Bebbington, 1976).

The form of the wastes and the place for their ultimate disposal are technical problems that now require decisions and development rather than research. The places for deposit will almost certainly be geological formations--natural salt beds and other crystalline or sedimentary bed-rock formations (Bebbington, 1976). Ideally, it appears as if reprocessing prior to disposal is the best alternative for two reasons: (1) it reutilizes valuable products, namely plutonium and uranium, and (2) by reprocessing these by-products the amount of high-level radioactivity is decreased prior to disposal. In addition, reprocessing reduces the need for uranium mining and milling and thus the uranium milling tailings generated from these operations may also be reduced.

Legislative/Regulatory Background

There has been much legislative activity concerning the disposal of nuclear waste. It includes the Energy Reorganization Act of 1974; the Atomic Energy Act of 1954 (and subsequent amendments in 1959); Department of Energy Organization Act of 1977; the Marine Protection, Research and Sanctuaries Act of 1972, as amended; the Uranium Mill Tailings Radiation Control Act of 1978; the Resource Conservation and Recovery Act of 1976 (as relating to uranium mine tailings and milling wastes); the 1958 United Nations Law of the Sea Convention on the High Seas; and the 1959 Antarctica Treaty. In addition, there are various regulations by the Nuclear Regulatory Commission regarding nuclear waste disposal. All of the above are briefly discussed below.

Energy Reorganization Act of 1974. Title II, sections 201, 202 and 203 of the Energy Reorganization Act are the sections of primary concern with respect to nuclear waste disposal. Section 201 of the Act established the Nuclear Regulatory Commission. Under Section 202 the Commission was given jurisdiction over (1) facilities used primarily for the receipt and storage of high-level radioactive wastes resulting from activities licensed under the Act, and (2) retrievable surface storage facilities and other facilities authorized for the express purpose of long-term storage of high-level radioactive wastes generated by the administration, which have no bearing on research and development activities. Section 203 of the Act provides for the evaluation of the methods concerning the transporting of special nuclear and other nuclear materials and the transporting and storing of high-level radioactive wastes so as to prevent radiation hazards to employees and the general public.

Atomic Energy Act of 1954. Under the Atomic Energy Act of 1954, as amended in 1959, and by the Energy Reorganization Act of 1974, waste management responsibilities are divided among ERDA (now DOE) and licensees of the Nuclear Regulatory Commission (NRC) or agreement states. As a result of both the Atomic Energy Act and the Energy Reorganization Act, the NRC is given the authority to establish criteria and standards for protection against radiation applicable to licensed activities. Chapter four, Section 31 of the Atomic Energy Act, granted the Atomic Energy Commission the authority to conduct research and development activities relating to (1) nuclear processes; (2) the utilization of special nuclear material, atomic energy, radioactive material, and the processes necessary in the production or utilization of atomic energy or such material for all other purposes, which is to include industrial and commercial purposes, and the generation of useable energy; and (3) the protection of health and the promotion of safety. The Commission was given the responsibility of regulating the disposal of by-product, source or special nuclear wastes into the ocean or sea , and the granting of a license for permission to dispose of those wastes deemed hazardous by the Commission under Chapter 19, Section 274 of the Act.

Department of Energy Organization Act of 1977. The Department of Energy Organization Act established the Department of Energy. Under Section 203 of the Act, nuclear waste management responsibilities are defined, including:

> "(A) the establishment of control over existing Government facilities for the treatment and storage of nuclear wastes, including all containers, casks, buildings, vehicles, equipment, and all other materials associated with such facilities;

(B) the establishment of control over all existing nuclear waste in the possession or control of the Government and all commercial nuclear waste presently stored on other than the site of a licensed nuclear power electric generating facility, except that nothing in this paragraph shall alter or effect title to such waste;

(C) the establishment of temporary and permanent facilities for storage, management, and ultimate disposal of nuclear wastes;

(D) the establishment of facilities for the treatment of nuclear wastes;

(E) the establishment of programs for the treatment, management, storage, and disposal of nuclear wastes;

(F) the establishment of fees or user charges for nuclear waste treatment or storage facilities, including fees to be charged Government agencies; and

(G) the promulgation of such rules and regulations to implement the authority described in this paragraph, except that nothing in this section shall be construed as granting to the Department regulatory functions presently within the Nuclear Regulatory Commission, or any additional functions than those already conferred by law."

The Marine Protection Research and Sanctuaries Act of 1972, as amended. This Act was promulgated to regulate the dumping of materials, such as radiological, chemical, etc., into the ocean. This Act may have an impact on the proposed solution regarding the burial of nuclear waste or in the ocean floor.

Uranium Mill Tailings Radiation Control Act of 1978. Congress has found that uranium mill tailings located at both active and inactive mill operations may pose a significant radiation hazard to the public, and that protection of public health, safety, welfare, and the regulation of interstate commerce require that every reasonable effort be made to provide for the stabilization, disposal, and control of these tailings in an environmentallly safe manner. Thus the purpose of this Act is two-fold: (1) where appropriate, to establish a program concerned with the reprocessing of tailings (from inactive sites) to extract residual uranium and other mineral values where practicable, in order to stablize and control such tailings in an environmentally safe manner so as to minimize or eliminate radiation health hazards to the public; and (2) to establish a program to regulate mill tailings during uranium or thorium ore processing at active mill operations, and after termination of such operations, a program to stablize and control such tailings in an environmentally safe manner.

Resource Conservation and Recovery Act (RCRA) of 1976. With respect to the nuclear fuel cycle only uranium enrichment, mine tailings, and milling wastes are regulated under this Act. All other components of the nuclear fuel cycle are regulated by the Atomic Energy Act of 1954, as amended.

The 1958 United Nations Law of Sea Convention on the High Seas. This Convention provided the foundation for modern international attempts to protect the maritime environment. Under this Act nations: (1) are to promulgate their own regulations so as to prevent pollution from the exploitation and exploration of the seabed and its subsoil; (2) take into account any international regulations, and "shall take measures to prevent pollution of the sea from the dumping of radioactive waste"; and (3) have an obligation to "cooperate with competent international organizations in taking measures for the prospects for sea disposal."

The 1959 Antarctica Treaty. This treaty specifically prohibits the "disposal" of radioactive waste in Antarctica. Thus, the use of the Antarctic ice sheet as a permanent repository for high-level waste is clearly prohibited. However, in 1991 the treaty becomes subject to review and possible modification on the request of any party; hence, the ice sheet disposal option may be subject to consideration in negotiating a modification.

Nuclear Regulatory Commission Regulations. Some of the applicable NRC summarized are described as follows: (1) licensees must solidify liquid high-level waste no later than five years after its generation and must transfer it to a DOE repository no later than five years after its solidification; (2) applicants for low-level waste burial licenses must provide an environmental analysis of the proposed site; (3) burial is only allowed on land which is owned either by the federal or a state government; (4) reprocessing plants and temporary storage facilities for high-level waste may be located on privately owned property; and (5) transuranic waste disposal can now take place on state or federal land. Proposed regulations would limit permanent disposition of such waste to property owned by the United States government.

EPA Proposed Criteria for Radioactive Wastes. The following are the proposed criteria under consideration for the guidance of federal agencies in providing environmental and radiological protection for all forms of radioactive wastes.

(1) Under proposed Criterion No. 1 all radioactive materials associated with the operation and decommissioning of nuclear reactors, the supporting fuel cycles, including spent fuel if discarded, fuel reprocessing wastes, and the naturally-radioactive residues of mining, milling, and processing of uranium ores shall be considered radioactive wastes requiring control for environmental and public health protection.

(2) The fundamental goal of Criterion No. 2 is the complete isolation of any type of radioactive waste over its hazardous life-time. Radioactive wastes with a hazardous life-time longer than 100 years should be controlled by as many engineered and natural barriers as are necessary.

(3) Under proposed Criterion No. 3 radiation protection requirements for radioactive wastes should be based primarily on an assessment of risk to individuals and populations. This assessment should include such factors as: (a) the amount and concentration of radioactive waste in a location and its physical, chemical, and radiological properties; (b) the projected effectiveness of alternative methods of control; (c) the potential adverse health effects on individuals and populations, and of uses of land, air, water, and mineral resources for 1,000 years, or any shorter period of hazard persistence; (d) estimates of environmental and health effects, when such estimates could influence the choice of control option; (e) the probabilities of releases of radioactive materials to the general environment; and (f) the uncertainties in the risk assessments and the models used for determining them.

(4) Proposed Criterion No. 4 defines risks which should be considered unacceptable. These include: (a) if risks to a future generation are greater than those acceptable to the current generation; (b) if probable events could result in adverse consequences greater than those of a comparable nature generally accepted by society; or (c) the probabilities of highly adverse consequences are more than a small fraction of the probabilities of high consequence events associated with productive technologies which are accepted by society.

(5) Proposed Criterion No. 5 states that locations for radioactive waste disposal should be chosen so as to avoid adverse environmental and human health impacts and, wherever practicable, to enhance isolation over time.

(6) Under proposed Criterion No. 6 additional procedures and techniques should also be applied to a waste disposal system if use of these additional procedures and techniques provide a net improvement in environmental and public health protection.

Presently, the management of high-level wastes is under the jurisdictionn of the federal government. The states do not have the power to regulate the management of high-level waste. However, many states, such as, California, Michigan and Connecticut have prohibited the construction of nuclear plants unitl suitable methods of disposal can be found. Such laws were recently declared null and void in federal count because the field is preempted by federal law.

Possible Future Regulatory Actions and Their Impacts

In all likelihood EPA will establish specific standards applicable to all waste classes. This will include standards for the following:

- High-level waste
- Transuranic waste (stable form)
- Interim guidance - active uranium mills
- Inactive uranium mill tailings
- Airborne pollutants associated with uranium mill tailings
- Residual activity - decommissioning
- Transuranic waste - other forms
- Active uranium mill standards

High-level (HLW) waste. EPA will probably promulgate a specific HLW standard. NRC will issue regulations for satisfying the licensing facilities for disposal of HLW. A waste classification will also be established by NRC that will classify radioactive wastes according to the type and duration of confinement required for safe disposal. DOE will implement a U.S. spent fuel policy by providing away-from-reactor storage facilities.

Transuranic (TRU) wastes. EPA will develop general environmental protection criteria applicable to all radioactive wastes, which will provide basic criteria to be satisfied by waste systems. They will also issue specific, numerical environmental standards for disposal of stable and other forms. NRC is developing and will propose a waste classification system, which will include a limit on the concentrations of transuranic (TRU) wastes that can be disposed of by shallow land burial. NRC will also issue TRU disposal regulations. A TRU reprocessing facility in Idaho has been proposed which would be available in 1987 to process TRU wastes to a stable form compatible with waste acceptance criteria established for the TRU federal repository.

Uranium Mill Tailings. Interim environmental standards and criteria are expected to be issued by EPA in 1979. These would be required to enable NRC and DOE to develop necessary regulations and procedures to implement the standards. It is expected that EPA will develop formal specific standards (numerical) cocerning mill tailings disposal after additional research on tailings disposal is completed and some actual tailing stabilization work is carried out at currently inactive sites. NRC has issued interim criteria on tailings disposal to facilitate the continued licensing of new operations and the renewal of existing licenses pending completion of formal regulations and criteria. EPA also has proposed legislation to assign responsibility and necessary resources to DOE for appropriate remedial action at inactive mill tailings sites. This legislation would classify radon and radium in mill tailings as a "by product" material, thereby making tailings subject to NRC authority.

Decommissioning. EPA will issue applicable environmental standards and criteria and NRC and DOE will develop necessary regulations and procedures. Legislatio will be required to: (1) assign responsibility for providing long-term surveillance of decomissioned facilities on sites not released for unrestricted use, and (2) assign responsibility for remedial action at abandoned sites which do not meet current standards for unrestricted use.

The economic impact of the actions described above will probably be small because the costs of the nuclear fuel cycle are not the predominant factor in the cost of nuclear power; thus, increases in these costs will not be reflected in substantial increases in the costs of power. Costs to some individual companies, such as those that operate uranium mills, could be substantial.

The timely development of these regulatory actions will undoubtedly benefit the nuclear power industry by helping to alleviate fears abot the adequacy and safety of nuclear waste disposal. To the extent that nuclear power development has been hindered by such fears on the part of the public, as reflected in the attitudes of state officals, the development of well-controlled waste disposal techniques should accelerate such development in many states.

Time Frame for Future Regulatory Action

Many of the regulatory actions previously discussed are currently underway. Some, such as the develop of standards and criteria for mill tailings, should be carried out within the next year. Because of the urgency of the problem of long term storage and disposal of radioactive wastes, it seems highly likely that nearly all of the actions discussed above will be carried out by 1985.

4.19 Environmental Impacts of Biomass Energy Production and Conversion

Description of the Issue

There are presently six major approaches for utlizing solar energy: (1) heating and cooling of buildings, (2) wind generating systems, (3) photovoltaic power systems, (4) solar thermal power plants, (5) ocean thermal power plants and (6) the production and conversion of biomass. Of the above approaches, the production and conversion of biomass will probably present the most significant environmental impacts.

The production and conversion of biomass is primarily concerned with the photosynthetic species of terrestrial and marine plant life. The energy from the sun is utilized by these organisms to transform elements of the air, water and soil into complex organic compounds, mainly carbohydrates. Accordingly, biomass production attempts to optimize photosynthesis while biomass conversion attempts to exploit the energy fixed within the cellular structure of plant matter (ERDA, 1977).

The major sources of biomass are terrestrial plant matter, organic waste (e.g., cellulosic wastes of agriculture, silviculture, and animal wastes), and marine plant matter. The latter source will not be dealt with because of limited information concerning the subject. The conversion processes which utilize this biomass consists of: thermochemical processes (pyrolysis, producer gas generation, hydrogenation and hydrogasification); bioconversion systems (anaerobic digestion to methane and alcohol; fermentation to ethanol), combustion, and direct hydrogen production. A brief description of each conversion process is discussed below.

Thermochemical Processes. Thermochemistry is defined as the utilization of heat to bring about chemical reactions between substrates or within a substrate through rearrangement of the molecular structure. There are four types of thermochemical conversion processes, including: pyrolysis, a method of converting organic materials into solid fuels by heating in a closed container with a limited supply of air; producer gas generation, which is a variation of the pyrolysis technology; hydrogenation, which is a chemical process characterized by the addition of hydrogen to organic compounds to obtain an oil with a high hydrogen to carbon ratio; and hydrogasification, a process that primarily produces methane by the degradation and saturation with hydrogen of higher organic compounds .

Bioconversion systems. Bioconversion is a term used to denote biomass conversion processes accomplished by the action of microorganisms. There are two major bioconversion processes: (1) anaerobic digestion, whereby organic matter is decomposed from complex forms to simpler, more stable compounds [decomposition proceeds in the absence of air (anaerobic)] resulting in a mixture of methane and carbon dioxide as its catabolic products; and (2) fermentation to ethanol.

Combustion. Combustion can be used to directly convert biomass into useable heat rather than into a secondary fuel. When dried to a proper moisture content, all biomass will undergo combustion (ERDA, 1977).

Direct Hydrogen Production. Under normal circumstances photosynthetic species, whether terrestrial or aquatic, will utilize sunlight for carbon fixation and the subsequent manufacture of carbohydrates. The production of small amounts of hydrogen accompanying photosynthesis has been observed, and determined to be the result of incomplete or partial photosynthesis (ERDA, 1977). There are two approaches to this conversion process: (1) to encourage photosynthetic growth in a biomass species, such as algae, and simultaneously alter the conditions--to "trick", upset, or unbalance the natural metabolism so as to maximize hydrogen production; and (2) to isolate the key chemicals and enzymes involved in the process and then generate hydrogen via a controlled synthetic reaction. (Note: this form of hydrogen production is in its early stages of development).

Either solid, liquid, or gaseous fuels can be produced from the conversion of biomass. A brief description of each is given below.

Solid Fuel. Pyrolysis is the basic method for the production of solid fuel (as well as low heating valve gases) from biomass. Wood, leaves, grass, or similar materials, including the organic component of municipal solid wastes, are heated in a closed container or converter by partial burning of a portion of the feedstock with air or oxygen introduced in a controlled manner. The products are a low-Btu gas, volatile vapors, and a solid carboniferous char. The gases are primarily hydrogen and carbon monoxide and the condensible vapors are steam and a variety of volatile organics. The char is a solid much like charcoal (Pollard, 1976), worldwide the most important solid fuel derived from biomass.

Liquid Fuel. At high temperature and with an increased air supply, most of the char and oil from a pyrolysis unit are converted into gaseous components, which can then be used as the synthesis gas for the production of methanol.

Methanol would also be the major by-product of using an agri-silviculture that combines food production and forestry in a closed cycle of food crops on cleared land followed by a planting of fast-growing trees before the last food crop is harvested. This system of joint cropping, which could be supplemented with biomass grown exclusively for methanol production, would be most beneficial in the tropics (Pollard, 1976).

Ethyl alcohol (ethanol) is another alcohol that could serve as a motor fuel. The U.S. Army Natick Laboratory, using a fungus that causes jungle rot in wood and other cellulosic material in Vietnam, found that an enzyme produced by selected strains of this organism is capable of converting properly prepared cellulose into glucose with very high yields. It is estimated that 5 million barrels of ethanol could be produced by the enzymatic hydrolysis of 3 million tons of cellulose (followed by fermentation) from municipal or agricultural wastes (Spano et al., 1976). Ethanol can also be produced by the fermentation and distillation of sugarcane (one of the most efficient natural photosynthesizers) (Calvin, 1976). In agri-silviculture management of tropical ecosystems there would be the possibility of combining both methanol and ethanol production. In clearing a forest, the good logs would be sold and the remaining branches, culls, and residual biomass delivered to a nearby methanol plant.

Gaseous fuel. Methane can be derived from agricultural wastes by anaerobic digestion (Poole, 1975). This will produce a mixture of methane, carbon dioxide, and small amounts of other gases. After scrubbing the carbon dioxide, the product is pipeline quality gas. There are two major advantages in anaerobic digestion over char-oil production: (1) animal wastes have too high a moisture content to be suitable as a feed stock for char-oil, but for the same reason are ideal for anaerobic digestion; and (2) agricultural wastes can be digested without loss of the original plant nutrients, and the digested sludge is rich in humus (Pollard, 1976). There is also a large potential for anaerobic digestion to methane in fast-growing plants such as water hyacinths in wetlands and marshes. Another possibility might be to grow forests of kelp in the ocean which would be harvested in large quantities for methane production.

There are three advantages to utilizing biomass as an fuel source. Probably the most important advantage is that biomass, unlike any present major energy sources, is renewable. Two other advantages are: (1) bioconversion does not lead to a net atmospheric buildup of carbon dioxide because, on the average, organic material would be grown as fast as its is burned; and (2) the potential production of solar-derived fuels is significantly greater in tropical regions in which traditional agriculture is rather difficult. However, despite the advantages, this technology has major disadvantages which can have an overwhelming impact on the environment.

There are five major environmental impacts associated with the various conversion processes. These include: (1) land resource requirements; (2) gaseous, liquid and solid residues from thermochemical conversion; (3) impacts related to the combustion of biomass (wood); (4) the depletion of the organic content of the soil and (5) the disposal of waste sludge from anerobic digestion. Each of these is briefly addressed as follows:

Land Resource Requirements. The production of terrestrial biomass requires substantial acreage (18 to 51 square miles for a commercial operation). Unused land which meets these acreage requirements is available; however, patterns of ownership, soil quality, water availability, and competition with food and fiber production affect its use for biomass fuel production (ERDA, 1977).

Gaseous, Liquid, and Solid Residues From Thermochemical Conversion. Thermochemical reactions generate sulfur-containing gases (H_2S, COS, CS_2, SO_x) and nitrogen-containing gases (HCN, NO_x, NH_3). The sulfur-containing compounds, specifically H_2S, represent the primary area of concern as potential air pollutants. However, biomass contains an inherently low sulfur content, and the production of sulfur-derived pollutants occurs at a much lower level than during coal gasification. Nevertheless, uncontrolled venting of these raw off-gases may result in violations of the local air standard and possible odor problems due to H_2S concentrations.

Thermochemical processes will also generate ash. This material does not undergo conversion and must be disposed of. However, the biomass ash contents are quite low compared to coal; consequently, land requirements for biomass ash disposal are not as great. In addition, because of the nutrient value of the ash, it is likely that the ash will be recycled to biomass plantations.

Water quality can be affected by the gaseous condensate, low-molecular weight oils, phenols, leachate from char and ash residues, and scrubber solutions, all of which may enter water bodies through discharge from disposal ponds and percolation to subsurface waters.

Impacts Related to Combustion of Biomass (Wood). The combustion of biomass fuel will affect air quality and produce solid waste that can have an environmental impact. Fuel storage, fuel handling, and ash disposal can also affect the surrounding environment. The air pollutants comprise particulates, nitrogen oxides, and carbon monoxide. Water pollutants of concern are leachates from storage piles or ash deposits, although in the latter case potential water quality impacts will be significantly less if the ash is recycled to plantation sites.

Depletion of Soil Organic Content Due to Residual Removal. The environmental impacts distinct to biomass production are associated with removal of the residues normally left in the field as opposed to those normally removed for disposal or sale. With respect to open farmland, crop residues play a major role in shielding soil from wind action, preserving moisture content and contributing organic content to the soil. Their removal will result in an increase of windblown dust which will serve to deplete the organic soil content that enhances the internal binding of the soil.

The possible increased erosion and resultant sediment loading of local waterways will impact water quality. This source of pollution also results from mechanisms contributing to wind erosion.

It should be noted that, as opposed to crop residue removal, forest residue removal may have beneficial impacts. Forest residues created by logging operations can clog streams, create sources of pests and pathogens, and increase the occurrence and intensity of forest fires. Removal of these forest residues mitigates such impacts and contributes to better forest management.

Disposal of Waste Sludge From Anaerobic Digestion. Waste sludge from small digesters is usually disposed of in an evaporation lagoon, while for large digesters, application of the sludge as fertilizer may be employed. If disposal occurs in a holding pond, there may be infiltration of sludge wastewater to groundwater. Overflow discharge from the pond into waterways may also occur. If the sludge is used as a fertilizer, application to one area for an extended period may cause an adverse build-up of salts and heavy metals in the soil, because digester wastewater or holding pond effluent may contain salt loads comparable to those present over much larger acreages than those to which the wastewater is applied.

Probable Solutions

With respect to the emission of hydrogen sulfide from thermochemical processes, the potential releases may be reduced by flaring the H_2S-containing waste gases to convert H_2S into less harmful quantities of SO_2 and water, or by chemically treating the gas to remove H_2S. The disposal of ash from these processes may include land spreading of the ash as a fertilizer, use in construction materials (i.e., cement) or landfilling (which would affect land use). Adverse effects on water quality from thermochemical processes may be prevented by channeling wastes to evaporation ponds, adequate in size so as not to require discharge into waterways. If required, chemical treatment of such ponds can be used to reduce their pollution potential.

The overall emissions from the combustion of wood may be affected by the selection of wood, the type of particulate control device, furnace design and operating conditions. Manipulation of these variables to achieve optimal conditions can reduce air pollutant emissions. Conventional control devices such as cyclones and fabric filters can be used to reduce particulate emissions.

The mitigation of potential fugitive dust and water erosion as a result of residue removal can be achieved by partial removal of residue quantities, as one possiblity, even though the percent that can be safely removed has not been determined. The use of "no-till" farming in conjunction with total crop removal schemes would decrease the fugitive dust with respect to till-farming conditions. No-till farming leaves the soil undisturbed for several seasons by not employing discing for seedbed preparation. No-till methods preserve root structure, providing aeration and organic content to the soil, thus aiding its binding ability.

The waste sludge from anaerobic digestion can be used as a fertilizer provided it is not applied to any one area for an extended period of time.

Legislative/Regulatory Background

Very little regislation has been enacted that specificaly addresses the environmental aspects of biomass energy conversion. The Solar Energy Research Development and Demonstration Act of 1974 was enacted to promote the development of solar energy, including biomass. Environmental factors were not specifically addressed, however. Other legislation that will affect biomass energy conversion is discussed below.

FWPCA (1972) and Amendments. Potential water pollutants such as runoff from forestry and agricultural residue areas, liquid and solid residuals from thermochemical biomass conversion such as phenols, low-molecular weight, oils, dust, and pollutants from runoff will be regulated by the FWPCA. If the discharging of these pollutants into navigable waters occurs, a NPDES permit will be required. EPA has issued guidelines identifying nonpoint sources of pollutants resulting from agricultural and silvicultural activities.

NEPA (1969). All agencies of the federal government must prepare detailed environmental statements on all actions significantly affecting the quality of the human environment. Biomass energy conversion, because of its large land requirement, will probably involve large areas of federally-owned land, at least in its initial stages. The EIS preparation and review process for the development of early biomass plantations is likely to be both lengthy and complex.

SDWA (1974) and Amendments. If regulations covering pits, lagoons, and ponds as potential waste disposal areas are promulgated under this Act, any technology utilizing such forms of waste diposal will have to meet the standards set by the EPA. (It is not known whether pits, lagoons, and ponds used as such areas will be addressed by this Act or by the FWPCA, RCRA, or TSCA.) In addition, under the SDWA groundwater monitoring may have to be incorporated into the scheduled environmental activities for developing technologies. Sludge from anaerobic digestion--BOD, COD, salts, and trace metals represent pollutants regulated under the SDWA.

RCRA (1976). With respect to biomass, the disposal of sludge from anaerobic digestion, salts, heavy metals, ash and char residuals from thermochemical conversion, and solid waste (ash) from biomass combustion will be regulated by RCRA.

CAA (1970) and Amendments. NSPS, PSD, NESHAPs visibility, and nonattainment provisions will have an effect on emissions to the ambient air, including particulate emissions resulting from agricultural and silvicultural operations. Thermochemical biomass conversion results in the emission of several gaseous residuals; including carbon dioxide, cyanide, ammonia, and particulates. In addition, hydrogen sulfide is emitted, which is chemically reactive and converts to other sulfur containing compounds, such as sulfur dioxide (SO_2), which is a criteria pollutant. Biomass conversion could contribute regionally to raising ambient levels of the above pollutants.

Other Acts that could affect fuels from biomass are:

- TSCA
- Fish and Wildlife Conservation Act
- Coastal Zone Management Act
- Wilderness Act
- Federal Land Policy and Mangement Act
- Endangered Species Act
- OSHA

In the case of direct combustion, there are no federal standards for wood-fired boilers or for the combustion of other types of biomass. However, nearly all the states have particulate emission standards for wood-fired boilers. These standards range from 0.1 to 0.8 pounds per million Btu, and separate standards have generally been promulgated for old and new sources.

There is little other state legislation regarding environmental aspects of biomass production and utilization. Some states are actively encouraging the use of biomass. For example, the State of Colorado has passed three bills designed to encourage renewable sources of energy through tax incentives. These were designed specifically to encourage the production of gasohol by: (1) promoting the use of fuels derived from agricultural wastes, through a $.05/gallon tax credit; (2) providing funds to investigate gasohol pollution, especially the effects at high altitudes; and (3) providing for a severance tax on the use of biomass resources.

Possible Future Regulatory Actions and Their Impacts

Because of the early stage of development of biomass energy technologies, it is difficult to predict specific regulations that might be implemented to address their enviromental problems. However, as discussed in the previous section, a broad legislative framework exists that should cover most environmental aspects of biomass conversion. Some of the key regulatory actions that could take place under existing legislative authority are:

- Under the CAA, promulgation of NSPS for wood-fired boilers, (for particulates and possibly for nitrogen oxides). Also, the development of NSPS for biomass gasification and pyrolysis technologies for sulfur and nitrogen compounds, and possibly NESHAPs for specific technologies that emit toxic air pollutants unique to biomass conversion.

- Under the FWPCA, the development of effluent limitations for new source categories that include several biomass conversion processes, and the specification of "best demonstrated control technology" (BDCT) for these processes. Nonpoint discharges from biomass production and harvesting may also be regulated, although such sources are not currently regulated under the NPDES.
- The solid wastes and/or sludges generated by gasification, pyrolysis and anaerobic digestion processes will be subject to the hazardous waste classification criteria under RCRA, Section 3001. It is still too early to determine whether such wastes will be declared hazardous, according to the criteria proposed by EPA (See Section 4.1).

- Products and by products of biomass conversion processes (e.g., pyrolysis oil) may be subject to regulation under TSCA, which would require, at minimum, extensive toxicological testing to determine whether such products or byproducts represent an unreasonable risk to health or the environment.

- OSHA standards and guidelines will be applicable to biomass conversion activities. Especially relevant will be exposure limits for substances such as sulfur and ammonia which are generated during thermochemical conversion. Other substances, especially known or suspected carcinogens, which have not been previously regulated, but which may be found in significant quantities in the work environment of biomass conversion processes, will likely come under OSHA regulation as the technologies develop.

Legislation and regulatory activity at the state level concerning water availability is likely to affect the production of biomass for energy conversion, although conflicts between this form of energy production and traditional uses (i.e., production of food crops) are not likely to be as severe as with fossil energy development. However, new biomass plantations may have difficulty obtaining necessary irrigation water in semi-arid regions of the West.

The impact of many regulatory activities (except water availability) will be to increase the cost of biomass fuels. Environmental control technologies should be available to treat the major waste streams. However, the increasing costs and complexity of thermochemical conversion technologies (including environmental control costs) will tend to favor simple technologies such as anerobic digestion and fermentation, which should have fewer and less costly control requirements.

Time Frame for Future Regulatory Action

In the near term (2-5 years) the only regulatory action likely to be taken with respect to biomass energy conversion is the promulgation by EPA of particulate emmission standards for new wood-fired boilers. Although currently addressed by many state regulations and SIPs, there is much variability from one state to the next. EPA, under mandate from the CAA Amendments, must take steps to prevent significant deterioration of air quality and protect visibility. As the combustion of wood for industrial and utility fuel increases, EPA must insure that minimum performance standards are met within each state. It seems likely that EPA will set an emission standard for large new wood-fired boilers at least as stringent as the new NSPS for coal-fired boilers--0.03 lb/million Btu.

The promulgation of other standards for biomass conversion and production should not occur before 1985 because of the very early stage of development of most of the technologies. In small scale demonstration or early commercial facilities (e.g., methanol production from agricultural residues in the

Midwest), permits will probably be issued on a case-by-case basis under existing NPDES and other review procedures.

4.20 The Nuclear Fuel Cycle

Description of the Issue

Health risks arise at all stages of the nuclear fuel cycle, from uranium mining to plant decommissioning. The assessment of these risks involves analysis of occupational accident rates, radiation exposure for workers and populations under normal operating conditions, and the probabilities and consequences of reactor accidents to public health. The sections below describe the health impacts from normal operations and accidents at various stages of the nuclear fuel cycle.

Mining. Mining is one of the primary sources of occupational hazards. Accidents in underground mining result in about 15 deaths per 10,000 miners or about 0.2 deaths per reactor year (U.S. Atomic Energy Commission, 1974). Estimates for open pit mining show smaller numbers. In addition to accidents, miners are exposed to external radiation in mines and to inhaled dust on which radon daughter decay products are adsorbed. Radon daughters inhaled in this manner may become trapped in tissue in the lower respiratory tract, where they can be carcinogenic (Mitre, 1977) Radon emissions during mining may also have an impact on public health. Earlier studies, noting the remote location of uranium mines, generally concluded that population exposures were negligible. However, a study performed by U.S. Nuclear Regulatory Commission (1974) concluded, that in addition to its direct decay products, radon-222 results in the formation of daughter decay products, with several of those, notably polomium-210 and lead-210, having the potential to enter the food chain by deposition on crops. The dominant pathway appears to be through the diet and not through direct inhalation.

Milling. Occupational accidents with respect to the milling of uranium ore are poorly documented but appear to be relatively low (U.S. NRC 1974). Milling operations result in the creation of huge tailings piles near the mills. These piles emit radon-222 continously for many thousands of years and can serve as a prospective source of long-term exposure.

Transportation, Conversion, and Fabrication - Relatively small volumes of material are involved in nuclear fuel production after the initial mining and milling operations. The levels of radioactivity at these stages of the uranium fuel cycle are small.

Normal Reactor Operations. During normal reactor operation, radioactive gases and volatile radioisotopes migrate out of the fuel, through small cladding defects into the coolant. These effluent gases which include iodine, xenon and krypton isotopes are held up and treated. Workers appear to be exposed primarily during refueling and repair operations.

Reprocessing. The occupational hazards of reprocessing are mostly radiological in nature. Population exposures as a result of reprocessing appear to be due predominatly to carbon-14, krypton-85 and other radioactive materials emitted in normal operation under present regulations. Carbon-14 not released in the reactor operation would in all probability be released as carbon dioxide. Reprocessng reduces the need for uranium mining and milling and thus potentially reduces occupational and public health consequences of these operations. According to an analysis by the Nuclear Regulatory Commission (1974), plutonium plays essentially no role in occupational or public health effects from reprocessing.

One of the most controversial issues concerned with nuclear reprocessing is the impact of plutonium on public health. The health risks of plutonium are dependent on the chances for its release into the environment and its subsequent behavior in the environment and in the food chain, its mode of uptake and translocation to various organs, and its particular radiotoxic effects. The hazards of plutonium are unique because of the very long-lived energetic a-emitters that are involved (U.S. NRC, 1974).

Because plutonium's radioactivity is in the form of alpha-radiation, it cannot penetrate the skin; thus it must be ingested or inhaled to be hazardous. Plutonium is not readily absorbed by the body. Under normal circumstances, any plutonium that enters the body via the digestive tract is excreted. The largest risk from plutonium is through inhalation of small particles which become lodged in the lower respiratory tract. The presence of plutonium in the lung can induce cancer; it can also translocate with the same effect to other tissues through absorption and transport in the lymphatic system and the blood. The health consequences of this translocation are expected to be largest in the liver and bone, in that order. There have never been any known deaths attributed to plutonium poisoning (U.S. NRC, 1974). There are documented studies of workers in a reprocessing plant ingesting large quantities of plutonium with no evidence of cancer (Gillette, 1974). In addition, it has been pointed out that within the last 30 years no human malignancy or other illness has been tied to plutonium inhalation. Reprocessing does introduce a source of high-LET radiation; however, this does not necessarily present large risks.

Exposure to radioactive materials associated with uranium mill tailings piles is another major health issue confronting the implementation of nuclear power. Mill tailings piles present a potential for exposure to radiation by several pathways. The most important pathway is believed to be that of radon-222. Radium-226 in the pile decays by alpha particle emission and becomes radon-222, a radioactive noble gas. The radon-222 that is released into the spaces between the grains of tailings materials diffuses toward the overlying tailings surface; some reaches the surface and some undergoes radioactive decay enroute. The radon-222 that reaches the surface escapes into the air above, where it is mixed into the passing airstream by normal local air turbulences. The concentration of the radon-222 in the air is continually decreased as the wind further mixes and dilutes it. This presents a hazard to people downwind of the tailings pile as they will be exposed to some concentration of radon-222 and its particulate radioactive decay products in the air they breathe. Some of the radioactive daughters of the radon-222 are retained in the tracheobronchial region of the lungs, irradiating the fluids and tissues, and thus increasing the risk of cancer formation there (Swift et al, 1976).

Another pathway for transmitting the radiation from the surface tailings is one in which the wind lifts particles containing radionuclides and carries them downwind, with simultaneous mixing, dilution and deposition. Inhalation of the particles leads to exposure in several ways; however, the principle exposure is to the pulmonary region.

The third principle pathway to radiation from the tailings piles is the emission of gamma radiation which may penetrate the overlying material and air to interact with body tissues of persons on or near the tailings piles.

The principle health risk to persons living near uranium mill tailings is associated with lung (bronchial) cancer which is considered to be 100 percent fatal. It has a latency period 10-15 years after the onset of the exposure followed by a plateau period of elevated risk lasting from 15 years to a lifetime. The health risk as a result of windblown particulate material probably will not be as significant because of the smaller radiation dose compared to that of radon-222. The particulate material dose is delivered to the pulmonary region of the lung, while the radon-222 dose is delivered to the bronchial epithelium region of the lung (Swift et al., 1976). Data from a report by the Natural Academy of Sciences (1972) indicated that the bronchial epithelium is much more sensitive to radiation than the pulmonary region of the lung.

With respect to the health risk associated with the pile's gamma radiation, this will also be of lesser significance because the whole body gamma radiation dose is considerably smaller than the dose to the bronchial epithelium from radon-222 daughter products (Swift, 1976).

The principle safety problems inherent in nuclear reactor operation do not arise because of the possibility of a nuclear explosion. (In a nuclear reactor, the fuel concentration is far too dilute, amounting to only about 3 percent enrichment in light water reactors, to allow for an explosive reaction). Rather, the principle concern with regard to nuclear safety is the large, inventory of radioactive fission products which accumulate in the reactor fuel during operation. However, as long as the radioactive fission products remain in the fuel, they represent no hazard. Should the fission products be released and transported to populated areas, significant damage could occur. Thus, nuclear reactors must be designed so that under no circumstances could such radioactive material be released from the core.

Probable Solutions

A majority of health problems associated with the nuclear fuel cycle appear to arise during the mining and milling of the uranium ore. One solution to this problem would be reprocessing of the plutonium and uranium from the spent fuel. Reprocessing would lessen the need for uranium mining and milling, thereby reducing the potential occupational and public health consequences of these operations. In addition, this would alleviate another major issue of concern, the problem of nuclear waste disposal (specifically high-level radioactive wastes). Essentially no occupational or public health effects arising from exposure to plutonium as a result of reprocessing have been noted. (U.S. NRC, 1974). Studies of people accidentally ingesting plutonium have shown that no malignances or adverse health effects other than anxiety to have developed (Gillette, 1974). In all phases of the nuclear fuel cycle good industrial hygiene practices will help alleviate any occupational exposures (e.g., the use of respirators, goggles, etc).

Several steps can be taken to reduce the releases of radioactivity from both active and inactive mill tailings. These include: grading the pile and constructing diversion ditches, to control drainage and prevent erosion; covering the pile with rock and/or soil, to prevent wind-blown erosion and dispersion of the tailings; and finally, permanent stabilization of the pile, by establishing a vegetative cover of native grasses. A soil covering of 2 to 4 feet will substantially reduce the emanation of radon-222 from the pile.

With respect to reactor accidents, the containment of radioactive fission products is accomplished by designing into a nuclear power plant a series of physical barriers which inhibit or prevent the release of fission products. Examples of some of these physical barriers are:

1. Ceramic fuel pellet - the first line of defense which entrains most of the nongaseous fission products and greatly inhibits the diffusion of gaseous fission products out of the fuel.

2. Fuel pellets - the fuel pellets themselves are contained in metallic tubes or cladding of zirconium or stainless steel which are designed to retain even the gaseous fission products which build up in the gap between the fuel pellet and the cladding tube.

3. Fuel Elements - The fuel elements are contained within a 20 cm thick steel pressure vessel which serves as a third barrier to fission product release.

4. The primary coolant loop - is piping approximately 8 to 10 cm thick, and the coolant water itself is continously circulated through filtering traps to separate out any radioactive material.

5. The pressure vessel - is surrounded by 2 to 3 meter thick concrete shielding and is located within a containment building which consists of one meter thick concrete walls lined with a 10 cm thick, leak-tight steel shell designed to prevent the release of radioactivity in the event of a major rupture of the primary coolant system.

There are still other precautions which are taken to ensure nuclear reactor safety. These major lines of defense include:

1. Quality assurance to guarantee that all components of the plant have been manufactured and assembled to required design specifications;

2. Highly redundant and diverse safety systems designed to protect against abnormal operating conditions;

3. Engineered safeguards systems designed to protect against the consequences of highly unlikely but potentially catastrophic accidents (e.g., a loss of coolant accident) including equipment failures, human error, and severe natural events (earthquakes, tornados, floods, etc.).

Finally, one of the most important aspects of nuclear reactor safety involves a careful analysis ofthe consequences of hypothetical accidents which are then factored into the plant design to provide acceptable protection to the public in the event that such an accident should occur.

Legislative/Regulatory Background

OSHA (1970) OSHA was enacted to protect the safety and health of working men and women by promulgating safety and health standards. Under OSHA standards, suitable protective equipment and control or technological procedures to be used in connection with hazardous working conditions are prescribed. All aspects of the nuclear fuel cycle will be required to comply with OSHA standards.

Federal Coal Mine Health and Safety Act (1977) The purpose of the Act is to promulgate mandatory health and safety standards for the protection of coal or other miners. This Act applies specifically to the mining aspects of the nuclear fuel cycle.

Nuclear Regulatory Commission Standards for Protection Against Radiation The purpose of these regulations is to establish standards for protection against radioactive hazards arising out of those activities which are licensed by the Nuclear Regulatory Commission and are issued pursuant to the Atomic Energy Act of 1954, as amended, and the Energy Reorganization Act of 1974. The maximum permissible dose (in rems) any individual in a restricted area can receive in any period of one calendar quarter is:

1. Whole body; head and trunk; active blood-forming organs; lens of eyes; or gonads: 1-1/4

2. Hands and forearms; feet and ankles: 18-3/4

3. Skin of whole body: 7-1/2

However, the above specified doses may be exceeded provided:

1. "that during any calendar quarter the dose to the whole body from radioactive material and other sources of radiation in the licensee's possession shall not exceed 3 rems; and

2. the dose to the whole body, when added to the accumulated occupational dose to the whole body, shall not exceed 5(N-18) rems where "N" equals the individual's age in years at his last birthday; and

3. The licensee has determined the individual's accumulated occupational dose to the whole body on form NRC-4, or on a clear and legible record containing all the information required in that form; and has otherwise complied with the requirements of Section 20.102. As used in paragraph (b), "Dose to the whole body" shall be deemed to include any dose to the whole body, gonads, active bloodforming organs, head and trunk, or lens of eye."

Of the states surveyed, Florida, Illinois, California, and Pennsylvania had the same standards for protection against radiation as prescribed by the Nuclear Regulatory Commission (NRC). They are all considered "agreement states" (Agreement state is any state which has entered into an effective agreement with the United States Nuclear Regulatory Commission pursuant to Section 274.b of the Atomic Energy Act of 1954, as amended). However, New York state regulations differ from that of the NRC. The are as follows:

1. If the individual is 18 years of age or over (occupational exposure)

   a. whole body: 3 rems (in any 13 consecutive weeks) or 5 rems (in any 52 consecutive weeks), except in the case of a pregnant women where no person shall knowingly permit a dose to the fetus of more than 0.5 rem during the approximate 39 consecutive week gestation period;

   b. hands and forearms, or feet and ankles: 25 rems in any 13 consecutive weeks or 75 rems in any 52 consective weeks;

   c. Skin of the whole body: 10 rems (in any 13 consecutive weeks) or 30 rems (in any 52 consecutive weeks);

   d. An individual 18 years or older may be permitted to receive an occupational dose to the whole body of 12 rems in any 52 consecutive weeks, if such occupational dose will not exceed 3 rems during any consecutive 13 weeks and will not, when added to the accumulated occupational dose, exceed 5 (n-18)rems where "n" equals the individuals age in years of his last birthday; and if such person has complied with all other requirements relating to such factors as any previously accumulated dose, past exposure, etc.

2. Permissible dose in uncontrolled areas:

   a. Whole body: 0.5 rem (in any 52 consecutive weeks); or

   b. If any individual were continuously present in the area, would result in his receiving a dose in excess of either 2 millirems in any hour or 100 millirems in any seven consecutive days.

The International Commission on Radiological Protection (ICRP) recommendations as well as those of other recommending bodies (e.g., the National Council on Radiation Protection), have resulted in exposure limits for occupational and the general public's protection based upon annual dose limitations of 5 rem/yr, and 0.5 rem/yr, respectively. The ICRP has set the permissible body burden for plutonium at 40 nanocuries (nCi) for workers in contact with plutonium and under continual monitoring. However, for the members of the general pulbic who are not monitored, the allowable body burden is set at 4 nCi. The maximum lung burden is set at 16 nCi for occupational exposure and 1.6 nCi for the general public.

The maximum ambient concentrations for facilities licensed by the U.S. Nuclear Regulatory Commission (NRC) were presented in Table 4-6. Occupational standards are approximately 40 times greater. NRC-licensed facilitites involve all in the nuclear fuel cycle.

There are also federal drinking water standards on radioactivity for community water supplies (41 FR 28402). Those were listed in Table 4-7.

<u>The Atomic Energy Act (1954)</u> Section 29 of the Act estalishes an advisory committee on reactor safety whose responsibility is to review safety studies and facility licensing applications and to advise the Atomic Energy Commission of the hazards of proposed or existing facilities and the adequacy of proposed provisions to protect health; to minimize danger to life or property; and to require the reporting and permit inspection of work performed, as the commission may determine. Under the Atomic Energy Act of 1954, as amended,

and Reorganization Plan No. 3 of 1970 (40 CFR, 190.10), environmental standards for the uranium fuel cycle were established. The standards established the following: (1) "the annual dose equivalent should not exceed 25 millirems to the whole body, 75 millirems to the thyroid, and 25 millirems to any other organ to any member of the public as the result of exposures to planned discharges of radioactive materials, radon and its daughters excepted, to the general environment from uranium fuel cycle operations and to radiation from these operations; and (2) the total quantity of radioactive materials entering the general environment from the entire uranium fuel cycle, per gigawatt-year of electrical energy produced by the fuel cycle, contain less than 50,000 curies of krypton-85, 5 millicuries of iodine-129, and 0.5 millicuries combined of plutonium-239 and other alpha-emitting transuranic radionuclides with half-lives greater than one-year."

CAA of 1970 and Amendments Section 122a of the CAA provides for a review of all the available information to determine whether or not emissions of radioactive pollutants (including source materials, special nuclear material, and byproduct material) into the ambient air will cause, or contribute to, air pollution which may reasonably be anticipated to endanger public health. If the Administrator determines that the substance will endanger public health, he shall include each substance in the list published under Section 108(a)(1), Air Quality Criteria and Control Techniques or Section 112(b)(1)(A), National Emission Standards for Hazardous Air Pollutants ("in the case of a substance which, in the judgement of the Administrator, causes, or contributes to, air pollution which may reasonably be anticipated to result in an increase in mortality or an increase in serious irreversible or incapacitating reversible illness), or shall include each catergory of stationary sources emitting such substance in significant amounts in the list published under Section 111(b)(1)(A), Standards of Performance for New Stationary Sources (NSPS), or may be listed under one or more of these categories.

The Uranium Mill Tailings Radiation Control Act of 1978 This act was established to prevent or minimize potential and significant radiation health hazards to the public resulting from uranium mill tailings located at active and inactive mill operations. Section 102(b) of the Act provides (within one year of the enactment) for an assessment by the Secretary of Energy concerning the potential health hazard to the public from the residual radioactive materials at designated processing sites.

Section 113 of the Act requires that not later than January 1, 1980, the Administrator of the Environmental Protection Agency, in consultation with the Commission (NRC), shall provide a report to Congress which identifies the location and potential health, safety, and environmental hazards of uranium mine wastes together with recommendations, if any, for a program to eliminate these hazards.

Possible Future Regulatory Actions and Their Impacts

The two areas most likely to be addressed by future regulations are the operational safety of nuclear power plants, and the exposure of workers and the general public to low level radiation. The reactor accident at Three Mile Island has prompted not only intensive investigation into the causes of the accident, but also has bought about strong public and congressional pressure to further tighten the NRC-administered reactor licensing and operating requirements. The most extreme action that could be taken is a complete prohibition of the construction of new nuclear power plants. However, given the nation's continuing energy crisis, this does not seem likely to happen. Some less extreme proposals that seem more likely to be adopted are as follows:

- Permanent assignment of NRC personnel to all commercial reactors for continuous monitoring of their operations.

- Federal government training and licensing of all nuclear power plant operating and maintenance personnel.

- Development of federally-approved emergency evaluation plans by all states in which reactors are operating.

- Stricter inspection and licensing requirements for new power plants.

While none of the above actions will result in severe restrictions or costs for the operators of commercial power plants, they are likely to pose additional delays and complexities for the construction and licensing of new facilitites.

The effects of low level radiation on the health of workers and the public has become increasinly controversial in recent years. The most recent report of the National Academy of Sciences, Committee on the Biological Effects of Ionizing Radiation (BEIR), has concluded that for regulatory purposes, it should be assumed that low doses of radiation produce proportionally the same biological damage as high doses (the linear model of radiation damage). If this recommendation is adopted by the regulatory agencies, it could result in substantial changes in radiation protection standards, because it could no longer be assumed that there was a "threshold" dose below which not effects would occur.

Upon the recommendation of EPA, the NRC recently lowered its exposure standard for the general public from 170 mrems to 25 mrems per year (whole body dose). There is now pressure on the NRC, as a result of the BEIR report and several occupational exposure studies, to lower its occupational exposure standard by a factor of 10, from 5 rem to 0.5 rem per year. Such an action would be strongly opposed by the nuclear power industry.

EPA, under authority of the CAA Amendments, is likely to promulgate standards for several radioactive species in order to insure protection of the general public. These could include both emission and ambient air quality standards for radon-222, krypton-85, xenon-133, iodine-131, carbon-14, tritium, and other species emitted from nuclear reactors, as well as for other radionuclides associated with all parts of the nuclear fuel cycle.

Time Frame for Future Regulatory Action

All the regulatory actions discussed above are likely to be carried out within the next few years, especially those dealing with the licensing and operations of nuclear power facilities. The CAA Amendments required the Administrator of EPA to promulgate standards for radionuclides by 1979. Although it is unlikely that such standards will be developed that soon, there will be increasing public pressure, including possible litigation by environmental groups, for standard setting to take place as soon as possible. To the extent that the required data is available, such standards will almost certainly be in place by 1985.

5. QUANTITATIVE ANALYSIS USING SEAS

Method of Approach

In the previous chapter, qualitative assessments were made of likely future regulatory actions for 20 major energy-related environmental issues. Some discussion was also presented on how such actions might affect DOE-supported energy technologies and programs. However, no quantitative analysis was carried out to determine the economic or environmental effects of those actions. In this chapter, estimates of costs and changes in residual loadings are developed for a subset of the 20 major issues.

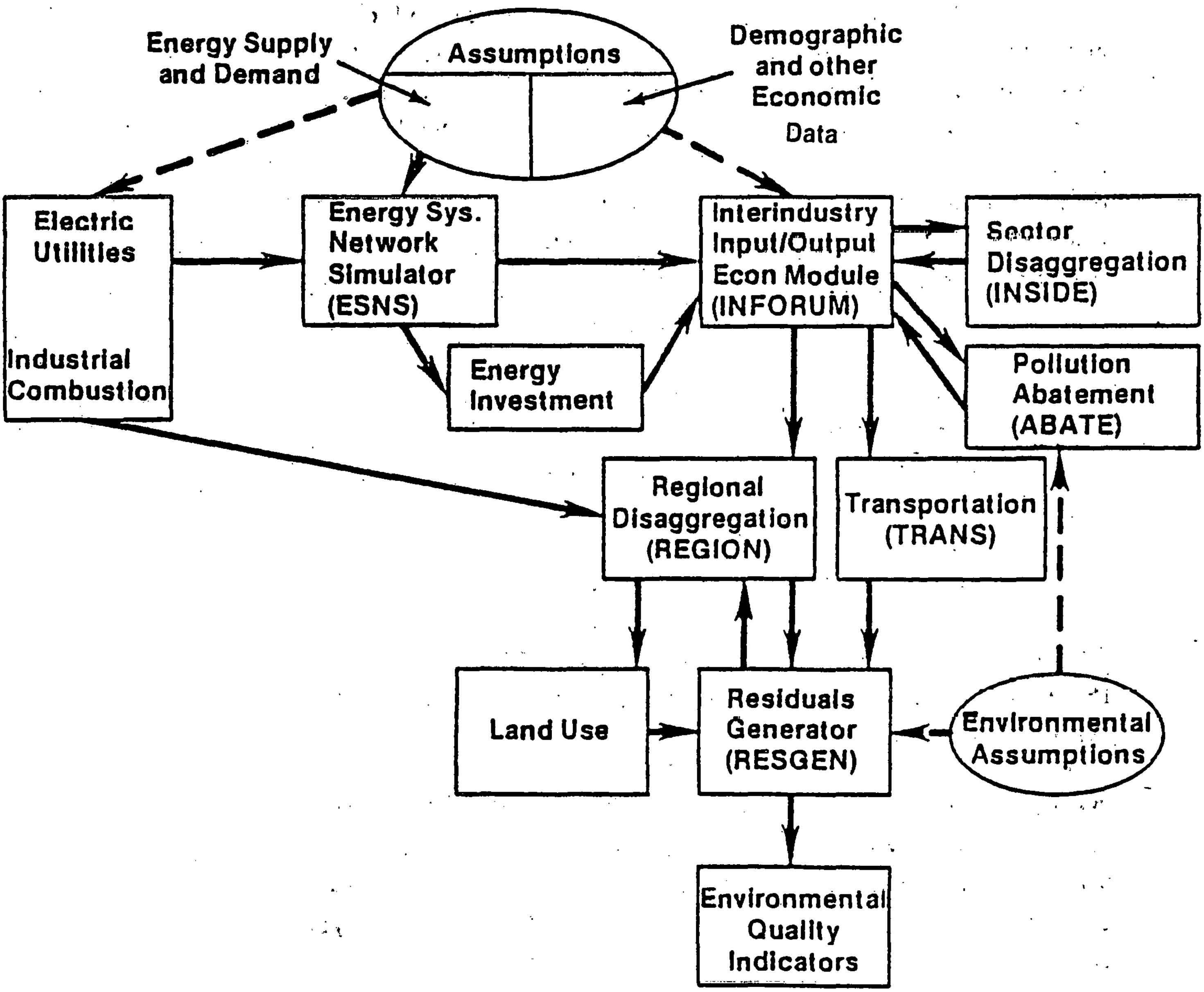
The method used to explore the impacts of changes in environmental regulation involved: inputting postulated regulatory changes into an existing energy-environmental-economic model; and examining their effects on the outputs of the model (environmental control costs and pollutant emissions), relative to a base case for several future years. The model used in the analysis was the Strategic Environmental Assessment system (SEAS).

SEAS is actually a set of interrelated energy, environmental, and economic computer models whose overall structure is shown in Figure 5-1. For a particular scenario of future energy and economic growth, SEAS calculates a variety of environmental residuals for energy and non-energy sectors of the economy. Projections are provided for both gross residuals (raw waste loads such as untreated stack gas) and net residuals (emissions actually released into the environment after the application of a control technology). The model also estimates quantities of secondary residuals, such as sludge, which result from the application of a control technology.

Residuals produced at any point in a production cycle are included. For example, the model reports not only the emissions from a coal-burning power plant, but also the related emissions from mining the coal. Projections from SEAS are produced at the national level, and for disaggregate areas such as federal regions, states, Air Quality Control Regions, and Standard Metropolitan Statistical Areas.

FIGURE 5-1

SEAS Block Diagram



For this analysis, the relevant outputs of SEAS are its computation of national gross and net residuals from the energy sectors of the economy, and tabulation of enviromental control costs for these sectors.

The SEAS model has been used in order to examine the effects of future environmental regulations postulated in Chapter 4. However, not all of the 20 environmental issues examined are amenable to such quantitative manipulation. Only those regulatory actions which can be expressed in terms of pollutant emissions limitations for particular technologies can be examined within the SEAS framework. Upon examination of the 20 issues and related regulatory actions, it was concluded that the following seven regulatory questions are amenable to analysis using SEAS:

(1) Disposal of solid waste from coal technologies.
(2) Fine particulate emissions from coal combustion.
(3) Trace element emissions from coal combustion.
(4) NO_x emissions from coal combustion.
(5) Treatment of geothermal effluents.
(6) Disposal of nuclear wastes.
(7) Wastes from biomass technologies.

The following sections will discuss and tabulate tons of emissions based on the regulatory actions postulated in Chapter 4, as well as the additional control costs resulting from such limitations.

The quantitative results were taken from an existing SEAS scenario based on the Second National Energy Plan (the high economic growth version). Data from NEP II (HIGH) essentially provides a "worst case" (the maximum expected environmental impacts for the period 1975-2000) for DOE analysts. The scenario relates to projections of currently supported DOE energy technologies and programs.

Emission Factors and Control Costs

The SEAS data base contains net residual emissions and control costs for most energy technologies based on current and likely near-term environmental regulations and assumptions about the effects of conventional control technologies on unregulated pollutants (E.G., trace elements). The data base for each of the seven issues listed above has been examined to determine changes that should be made to reflect further regulatory actions. The SEAS data base contains gross and net emissions of residuals in terms of tons of residuals per 10^{12} Btu of energy produced, and estimates of environmental control costs (capital and O&M) in terms of dollars per 10^{12} Btu of energy produced. All postulated changes in the data base area assigned similar units in the following discussions.

5.1 Disposal of Solid Wastes from Coal Technologies

The major impact of regulations developed under RCRA on coal conversion facilities will be an increase in the cost of transportation and disposal of non-combustible solid wastes. If such wastes are designated "hazardous" by EPA, a number of operations will have be added to conversion facilities' waste disposal practices. These may include chemical fixation of the wastes, impermeable liners at disposal sites, collection and treatment of leachate from the waste pile, groundwater monitoring, permanent covering and revegetation of the disposal site, and so on.

Presently, solid wastes (ash and scrubber sludge) from conventional coal-fired power plants are designated by EPA as "special" wastes and disposal requirements are approximately the same as for non-hazardous wastes on an interim basis. The current national average disposal cost for conventional non-combustible solid wastes is about $6/ton.

Application of RCRA standards for both hazardous and non-hazardous waste disposal would increase this figure for both new and existing facilities. A recent study for the Department of Energy (Fred C. Hart Associates, 1979) estimates that the disposal requirements under proposed RCRA regulations would increase the national average disposal costs for wastes designated hazardous by about $6.60/ton at existing facilities and by $10.20/ton at new facilities. For non-hazardous wastes, the costs would increase by $3.60/ton and $.5.70/ton, respectively.

In addition to increased disposal costs, greater costs will be incurred in transporting wastes to suitable disposal sites rather than committing them to on site disposal. Fred C. Hart Associates (1979) estimates these costs, for a 2 to 25 mile haul distance, to be $1.50-2.25/ton for non-hazardous wastes, and $10.50-15.75/ton for hazardous wastes.

Although the costs presented above have been developed for power plant ash and sludge, it was assumed that they also apply to the wastes of coal conversion technologies, such as coal gasification, liquefaction, and magnetohydrodynamics. To assess the impact of RCRA regulations on the disposal cost of coal conversion wastes, two cases were proposed. The first is the Maximum Impact Case in which all non-combustible solid wastes (power plant ash and sludge) are declared hazardous after 1980. Based on the cost estimates presented above, including transportation costs in the middle of the range shown, the total average cost of waste disposal is estimated to be $25/ton for existing facilities and $30/ton for new facilities.

The second case examined the Intermediate Impact Case in which power plant ash and sludge are designated special wastes on a permanent basis, and thus incur disposal costs approximately the same as the non-hazardous designation. In this case, the average disposal costs for power plant ash and sludge would be $12/ton for existing facilities and $14/ton for new facilities. Disposal costs for the coal conversion facilities would remain the same as the Maximum Impact Case.

The preceding disposal costs are somewhat different than those currently contained in the SEAS data base, which are $6/ton and $7-12/ton (current practice costs) for utility ash and sludge, respectively. Under RCRA, ash designated non-hazardous is $8-9/ton, $11-12/ton when designated hazardous; sludge designated non-hazardous is $12-18/ton; and $16-21/ton when designated hazardous.

The impact of increased disposal costs on the cost per 10^{12} Btu of coal conversion products will vary with the amount of solid waste generated per unit of product; which in turn is a function of coal type, conversion process, conversion efficiency, and so on. According to the scenario (NEP II, HIGH) the coal conversion processes will contribute about 15% to the total non-combustible solid waste load from utilities by the year 2000. While in both cases the net tonnage generated is the same (see Table 5-3) the cost of disposal for the maximum case will be more than twice the cost for the intermediate case.

Maximum Impact Case

This case assumes that both coal conversion and conventional coal-fired wastes are classified hazardous by EPA. A cost factor of $25/ton was applied to facilities operating before 1980 ($30/ton after 1980). See Tables 5-1 and 5-3 for the results of this analysis.

Intermediate Impact Case

This case assumes that conventional coal-fired wastes are classified special, while coal conversion wastes remain hazardous. A cost of $12/ton for existing plants (pre-1980) and $14/ton for new plants (post 1980) was applied to special waste; $30/ton for new plants was applied to hazardous wastes. See Table 5-2 and 5-3 for the results of this analysis.

5.2 Fine Particulate Emissions from Coal Combustion

The control of primary fine particulate emissions from coal-fired boilers can be achieved using technology suitable for the control of total particulates. Typically, however, the control efficiency of such devices is much lower for fine particulates (less than 2 microns in diameter) than for larger particulates. Of the control devices now in use, cyclones are probably the worst in this regard, achieving removal efficiencies of perhaps only 50% for fine particulates. Wet scrubbers are somewhat better. However, neither of these technologies will be able to meet the revised NSPS for particulates of 0.03 lb per 10^6 Btu. The only realistic candidates at present are electrostatic precipitators (ESPs) and fabric filters (baghouses).

TABLE 5-1

SOLID WASTE DISPOSAL COST FOR COAL TECHNOLOGIES
UNDER THE MAXIMUM IMPACT CASE
($Million)

PROCESS	1975	1980	1985	1990	2000
Conventional	1,044	1,158	1,831	2,317	3,114
Coal Conversion					
SRC	0	0	0	0	0
H-Coal	0	0	0	18	372
Lurgi (L)	0	0	0	0	54
Lurgi (WSB)	0	0	0	0	0
Synthane (WSB)	0	0	0	0	35
Synthane (L)	0	0	0	0	0
IGT U-gas (C)	-	-	-	-	-
IGT U-gas (NC)	-	-	-	-	-
Totals	1,044	1,158	1,831	2,335	3,575

All costs were based on dry weight equivalents for non-combustible solid wastes generated by both coal conversion and conventional coal-fired processes. Numbers cited above are total annual costs.

Lurgi and Synthane processes have coal types in parentheses (Lignite, W. SubBituminous, E. Bituminous). IGT U-gas process distinctions refer to caking and non-caking coals, however, no projections are found in the NEP II, High scenario.

TABLE 5-2

SOLID WASTE DISPOSAL COST FOR COAL TECHNOLOGIES
UNDER THE INTERMEDIATE IMPACT CASE
($Million)

PROCESS	1975	1980	1985	1990	2000
Conventional	501	556	871	1,099	1,470
Coal Conversion					
SRC	0	0	0	0	0
H-Coal	0	0	0	18	372
Lurgi (L)	0	0	0	0	54
Lurgi (WSB)	0	0	0	0	0
Synthane (EB)	0	0	0	0	35
Synthane (WSB)	0	0	0	0	0
Synthane (L)	0	0	0	0	0
IGT U-gas (C)	-	-	-	-	-
IGT U-gas (NC)	-	-	-	-	-
Total	501	556	871	1,117	1,931

All costs were based on dry weight equivalents for non-combustible solid wastes generated by both coal conversion and conventional coal-fired processes. Numbers cited above are total annual costs.

Lurgi and Synthane processes have coal types in parentheses (Lignite W. SubBituminous, E. Bituminous). IGT U-gas process distinctions refer to caking and non-caking coals, however, no projections are found in the NEP II, High scenario.

TABLE 5-3

SOLID WASTE GENERATED BY COAL TECHNOLOGIES
FOR MAXIMUM IMPACT AND INTERMEDIATE IMPACT CASES
(Million Tons)

PROCESS	1975	1980	1985	1990	2000
Conventional	42	54	70	85	111
Coal Conversion					
SRC	0	0	0	0	0
H-Coal	0	0	0	0.1	12.4
Lurgi (L)	0	0	0	0	1.8
Lurgi (WSB)	0	0	0	0	0
Synthane EB)	0	0	0	0	1.2
Synthane (WSB)	0	0	0	0	0
Synthane (L)	0	0	0	0	0
IGT U-gas (C)	-	-	-	-	-
IGT U-gas (NC)	-	-	-	-	-
Total	42	54	70	85.10	126.4

Lurgi and Synthane processes have coal types in parentheses (Lignite, W. SubBituminous, E. Bituminous). IGT U-gas process distinctions refer to caking and non-caking coals, however, no projections are found in the NEP II, High scenario.

ESPs are currently the most common control method for particulates. Although much superior to cyclones or wet scrubbers, their ability to remove fine particulates is also limited. Numerous measurements have been made of particle removal efficiency as a function of particle size (Szabo and Gerstle, 1977; Abbott and Drehmel, 1976). These measurements show that an ESP achieving an overall particle removal efficiency of, say 99.5%, will remove particles less than 2 microns in diameter with an efficiency on the order of 97%. Future regulatory requirements for fine particulates may require higher control efficiencies. Measurements made on fabric filters (Abbott and Drehmel, 1976; Ensor et al., 1976) indicate very high removal efficiencies for fine particulates. For a glass/teflon fabric filter with an air-to-cloth (A/C) ratio of 2:1 (cubic feet of combustion gases per minute/square feet of filter area), total particulate removal efficiencies of 99.8-99.9% are readily attained, and fine particulate removal efficiencies are in excess of 99%. Because of their superior performance, EPA is beginning to view fabric filters as the technology of choice for the control of fine particulates (EPA, 1978). They are especially attractive for use on boilers firing western coal with high resistivity fly ash, which is less amenable to ESP control.

It is assumed that by 1985 fabric filters will be required by EPA as BACT for coal-fired utility boilers, as a result of one or a combination of the following regulations: particle size-based NSPS; standards for the protection of visibility; NAAQS and PSD increment specifications for fine particulates.

Although fabric filters are not in widespread utility use, procedures have been developed for estimating the cost of fabric filters for large size (500 MW) utility boilers (Bubenick, 1977). Using these procedures, the capital cost of a glass/teflon fabric filter (capable of achieving 99.8% total particulate removal efficiency on a coal-fired utility boiler) would be $25/kW for both eastern and western coal, and the operating and maintenance (O&M) cost would be 0.32 mill/kWh. In units appropriate to the SEAS data base, the annualized capital cost would be $183,000/10^{12}$ Btu and the O&M cost would be $94,000/10^{12}$ Btu.

The SEAS data base does not separately account for fine particulate emissions-only total particulate emissions are computed. The particulate emissions for 99.8% control efficiency for both eastern coal (11,500 Btu/lb; 9.2% ash) and western coal (10,000 Btu/lb; 7.7% ash) would be 18.4 tons per 10^{12} Btu of electricity. This corresponds to 0.013 lb per 10^6 Btu coal-fired.

The SEAS data base currently assumes the use of ESP's (98.3% efficiency) to achieve an NSPS of 0.1 lb per 10^6 Btu (147 tons per 10^{12} Btu electricity), increasing to 99.2% efficiency for new sources to meet a postulated NSPS of 0.05 lb per 10^6 Btu (73.5 tons per 10^{12} Btu electricity) after 1984. The ESP costs used in the SEAS data base are $44/kW ($310,000/10^{12} Btu annualized) capital cost and 0.1 mill/kWh ($30,000/$10^{12}$ Btu) O&M cost for western coal, and $18/kW ($140,000/10^{12} Btu annualized) capital cost and 0.07 mill/kWh ($20,000/$10^{12}$ Btu) O&M cost for eastern coal.

According to the SEAS analysis, the net amount of particulate emissions from utility boilers varies considerably with the type of control technology. The use of fabric filters provides the best control. By the year 2000, less than 1% of the national net particulate loading would be contributed by electric utilities if all utilities built after 1985 used fabric filters; this figure is 12% if ESPs are used. (See Table 5-4). It appears that fabric filters would provide better nationwide control of particulate emissions from coal-fired boilers. This can be done at less cost in the West than for ESP controls. See (Tables 5-5 and 5-8).

5.3 Trace Element Emissions from Coal Combustion

The control of trace element emissions from coal combustion is achieved simultaneously with the control of particulate emissions. However, the level of control achieved varies widely from one type of trace element to the next. It has been well established that a number of toxic trace elements tend to concentrate preferentially in the output of control devices, such as ESPs, relative to the input. In addition, some volatile elements, such as mercury and fluorine, are emitted in the gaseous state; and are only partly removed, (if at all) by particulate control devices.

TABLE 5-4

NET RESIDUALS FOR UTILITY BOILERS
(Thousand Tons)

	1985	2000
Eastern Coal		
ESP	58.1	239.0
Fabric Filter	14.6	59.8
Western Coal		
ESP	29.1	235.2
Fabric Filter	7.3	58.9

TABLE 5-5

ABATEMENT COST FOR UTILITY BOILERS
($Million)

	1985	2000
Eastern Coal		
ESP		
Capital	110.7	454.7
Other	15.8	65.0
Fabric Filter		
Capital	144.8	594.4
Other	74.4	305.3
Western Coal		
ESP		
Capital	122.8	992.0
Other	11.9	96.0
Fabric Filter		
Capital	72.5	585.6
Other	32.7	300.8

All capital costs cited above are annualized.

TABLE 5-6

EMISSION COEFFICIENTS FOR TOXIC TRACE ELEMENTS
FROM COAL FIRED BOILERS - EASTERN COAL
(Tons/10^{12} Btu Electric)

ELEMENT	GROSS EMISSION	NET EMISSION	
		ESP	Fabric Filter
Arsenic	1.20	0.14	0.11
Beryllium	0.20	0.14	0.07
Cadmium	0.03	0.0014	0.0014
Fluorine	7.00	0.54	0.54
Lead	1.20	0.10	0.01
Manganese	20.50	1.20	1.20
Mercury	0.16	0.16	0.03
Selenium	0.44	0.14	0.04

TABLE 5-7

EMISSION COEFFICIENTS FOR TOXIC TRACE ELEMENTS
FROM COAL FIRED BOILERS - WESTERN COAL
(Tons/10^{12} Btu Electric)

ELEMENT	GROSS EMISSION	NET EMISSION	
		ESP	Fabric Filter
Arsenic	0.14	0.007	0.007
Beryllium	0.16	0.001	0.001
Cadmium	0.04	0.001	0.001
Fluorine	7.30	0.56	0.56
Lead	0.58	0.05	0.006
Manganese	2.50	0.14	0.14
Mercury	0.005	0.005	0.0004
Selenium	0.14	0.04	0.013

TABLE 5-8

ABATEMENT COST FOR INDUSTRIAL COMBUSTION
($Million)

	1985	2000
EASTERN COAL		
ESP		
Capital	68.3	489.0
Other	9.8	69.9
Fabric Filter		
Capital	89.3	639.0
Other	17.2	328.0
WESTERN COAL		
ESP		
Capital	75.6	541.6
Other	7.3	52.4
Fabric Filter		
Capital	44.6	319.7
Other	22.9	164.2

All capital costs cited above are annualized.

Although there is limited data on the control of trace elements by devices other than ESPs, there is some evidence (Yeh et al, 1976, Ensor et al, 1976) to indicate that fabric filters are more efficient in removing most toxic trace elements, including volatile elements. This effect may be partly due to the fabric filter's higher efficiency in removing fine particulates, upon which the trace elements tend to concentrate.

Due to the better performance of fabric filters in controlling trace element emissions, and since it is unlikely that other control devices for removing trace elements from stack gases will be developed in the next 5-10 years, it is postulated that fabric filters will be designated as BACT for toxic trace elements after 1985. Such a designation will be economically advantageous in that no additional costs will be incurred beyond that required for particulate control.

The net emissions of several toxic trace elements using fabric filter control were estimated based on the limited data at hand (Yeh et al, 1976; Ensor et al, 1976). These emission coefficients are listed in Tables 5-6 and 5-7 along with the gross and net emission coefficients (assuming ESPs for particulate control) currently contained in the SEAS data base. Where there were no data available, or where the data indicated comparable removal efficiencies, the net emissions from fabric filters were assumed to be the same as from ESPs.

While the net tonnage of trace element air emissions increases through the year 2000, (even with the use of fabric filters) a considerable reduction is made over projected ESP removals. For example, ESP removal of berylluim for electric utilities in 1985 (national) leaves 111.1 net tons while fabric filters leave only 55.8 net tons. Also, ESP capital and O&M costs are considerably higher in the East than for the more efficient fabric filters. (See Tables 5-5, 5-8 through 5-10 for the results of this analysis.)

5.4 NOx Emissions from Coal Combustion

To meet the NO_x NSPS for coal-fired boilers of 0.7 lb per 10^6 Btu (recently revised downward to 0.6 lb per 10^6 Btu for bituminous coal and 0.5 lb for 10^6 Btu for sub-bituminous coal), power plant operators use one or a combination

TABLE 5-9

TRACE ELEMENT EMISSION FROM UTILITY BOILERS
(Tons)

	1985			2000		
	Gross	ESP	FF	Gross	ESP	FF
Eastern Coal						
Arsenic	949	111	87	3890	455	357
Beryllium	158	111	55	650	455	227
Cadmium	24	1	1	97	5	5
Fluorine	5537	427	427	22736	1754	1754
Lead	949	79	8	3898	325	33
Manganese	16216	949	949	66584	3898	3898
Mercury	127	127	24	520	520	97
Selenium	348	111	32	1429	455	130
Western Coal						
Arsenic	55	3	3	448	0	0
Beryllium	63	0	0	512	3	3
Cadmium	16	0	0	128	3	3
Fluorine	2891	222	222	23360	1792	1792
Lead	230	20	2	1856	160	19
Manganese	990	55	55	8000	448	448
Mercury	2	2	0	16	16	1
Selenium	55	16	5	448	128	42

ESP = Electrostatic Precipitator

FF = Fabric Filter

0 = Indicates there would be less than 1 ton of net emissions generated.

TABLE 5-10

TRACE ELEMENT EMISSIONS FROM INDUSTRIAL COMBUSTION
(Tons)

	1985			2000		
	Gross	ESP	FF	Gross	ESP	FF
<u>Eastern Coal</u>						
Arsenic	586	68	54	4192	489	384
Berrylium	98	68	34	699	489	245
Cadmium	15	1	1	105	5	5
Fluorine	3416	264	264	24451	1886	1887
Lead	586	49	5	4192	349	35
Manganese	10004	586	586	71607	4192	4192
Mercury	78	78	15	559	559	105
Selenium	215	68	20	1537	489	140
<u>Western Coal</u>						
Arsenic	34	2	2	245	12	12
Berrylium	39	0	0	280	2	2
Cadmium	10	0	0	70	2	2
Fluorine	1781	137	137	12753	978	978
Lead	142	12	2	1013	87	11
Manganese	610	34	34	437	245	245
Mercury	1	1	0	9	9	1
Selenium	34	10	3	245	70	23

ESP = Electrostatic Precipitator

FF = Fabric Filter

0 = Indicates there would be less than 1 ton of net emissions generated.

of combustion modification techniques. These include flue gas recirculation, firing with low excess air, and off-stoichiometric combustion. These techniques have been shown to be successful in reducing NO_x emissions by 10 to 40 percent (individually). In addition, advanced burner designs are being developed which can achieve up to 50 percent reductions in NO_x emissions (EEA, 1978).

Although the methods listed above may be adequate to meet current NSPS, the development of further regulatory constraints on NO_x could force the adoption of more effective, and costly, control technology. These regulatory constraints may include (as discussed in Chapter 4) a short-term NAAQS, PSD increment specifications, visibility protection requirements, and control requirements for precursors of acid rain and secondary fine particulates.

In order to meet such regulatory constraints, it appears that some form of stack gas treatement will be required to achieve required NO_x removal efficiencies as high as 90%. Two methods of stack gas treatment have been used successfully in Japan on oil and gas-fired boilers. These may be characterized as "dry" and "wet" processes (EPA, 1978). Dry processes typically involve the reduction of NO_x to nitrogen and oxygen or water through the injection of ammonia (sometimes in the presence of a catalyst). Wet processes typically involve scrubbing the gas stream to remove NO_x, and are similar to SO_2 removal. Since wet processes do not work well where SO_2 and particulates are present, (and because dry processes are more fully developed) it is assumed that a dry process, selective catalytic reduction (SCR), will be designated BACT for NO_x control on coal-fired utility boilers.

It is postulated that a BACT requirement for SCR and a concomitant NSPS of 0.3 lb per 10^6 for coal-fired utility boilers will come into effect in 1988 because stack gas treatment systems for NO_x are not likely to be available before the mid 80's.

Due to the early stage of development of SCR in the United States, cost data are sketchy. However, several sources have presented estimates that indicate that costs are of the same order as for SO_2 removal systems (EEA, 1978; EPA, 1978). Based on these sources, it is estimated that the capital costs of SCR are about $75/kW ($550,000/10^{12} Btu annualized), while O&M cost are about 1.0 mill/kWh ($290,000/$10^{12}$ Btu).

The SEAS data base has no control costs for NO_x reduction because combustion modification techniques are very inexpensive. It assumes that the NSPS of 0.7 lb/10^6 Btu will continue in effect through the 1980's. A figure of 0.6/lb/10^6 Btu is used to represent BACT (required in non-attainment areas, for example).

Using the NEP II HIGH Scenario from SEAS electric utilities burning new coal under BACT would contribute about 8% of the net national NO_x residuals in 2000 (using flue gas recirculative firing with low excess air, and off stoichiometric combustion). With the new dry process stack gas treatment (SRC), NO_x is reduced by half. However, the cost will be high (see Tables 5-11 and 5-12).

5.5 Treatment of Geothermal Effluents

The pollution control requirements for geothermal energy facilities over the next few years will center on the discharge of aqueous effluent (condensed steam or hot water) and atmospheric emissions (hydrogen sulfide, H_2S). The current and most likely future method for the disposal of aqueous effluent is to reinject it into the producing zone.

At the Geysers geothermal power plant in Northern California (a dry steam field), effluent disposal is handled by the Union Oil Company, which also supplies steam to the power plant. The cost of reinjection is 0.5 mill/kWh ($146,000/$10^{12}$ Btu). Although costs may vary from one field to the next, this cost will be assumed to represent the cost of reinjection for all dry steam resources.

The abatement of H_2S emissions at the Geysers is currently achieved by applying the Stretford process to the noncondensible gas steam. The capital cost of this treatment is approximately $60/kW ($440,000/10^{12} Btu annualized). Such treatment reduces the emissions of H_2S by 90% (Ramachandran et al, 1977). It is postulated that local air pollution regulations, as well as stringent H_2S ambient air standards in some areas, will require 99% H_2S

TABLE 5-11

NO_x ABATEMENT COST

($Million)

	1988	1990	2000
Capital	557	891	1217
O&M	294	470	648

All capital costs cited above are annualized.

TABLE 5-12

NET NO_x RESIDUALS

(Thousand Tons)

	1988	1990	2000
No control (1326 tons/ 10^{12} electric)	1300	2100	2900
With control (SEAS) (882 tons/10^{12} electric)	900	1400	2000
With control (SRC) (441 tons/10^{12} electric)	400	700	1000

SEAS control involves flue gas recirculative firing and off-stoichiometric combustion. SRC control is a new dry process stack gas treatment which is expected to be used in the 1980's.

abatement by all future geothermal facilities. This can be achieved by using a hydrogen peroxide (H_2O_2) or ozone (O_3) treatment system, in addition to Stretford treatment of the noncondensible gases. These remove H_2S from the steam condensate that would otherwise be released in the cooling towers. The H_2O_2 system has a capital cost of $9-11/kW ($63,000-78,000/10^{12} Btu annualized) and an O&M cost of 0.43-1.6 mill/kWh ($126,000-454,000/$10^{12}$ Btu), while the O_3 system has a capital cost of $16-35/kW ($114,000-260,000/10^{12} Btu annualized) and an O&M cost of 0.44-0.72 mil/kWh ($129,000-211,000/$10^{12}$ Btu) (Ramachandram et al, 1977). Both systems achieve about the same level of control at the 99% level of control, the net emissions of H_2S from a dry steam power plant with the same H_2S inlet concentration as the Geysers in 0.04 lb/MW-hr (5.7 tons/10^{12} Btu of electricity).

Due to the early stage of development of wet steam or hot water geothermal resources, few reliable estimates have been made of their environmental control costs. The cost of fluid reinjection will be much higher, however, than for dry steam resources because of a much larger waste volume. Fluid reinjection can cost as much as 30% of the cost of the producing wells (Bloomster, 1976). The likely production cost of hot water in resource ovens (such as those in California's Imperial Valley) is estimated at 17-27 mills/kWh. Resources costing more than this to produce are likely to be considered uneconomical (Ramachandran et al). Thus, fluid reinjection costs could be 5-7 mills/kWh ($1.5-2.1x$10^6$/$10^{12}$ Btu).

The costs of H_2S abatement will vary with the H_2S content of the resource and the technology used to convert the hot water to electricity. A flash injection system for electricity production would yield about three times as much emissions (i.e., the Geysers). The capital costs for 99% of H_2S emissions (using the Stretford process plus H_2O_2 or O_3 treatment) are estimated to be $210-280/kW ($1.5-2.1x10^6/10^{12} Btu annualized), with O&M costs of 1.3-3.7 mill/kWh ($.38-$1.4x10^6/10^{12} Btu). In this case the net emissions of H_2S would be 0.12 lb/MW-hr (10.4 tons/10^{12} Btu of electricity).

It is difficult to determine which emissions control system (ozone or peroxide) is more economical, since in the case of ozone the capital cost is considerably higher than peroxide and in the case of peroxide the O&M is considerably higher than the ozone. Ultimately, either system employed will cost 13-150 million dollars between 1975-2000.

NEP II HIGH did not contain emissions data for H_2S. It also projects no activity for the liquid dominated flash injection geothermal energy process (see Tables 5-13 and 5-14).

Given just the Stretford system control of H_2S (90%) the cost will be \$8-114 x10^6 from 1975-2000. The cost achieving 99% abatement then is an additional \$5-36x10^6 from 1975-2000.

5.6 Disposal of Nuclear Wastes

The disposal of high level reactor wastes is currently treated in the SEAS data base. Costs are included for high level liquid waste vitrification, transuranic waste treatment, and construction and operation of a permanent geologic repository. However, one aspect of the nuclear fuel cycle which has come under recent scrutiny (from which control costs and emissions reductions have not been assigned in the SEAS data base) is the production of tailings from uranium mills. This operation releases more radioactivity into the environment (air, land, and water) per unit of final electricity produced than any other step in the nuclear fuel cycle.

It is postulated that under the Uranium Mill Tailings Radiation Control Act of 1978, all uranium mills will require additional control and stabilization of tailings after 1980 (See Table 5-15). The cost of effectiveness of various methods of control have been assessed (Sears et al, 1975). The most cost-effective treatment involves: washing the tailings sands to remove easily leached radionuclides; landfilling the treated sands; fixation of the liquid waste solutions with Portland cement; and covering the tailings sands and fixed waste landfill with 20 feet of dirt topped by coarse rocks as milling operations proceed.

The estimated capital cost for this treatment system is \$6.3-7.6 million, and the O&M cost is \$1.6-1.8 million/year for a mill processing 2000 tons of uranium ore per day. The increased capital cost of producing electricity with

TABLE 5-13

COST OF CONTROLLING GEOTHERMAL WASTE
($Million)

PROCESSES	1975	1985	1990	2000
Peroxide				
Capital	1.0	4.7	8.1	12.6
O&M	3.9	19.4	33.1	51.3
Ozone				
Capital	2.5	12.5	21.4	33.1
O&M	2.3	11.4	19.4	30.1
Stretford	6.0	29.4	50.2	77.8
Fluid Reinjection	2.0	9.8	16.7	25.8

Capital costs for peroxide and ozone processes are annualized. The annualized capital cost of removing 90% of the H_2S waste stream (Stretford process) is cited above. Fluid reinjection cost is cited as total annual cost.

TABLE 5-14

GEOTHERMAL RESIDUAL (H_2S) GENERATION
(Thousand Tons)

	1975	1985	1990	2000
Controlled	.08	.38	.65	1.01

These numbers were calculated based on a 5.7 ton/10^{12} Btu figure (the low end of a 5-1000 ton/10^{12} Btu estimate in the Data Book prepared for DOE by The MITRE Corporation in January, 1979).

light water reactors (using uranium from mills with such a treatment system) is $\$9700/10^{12}$ Btu (annualized) and $\$9700/10^{12}$ Btu for the annual OTM costs. The calculated release of radionuclides may be compared with the uncontrolled releases currently contained in the SEAS data base. These are shown in Tables 5-15 through 5-17.

5.7 Wastes from Biomass Conversion

Development of biomass conversion technologies are in their infancy. Therefore, very few estimates have been made for the cost of controlling effluents. The SEAS data base does contain emissions estimates for biomass plantations, silvicultural residue collection, and anerobic digestion. However, no control efficiencies or costs have been specified for these emissions.

The only pollution control technologies that have been addressed in any detail are those for the control of particulate emissions from wood-fired utility boilers (PED Co., 1977). It is postulated that after 1980 particulate removal efficiencies of approximately 99% will be required to comply with NSPS and state regulations. This control efficiency can be achieved by using a combination of technologies (such as multiple cyclones, plus a dry scrubber).

The estimated capital cost for these combined technologies is \$22/kW ($\$160{,}000/10^{12}$ Btu annualized) (PED Co., 1977). The O&M is estimated to be 0.4 mill/kWh ($\$120{,}000/10^{12}$ Btu) per year.

Based on a gross emission rate for particulates of 842 tons/10^{12} Btu in the SEAS data base, the net emission rate with 99% control will be 8.4 tons/10^{12} Btu electricity. Tables 5-18 and 5-19 project the increased cost and reduction in residuals for the above mentioned control technologies.

According to the SEAS analysis gross biomass emission for electricity generation contributes less than 1% of the year 2000 waste loading. However, biomass heating is expected to contribute 13% of the 2000 waste loading. Reduction of 99% would not greatly impact the national loading of particulates for electric utilities.

TABLE 5-15

CONTROLLED VS. UNCONTROLLED RELEASES
OF RADIONUCLIDES FROM URANIUM MILLING
(Curies/10^{12} electric)

RADIONUCLIDE	UNCONTROLLED	CONTROLLED
Air		
Radon - 222	3.55×10^{0}	0.90×10^{0}
Radium - 226	9.5×10^{-4}	3.0×10^{-10}
Thorium - 230	9.5×10^{-4}	4.5×10^{-10}
Uranium (natural)	1.4×10^{-3}	1.1×10^{-8}
Water		
Uranium and daughters	9.5×10^{-2}	0

TABLE 5-16

NUCLEAR WASTE ABATEMENT COST
(Additional cost for electricity generation using LWR)
($Million)

	1980	1985	1990	2000
Capital	13	20	30	50
O&M	13	20	30	50

All capital costs cited above are annualized.

TABLE 5-17

URANIUM MILLING RESIDUALS GENERATION
(Curies)

	1980	1985	1990	2000
UNCONTROLLED				
Air				
Rn-222	4.7×10^{3}	7.3×10^{3}	1.1×10^{4}	1.9×10^{4}
Ra-226	1.3×10^{0}	2.0×10^{0}	3.0×10^{0}	5.0×10^{0}
TH-230	1.3×10^{0}	2.0×10^{0}	3.0×10^{0}	5.0×10^{0}
U-Nat.	1.9×10^{0}	2.9×10^{0}	4.4×10^{0}	7.4×10^{0}
Water (U^{238} + daughters)	5.5×10^{1}	1.3×10^{2}	3.0×10^{2}	5.0×10^{2}
CONTROLLED				
Air				
Rn-222	1.2×10^{3}	1.9×10^{3}	2.8×10^{3}	4.7×10^{3}
Ra-226	4.0×10^{-7}	6.2×10^{-7}	9.5×10^{-7}	1.6×10^{-6}
TH-230	6.0×10^{-7}	9.3×10^{-7}	1.4×10^{-6}	2.4×10^{-6}
U-Nat.	1.5×10^{-5}	2.3×10^{-5}	3.5×10^{-5}	5.8×10^{-5}
Water (U^{238} + daughters)	0	0	0	0

TABLE 5-18

BIOMASS EMISSION CONTROL COST
($Million)

	1980	1985	1990	2000
Forest Electric				
Capital	0	0	16	48
O&M	0	0	12	36
Forest/Farm Electric				
Capital	0	0	5	16
O&M	0	0	4	12

All capital costs cited above are annualized.

TABLE 5-19

NET RESIDUALS FROM BIOMASS TECHNOLOGIES
(Thousand Tons)

	1980	1985	1990	2000
Uncontrolled	0	0	2.0	86.0
99% Control	0	0	0.3	0.9

Control percentages may be off due to rounding.

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6. SUMMARY DISCUSSION AND CONCLUDING REMARKS

6.1 Long-Range Environmental Goals

The objective of this study has been to identify the major candidates for environmental regulatory action with significant potential effects on the implementation of energy technologies between now and the year 2000. As discussed elsewhere, this has been approached from two directions: 1) by surveying environmental interests, as well as state and federal regulatory policies; and 2) by reviewing the environmental aspects of the major energy technologies. The first activity was necessary in order to discover the long-range environmental goals which would potentially be pursued by these groups, as well as any specific technologies and issues recognized as important to their accomplishment. The second activity was necessary in order to reasonably guarantee that all significant potential impacts of the technologies had been considered, and to identify the specific technology/environment issues which would be the subject of the final candidate regulatory actions.

The policy/regulatory survey led to identification of three aspects of long-term environmental goals: generic problems, target technologies, and specific environmental threats. These results are listed in Table 6-1. These long-range goals are not independent -- for example, consider the relationship between water quality protection and protection of wildlife and endangered species. For the purpose of this discussion, we will therefore employ a restructured set of goals which will permit consideration of all the problems, targets and threats of Table 6-1. These long-range goals are as follows:

(1) Protection of the long-term climate of the earth via protection of the quality of the global atmosphere;

(2) Conservation of the limited amount of water in the West, to allow its allocation to the most beneficial long-term uses;

(3) Protection of water quality, especially groundwater in the West, during interim years so that water will be available during those and later years for allocation to its most beneficial long-term uses;

(4) Long-term conservation of land for its most beneficial use; in particular, the protection of prime and secondary agricultural lands;

(5) Long-term protection of human health and welfare via prohibition of all carcinogens from the human and ecological environment, and strict control over the entry of all toxic pollutants thereto (including human working spaces); and

(6) Maintenance for the long term of the pristine quality of the environment throughout those areas where energy resource development threatens to degrade it.

6.2 Specific Environmental Issues

A detailed environmental review of the key fossil energy technologies contemplated for development and application between now and the year 2000 was used to identify specific technology targets and critical candidates for future regulatory action. Table 6-2 shows the relationship between the technology modules (identified in a generic sense only) and the long-range environmental goals by using the 20 major issues to connect environmental goals with important environmental effects of the modules. These major issues were summarized in Chapter 4. Several aspects of these results, as displayed in Table 6-2, are of interest.

First, these issues span all technologies and modules -- that is, they represent a broad approach to the future technologies. Even so, it is clear that these issues are focused upon the coal combustion and synfuels (coal and oil shale) technologies.

Second, these issues span the restructured set of generic goals identified by the policy and regulatory survey: long-term protection of climate, water availability and quality, most beneficial land use, human health and pristine environments.

TABLE 6-1. POLICY AND REGULATORY SURVEY RESULTS

GENERIC PROBLEMS	TARGET TECHNOLOGIES
1. Climate Protection	1. Synthetic Fuels
2. Quality of Life	2. Coal Industry
3. Protection of Wildlife and Endangered Species	3. Tankers (accidents)
4. Most Beneficial Land Use	4. Liquefied Natural Gas
5. Most Beneficial Water Use	5. Offshore Oil and Gas Development
6. Protection of Surface and Groundwater Quality	6. Nuclear Power
7. Visibility	SPECIFIC THREATS
8. Pristine Area Protection	1. Trace Metals
9. Health Protection	2. Nitrogen Oxides
10. Efficiency in End Use	3. Solid Wastes
	4. CO_2 (greenhouse effect)
	5. Boomtowns
	6. Radionuclides

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TABLE 6-2. RELATIONSHIP BETWEEN LONG-TERM ENVIRONMENTAL GOALS AND ENERGY TECHNOLOGY MODULES

ENERGY SOURCE	TECHNOLOGY MODULE	CLIMATE	WATER AVAILABILITY	WATER QUALITY	OPTIMUM LAND USE	HUMAN HEALTH	PRISTINE ENVIRONMENTS
OIL AND GAS	EXPLORATION AND EXTRACTION						• OCS
	CONVERSION AND END USE	• CO_2 Greenhouse Effect • Fine Particulates		• POM	• OCS (onshore facilities) • LNG	• POM • NO_x	• OCS • LNG
COAL	EXPLORATION AND EXTRACTION		• Groundwater Contamination	• Solid Waste Disposal • Trace Elements • Groundwater Contamination • Land Disturbance • Radioactivity	• Solid Waste • Siting • Land Disturbance	• Solid Waste Disposal • Radioactivity • Trace Elements • Groundwater Contamination • Deep Mining-Health & Safety	• Solid Waste Disposal • Siting
	CONVERSION AND END USE	• CO_2 Greenhouse Effect • Fine Particulates	• Water Consumption • Groundwater Contamination	• Solid Waste Disposal • POM • Trace Elements • Groundwater Contamination	• Solid Waste Disposal • Siting • Land Disturbance (In-Situ)	• Fugitive Emissions • Solid Waste Disposal • Fine Particulate • POM • Trace Elements • Radioactivity • NO_x • Groundwater Contamination	• Boomtown • Solid Waste Disposal • Siting
OIL SHALE	EXPLORATION AND EXTRACTION		• Groundwater Contamination	• Trace Elements • Groundwater Contamination • Land Disturbance	• Land Disturbance	• Groundwater Contamination	• Siting
	CONVERSION AND END USE	• CO_2 Greenhouse Effect • Fine Particulates	• Water Consumption • Groundwater Contamination	• Solid Waste Disposal • POM • Trace Elements • Groundwater Contamination	• Solid Waste Disposal • Siting • Land Disturbance (In-Situ)	• Solid Waste Disposal • POM • Trace Elements • Groundwater Contamination • Fugitive Emissions • Fine Particulate • NO_x	• Solid Waste Disposal • Siting • Boomtown
GEOTHERMAL	STEAM PRODUCTION AND ELECTRICITY GENERATION		• Groundwater Contamination	• Trace Elements		• H_2S Emissions	
BIOMASS	PRODUCTION	• CO_2 Greenhouse Effect	• Water Consumption	• Land Disturbance	• Land Disturbance		• Siting
	CONVERSION	• Fine Particulates				• POM	
NUCLEAR POWER	MINE MILLING AND CONVERSION		• Groundwater Contamination	• Radioactivity	• Solid Waste Disposal	• Low-Level Radiation	
			• Water Consumption	• Radioactivity	• Solid Waste Disposal • Siting	• Low-Level Radiation • Accidents	

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Third, most of these specific issues represent departures from the classical environmental concerns which have received most attention from public and regulatory bodies in the past, such as: the CO_2 greenhouse effect, fine particulates as opposed to TSP, groundwater as opposed to surface water, water allocation as well as quality, effective attention to solid waste disposal (rather than an air/water emphasis), and attention to carcinogens and toxics in all media (POM and trace elements as opposed to the classic air and water pollutants). Further, many of these issues differ from classic environmental issues in that they are truly multi-media in nature, such as the protection against trace element and POM entry to land, air and water.

Fourth, the solutions to many of these issues (problems) will tend to be in conflict with the solutions of others. For example: health effects of deep mining can be reduced by turning to surface mining, which in turn exacerbates the problems of water availability, groundwater quality, land use and disturbances, trace elements and pristine environments in the West; similarly, stringent controls on OCS development or LNG facilitites will lead to exacerbation of the above coal-related problems. The important point is that these issues represent a connected whole, within which there will be many antagonistic as well as cooperative interactions as solutions are sought to specific issues.

Fifth and finally, unlike the classic issue where the public could see a polluted stream and demand it be cleaned up, the level of controversy and resolution of controversy are directly related to state of knowledge and research. For example, knowledge of potential climatic effects largely results from research published in the last 5 years. Intensity of debate, appraisals of the seriousness of the CO_2 issue and proposals for its resolution all depend on work in progress. The same applies to toxics, trace metals, NO_x, groundwater quality, and low level radiation.

6.3 Possible Impacts of Future Regulatory Actions

In previous sections, we have identified 20 issues as those most likely for major future regulatory action. Possible forms of regulatory action (e.g., NSPS, NAAQS, water use allocation) have been discussed for each issue. The specific regulatory forms and the likelihood that they will be implemented were shown to depend upon several important variables. These include:

- Geographic location of technology.
- Scale of technology application.
- Economic circumstances nationally and worldwide.
- Public attitudes on conservation, environment and lifestyle.
- Level of research and knowledge on the seriousness of the problem, and on potential solutions.
- National trade-offs on basic aspects of energy development, such as health effects versus ecological effects.
- Implementation of extant laws and regulations.

These future regulatory actions can be at federal and state levels and can take several forms, including: air, water and land ambient standards; air, water and solid waste emission standards and handling guidelines; siting requirements for facilities and disposal sites; occupational health and safety guidelines; restrictions on water use for certain purposes depending upon locale and competing beneficial uses; and restrictions upon the overall magnitude of fossil fuel consumption. The complexity of just the siting and emission requirements for the air medium alone is displayed in Table 6-3 for the CAA as amended in 1977. (A brief analysis of the CAA leading up to Table 6-3 is presented in Appendix C, along with definitions of the terms used there.) As indicated in the previous section, such requirements can be expected to become more complex in the long term, especially as multi-media aspects become more important. It is apparent from Table 6-3 and the discussion in Appendix C that environmental laws and regulations are being constructed so as to drive both urban and non-urban emission controls to more

TABLE 6-3

POSSIBLE MECHANISMS OF CAA IMPACT ON NEW AND EXISTING SOURCES[1]

							MUST ALSO CONSIDER IMPACT ON (7), (8) AND (9) IN ORDER TO IDENTIFY POSSIBLE ADDITIONAL RESTRICTIONS ON NEW AND EXISTING SOURCES						
	(1) NSPS (Federal)	(2) RACT (Local)	(3) LAER (National)	(4) BACT (State)	(5) BART (State[2])	(6) OFFSET (Local)	(7) DISTANT NON-ATTAINMENT AREA (State)	(8) LOCAL PSD AREA (State/Local)	(9) DISTANT PSD AREA (State)	(10) EMISSIONS CONTROL (State/Local)	(11) LOCATION (State/ Local)	(12) CAPACITY (State/ Local)	(13) NESHAPS (Federal)
NEW OR MODIFIED SOURCES													
Location													
Non-Attainment Area	X		X		X	X	X		X	X	X	X	X
PSD Area	X			X	X		X	X	X	X	X	X	X
EXISTING SOURCES													
Location													
Non-Attainment Area		X			X[3]		X			X		X	
PSD Area					X[3]		X			X		X	

[1] See Appendix C for discussion and definitions.

[2] EPA promulgates BART for fossil fuel generating plants with capacity greater than 750 megawatts.

[3] Applies only to plants in operation less than 15 years.

LEGEND:

NSPS - New Source Performance Standards
RACT - Reasonably Available Control Technology
LAER - Lowest Achievable Emission Rate
BACT - Best Available Control Technology
BART - Best Available Retrofit Technology
OFFSET - Emission of offset required for new or modified source permit in non-attainment area
NESHAPS - National Emission Standards for Hazardous Air Pollutants
PSD - Prevention of Significant Deterioration

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stringent levels. These trends toward greater stringency and complexity may be accompanied by the following developments:

- Comprehensive multi-pollutant, multi-media and even regional regulatory packages for each major fossil energy technology.
- Broadening of the conservation issue to include water and land resources as well as energy; in particular, restrictive allocation of water to achieve the most beneficial use.
- National level mechanisms for balancing and distributing the costs and benefits of energy development (e.g., balancing the occupational health risks of deep mining versus the ecological hazards of surface mining).
- International programs to manage the long-term impacts of fossil fuel use, such as the CO_2-greenhouse effect.

The overall implications of the issues suggest that the energy-environment conflicts of the future will differ from the past in that:

- The arguments will be more sophisticated on all sides. There will be greater reliance on current research data, which will be watched more closely than in the past. There will be greater use of projections of long range effects.
- There will be greater stress on agency decisions balancing benefits and costs in disparate areas of interest, and there will be a premium on legislation and agency decisions rationally supported by recognition of widely disparate benefits and costs.
- Many problems may not be amenable to a "quick fix." If carbon dioxide comes from both damaged cuttings in forests and fossil energy combustion, the legislated solution may nevertheless require restricted use of fossil resources.

In general, this analysis suggests several major responses by the Department of Energy:

- More forward-looking research that attempts to obtain pertinent data on environmental effects further in advance, both to insure that national debates are informed by accurate data and to develop solutions for problems insofar as possible.
- Greater use of forecasting of cumulative effects of planned energy activities and their effects in combination with other predicted activities in the world.
- Greater attention to agency decision methodologies that insure that nonenergy values impacted by a decision are understood and effectively considered from the earliest stage of planning.

It is in the face of possible developments such as these, and in the context of extant laws and regulations such as indicated in Table 6-3, that the impact of possible future environmental regulations upon the energy technologies should be evaluated.

APPENDIX A

SUBMODULES OF THE MAJOR TECHNOLOGIES

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APPENDIX A

SUBMODULES OF THE MAJOR TECHNOLOGIES

1. OIL

1.1 Exploration

Surveying
Exploratory Drilling

1.2 Extraction (onshore-offshore)

Primary Recovery
Secondary Recovery
Tertiary or Enhanced Recovery

Thermal
Chemical

1.3 Pretreatment

Gas/Oil Separation Techniques

1.4 Transportation

Shipping/Receiving Terminals
Pipeline
Vehicular Transport (tanker, rail, car)

1.5 Conversion

Main Crude and Vacuum Distillation
Hydrotreating
Catalytic Reforming
Fluidized Catalytic Cracking
Alkylation
Hydrocracking
Lubricant Treating

1.6 Product Transportation

Shipping/Receiving Terminals
Pipeline
Vehicular Transport (tanker, rail, car, truck)

1.7 End Use

Transportation Fuels
Electricity
Industrial

Residential

2. GAS

2.1 Exploration

Surveying
Exploratory Drilling

2.2 Extraction (onshore-offshore)

Primary Recovery
Non-nuclear Fracturing
Nuclear Fracturing

2.3 Pretreatment

Dehydration
Gas Purificaton

2.4 Transportation

Pipeline

2.5 Conversion

LPG and Natural Gasoline
Natural Gas and LNG

2.6 Transportation

Vehicular
Pipeline
Terminals and LNG Tankers

2.7 End Use

Residential
Electricity
Industrial

3. COAL LIQUEFACTION

3.1 Exploration

Surveying
Drilling

3.2. Extraction

Surface Mining

Underground Mining

3.3 Transportation

Conveyor
Truck
Rail

3.4 Pretreatment

Beneficiation
Slurrying

3.5 Conversion

Processing

Catalytic Hydrogenation
Solvent Extraction
Pyrolysis

Purification

Gas Treatment
Solid/Liquid Separation

3.6 Transportation

Shipping/Receiving Terminals
Pipeline
Vehicular (tanker, rail, truck)

3.7 End Use

Advanced Power Cycle
Industrial
Refinery Syncrude

4. COAL GASIFICATION

4.1 - 4.4 (same as 3.1 - 3.4)

4.5 Conversion

High Btu Gas

Gasification
Shift Conversion
Purification
Methanation

Low Btu Gas

Gasification
Purification

4.6 Transportation

Pipeline

4.7 End Use

Domestic heating (high Btu)
Advanced Power Cycle
Industrial (low Btu)
Synthesis Gas (low Btu, chemical feedstock)

5. COAL COMBUSTION

5.1 - 5.4 (same as 3.1 - 3.4)

5.5 Conversion

Conventional Combustion
Atmospheric Fluidized Bed

Combustion
Gas Purification
Solids Removal

Pressurized Fluidized Bed

Combustion
Gas Purification
Steam Generation

5.6 Transportation

Electrical Transmission

5.7 End Use

Lighting and Appliances
Machinery
Heating

6. MHD

6.1 - 6.4 (similar to 3.1 - 3.4)

6.5 Conversion

Coal Gasification
Seed Recycle (ionized gas)
Power Generation (electromagnetic induction)
Slag Separation
Seed Condensation and Regeneration
Steam Turbine-Power Generation
Solid Seed Extraction

6.6 Transportation

Electrical Transmission

6.7 End Use

Lighting and Appliances
Machinery
Heating

7. OIL SHALE

7.1 Exploration

Surveying
Drilling

7.2 Extraction

Surface Mining
Underground Mining

7.3 Transportation

Conveyor
Vehicular (rail, truck)

7.4 Pretreatment

Crushing and Screening

7.5 Conversion

Retorting

Direct Pyrolysis
Indirect Pyrolysis

Upgrading

Hydrotreating
Gas Purification
Distillation

7.6 Transportation

Pipeline
Vehicular (truck, rail)

7.7 End Use

Refinery Syncrude
Direct Combustion
Advanced Power Cycle

8. IN SITU OIL SHALE

8.1 Exploration

Surveying
Drilling

8.2 Extraction (N/A)

8.3 Transportation (N/A)

8.4 Pretreatment

Drilling
Fracturing (nuclear and non-nuclear)

8.5 Conversion

Retorting (<u>in situ</u>)
Upgrading

Hydrotreating
Gas Purification
Distillation

8.6 Transportation

Pipeline
Vehicular (truck, rail)

8.7 End Use

Refinery Syncrude
Direct Combustion
Advanced Power Cycle

9. <u>IN SITU</u> COAL GASIFICATION

9.1 Exploration

Surveying
Drilling

9.2 Extraction (N/A)

9.3 Transportation (N/A)

9.4 Pretreatment

Drilling
Fracturing

9.5 Conversion (<u>in situ</u>)

Gasification (low-medium Btu Gas)
Purification

9.6 Transportation

Pipeline

9.7 End Use

Advanced Power Cycle
Industrial
Synthesis Gas

10. GEOTHERMAL ENERGY

10.1 Exploration

Drilling of probe holes
Exploratory drilling (discovery wells)
Drilling (evaluation wells)

10.2 Drilling of Production Wells

10.3 Steam and Electricity Production

Steam production

Dry steam fields
Wet or hot-water fields
Geopressured resources
Impermeable dry rock
Magna systems

Electricity Generation

11. NUCLEAR FUEL CYCLE

11.1 Mining

Underground
Open pit

11.2 Milling
Solvent extraction (U_3O_8)
Calcination (yellow cake)

11.3 Conversion

Hydrogenation to convert UO_3 to UO_2
Reacting UO_2 within hydrogen fluoride to produce UF_4
Addition of fluorine salt to convert UF_4 to UF_6

11.4 Enrichment

Electromagnetic separation
Gaseous diffision
Ultracentrifuges
Laser photochemistry

11.5 Fabrication

Chemical conversion (UF_6 to a ceramic)
Sintering of ceramic powder
Cladding

11.6 Electricity Produuction

Fuel burnup in reactor core
Steam production/power generation

11.7 Spent Fuel Storage and Decay

11.8 Reprocessing (optional)

Reclaim unused uranium

11.9 Waste Disposal

Solidification
- Fluidized, bed calcination
- Spray Solidification
- Pot calcination
- Phosphate glass solidification
- Borosilicate glass solidification

Disposal
- Ocean disposal
- Ice disposal
- Shallow burial in arid zones
- Salt beds
- Disposal in granite, shale or clay

11.10 Decontamination and Decommissioning

Hydrogenation to convert UO_3 to UO_2
Reacting UO_2 within hydrogen fluoride to produce UF_4
Addition of fluorine salt to convert UF_4 to UF_6

12. BIOMASS

12.1 Biomass Harvesting

Terrestrial Plant Matter
Marine Plant Matter
Animal Wastes

12.2 Drying

12.3 Shredding/Separation

12.4 Conversion

Thermochemical conversion

Pyrolysis
Producer gas generation

Hydrogenation
Hydrogasification

Bioconversion

Anaerobic digestion
Alcohol fermentation

Combustion

Direct Hydrogen Production

12.5 End Products

Synthetic natural gas
Synthetic liquid fuels
Hydrogen
Methanol
Ethanol

APPENDIX B

LIST OF CANDIDATE ISSUES GENERATED IN THE TECHNICAL ANALYSIS

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APPENDIX B

LIST OF CANDIDATE ISSUES GENERATED IN THE TECHNICAL ANALYSIS

1. Siting of LNG facilities
2. Water availability for slurry pipeline
3. Siting of coal-related facilities
4. Land required for solid waste disposal (coal)
5. Water required for coal conversion
6. Land required for disposal of spent shale
7. Water required for retorting, upgrading of shale oil and disposal of solid waste
8. Land required for the construction of slurry pipeline
9. Hydrocarbon emissions from oil transportation, conversion and end use
10. Sulfur plant tail gas emission from oil refineries, gas processing, coal liquefaction and gasification and oil shale
11. Particulate emission (fine particules) from burning coal, oil and shale oil
12. Asphalting precursor emission from oil conversion
13. Carbon dioxide greenhouse effect related to fossil fuel combustion
14. Nitrogen oxide emission from burning all kinds of fossil fuel
15. Carbon monoxide emission (mobile source)
16. Sulfur oxides emission from burning coal, shale oil, and oil
17. Radioactive gas emission caused by nuclear fracturing
18. Particulate emission/surface mining
19. PAH emission caused by all technologies burning coal
20. Trace elements emission resulting from coal combustion
21. Emission of radioactive material (mining and converting coal)
22. Air pollutant emission through fissures and cracks in <u>in situ</u> coal gasification and <u>in situ</u> shale retorting (CO, CO_2, H_2S, HCN, COS)
23. Surface and underground water contamination by oil/water formed in the oil pretreatment and conversion processes
24. Water/oil spill (tanker accidents)
25. Aquifer contamination by injected chemicals in secondary and tertiary recovery of oil and gas
26. Radioactive contamination of groundwater (nuclear fracturing)
27. Acid mine drainage (coal, surface, and underground)
28. Leaching of solid waste resulting from coal combustion (especially for MHD because of the high salt content)
29. Contamination of surface water by organic condensate
30. Contamination of aquifers by leaching of salt and trace metals in <u>in situ</u> gasification of coal, and <u>in situ</u> retorting of oil shale
31. Leaching of solid waste in surface retorting of shale

32. Land/oil spill in the process of exploration, extraction, and transportation of oil
33. Subsidence caused by extraction of oil and gas
34. Impact of pipelines (especially in Arctic)
35. Land disturbance and reclamation by surface mining of coal and shale
36. Subsidence caused by over-extraction of groundwater for slurry lines
37. Land impact caused by power lines and underground cables
38. Land disturbance and subsidence caused by _in situ_ coal gasification and _in situ_ shale retorting
39. Health and safety associated with catalysts in oil conversion
40. Health and safety relevant to hydrogen sulfide, mercaptans, and chemicals in gas conversion
41. LNG explosions
42. Health and safety associated with deep mining coal
43. High voltage impact of transmission line
44. Health and safety of workers in a MHD plant exposed to magnetic field, high pressure boiler, potassium salt, and toxin in slag
45. Radioactivity associated with nuclear fracturing of shale, coal (occupational hazard to workers)
46. Socioeconomic impact of land use for mining and energy extraction
47. Boomtowns associated with coal mining, coal conversion, shale retorting
48. High pressure/high temperature-imposed occupational hazards (coal gasification and liquefaction processes)
49. Occupational and public health problems from fugitive emissions in coal gasification and liquefaction processes (including refining of syncrude)
50. Health and safety problems associated with end use of coal liquids
51. Waste water generated in coal gasification and liquefaction
52. Impact of solid waste generated in coal gasification and liquefaction (radioactivity, trace elements, site selection)
53. POM emissions from coal gasification and liquefaction
54. OCS oil and gas drilling (impacts)
55. Groundwater aquifer and surface water contamination from surface mining of coal in West (other than acid mine drainage)
56. Onshore development related to offshore oil recovery, especially in sensitive coastal areas (pipelines, refineries, petrochemical plants, etc.)
57. Subsidence associated with advanced underground coal mining techniques (longwall and shortwall mining)
58. Brine disposal from recovery of natural gas from geopressure zones
59. Water discharges from dewatering coal slurry.
60. Hydrogen sulfide emissions from geothermal energy
61. Geothermal liquid effluent disposal

62. Nuclear waste disposal
63. Land disturbance from biomass production
64. Air and water effluents from biomass conversion
65. Nuclear fuel cycle.

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APPENDIX C

CLEAN AIR ACT EMISSION AND LOCATION REQUIREMENTS FOR FOSSIL FUEL TECHNOLOGIES

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APPENDIX C

CLEAN AIR ACT EMISSION AND LOCATION REQUIREMENTS FOR FOSSIL FUEL TECHNOLOGIES

1. Types of Clean Air Act Impacts

The recent CAA Amendments are essentially a reaffirmation of the original CAA of 1970; calling for accomplishment of air quality goals by legislated dates in the near future. In addition, the CAA Amendments explicitly add: PSD and visibility programs; interstate NAAQS enforcement (including long range management of hydrocarbon and nitrogen oxides plumes for oxidant control); the identification of specific pollutants for future regulations; and federal and state technology forcing leverage. A major first step in technology forcing is the requirement that NSPS require both emission limits and percentage reduction of pollutants. The impact of these CAA components upon technology will be felt in various ways, including the following:

(1) Emission control requirements
(2) Location requirements
(3) Site design requirements (e.g., capacity, stack height, fuel type)
(4) Site operation requirements
(5) Dollar/energy costs resulting from (1) through (4).

The processes via which these restrictions will be felt are complex, with some of their ultimate outcomes difficult to predict without special analysis--for example, separate processes such as PSD and NAAQS attainment are designed by the CAA so as to reinforce one another via the BACT required by the PSD sections of the CAA.

2. Possible Impact Mechanisms

The situation facing both existing and new or modifed sources is displayed in Table C-1. Briefly, the situation is as follows:

The CAA as amended in 1977 requires new emission controls on both new and existing sources; the specific requirements will depend upon the location (attainment versus nonattainment) areas and whether the source is existing or new.

(1) NSPS - Apply directly only to new or modified sources independent of location. NSPS is the minimum performance control technology permitted on new or modifed sources by the CAA, and is therefore a federally specified emission standard. A new form of NSPS is specified by the CAA: emission limits and percent reduction. This will have an important impact upon fuel use (e.g., low versus high sulfur coals), availability of flue gas desulfurization systems, and development of western low sulfur coal.

(2) RACT - Reasonably Available Control Technology is required of existing sources located in nonattainment areas. It is defined as that control required of existing sources to roll back ambient concentrations to the NAAQS by the new attainment date; December 31, 1982.* This can be a major new thrust of the CAA, and the magnitude of the requirement needs evaluation. RACT is defined in the State Implementation Plan (SIP) for the Air Quality Control Region (AQCR) in which the subject existing source is located. It is therefore locally specified.

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*Postponable to December 31, 1987 for oxidants (O_x) and carbon monoxide (CO).

(3) LAER - Lowest Achievable Emission Rate is required of new or modified sources in nonattainment areas. It is defined as the lowest nationally achievable rate, either in an SIP or in practice, whichever is most stringent. Therefore, although LAER is defined by the SIP of a particular state, its stringency is driven by national performance, and in particular the performance required in stricter states (e.g., western states). LAER must be a least as stringent as the NSPS.

(4) BACT - Best Available Control Technology is required of new or modified sources located in all attainment (PSD) areas for all pollutants regulated by the CAA, and is defined as the best available subject to economic, energy and environmental considerations. It is selected on a case-by-case basis by the states, but must at least be as strict as the NSPS. BACT can be expected to be very strict relative to NSPS in some states, and state competition can also be expected to force all state BACT specifications downward (tighter). Of great importance is the influence of BACT upon LAER: by definition BACT is one of the technologies which must be equalled or improved upon by the LAER. Therefore, the lowest BACT selected by any state will drive LAER throughout the country, and the PSD and NAAQS attainment program are thus closely interrelated via BACT: the cleaner the attainment air is maintained, the stricter LAER becomes. It is important to evaluate both the feasibility (economic and otherwise), rate of convergence and final level of this coupled action.

We will return to the coupling below.

(5) BART - Best Available Retrofit Technology is demanded of existing sources less than fifteen years old. BART is to be designed to protect or recover the visibility conditions of the federally mandated Class I PSD areas,* and applies no matter where the source is located. BART is

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specified by the states, except that EPA promulgates BART requirements for fossil fuel generating plants with capacity greater than 750 megawatts.

(6) OFFSET - Emission OFFSET are required whenever a new or modified source goes online in a nonattainment areas so that total emissions are reduced in the areas in a fashion which will make reasonable progress towards the NAAQS attainment. Clearly such OFFSET must derive from other than a new source--i.e, existing sources must be reduced below the level required by the SIP at the time of new source operation. Whether or not such OFFSET are available at a given calendar date in a given AQCR will depend both upon the rate of growth there, and upon the concentation reductions needed to attain the NAAQS. This can be evaluated for future years and it is important to do so. The magnitude of emission OFFSET required for permitting a new or modified source of given emission characteristics will depend upon the local AQCR approach: What part of the emission decrements required to achieve NAAQS are derived via RACT (old sources), LAER (new sources) or emission OFFSET (new sources)? If RACT and LAER are relatively stringent, then emission OFFSET may be essentially one-to-one. If RACT and LAER are relatively less stringent, then emission OFFSET may be greater than one-to-one. Depending upon relative costs of RACT, LAER and OFFSET, there will be a preferred balance between the stringency of these three requirements which can and should be evaluated. The coupling between BACT and LAER discussed above will bias this balance and should be evaluated.

*International parks and national wilderness areas which exceed 5,000 acres in size, national memorial parks which exceed 5,000 acres in size, and national parks which exceed 6,000 acres in size (all of which are in existence on the date of enactment of CAA Amendments) and all areas which were redesignated as Class I under regulations promulgated before such date of enactment.

(7) Distant Nonattainment Area - No matter where they are located, new and existing sources must not be permitted to interfere with the attainment or reattainment of NAAQS in distant AQCRs. New sources must improve emission controls, change location or reduce capacity, and existing sources also must improve their emissions control or reduce capacity if they threaten NAAQS in other states. No matter which of the preceding emission requirements have been met, additional emission reductions to prevent such a distant impact are required.

EPA is placing increasing emphasis on such inter-AQCR impacts. Their control will require management, for example, of hydrocarbons and nitrogen oxides plume interactions, a very complex regulatory/ pollutant control problem. The actual magnitude of such long range impacts needs assessing, as does the portion of NAAQS attainments costs which would be borne by distant sources outside the local AQCR. If this portion is large, then these inter-AQCR, interstate pollution abatement programs will stimulate significant interaction between AQCRs and between states, since each will be seeking least (local) cost SIPs at the expense of the other.

(8) Local PSD Area - New sources located PSD areas must meet the incremental concentration and visibility protection requirements of the class area in which they reside. If not, they must apply control technology better than BACT or reduce capacity. The remaining increment available for a new source will depend upon the local allocation philosophy (e.g., retain some for future or different source categories) and upon the amount of previous growth subsequent to the baseline year. This will have an important impact upon new sources and should be evaluated.

(9) Distant PSD Area - New sources located anywhere must not cause an exceedance of the PSD increment, or an unacceptable degradation of visibility, in a distant PSD area. If they do so under specified BACT or LAER, then that control technology must be improved upon, the new source must be moved, or its capacity reduced.

These latter two permitting requirements will tend to drive BACT downward. As discussed above, BACT in turn drives the emission standards for new sources in nonattainment areas (LAER). This dependence is depicted in Figure C-1, and is important to evaluate. Although a random process, it should be possible to forecast is likely impact on emission requirements in PSD and nonattainment areas.

(10) NESHAPS - National Emission Standards for Hazardous Air Pollutants are required of all new or modified sources located anywhere. In attainment (PSD) areas BACT must be applied for all the hazardous air pollutants. This may drive emission requirements for hazardous emissions below NESHAPS levels.*

*Local and distant PSD and distant NAAQS attainment requirements.

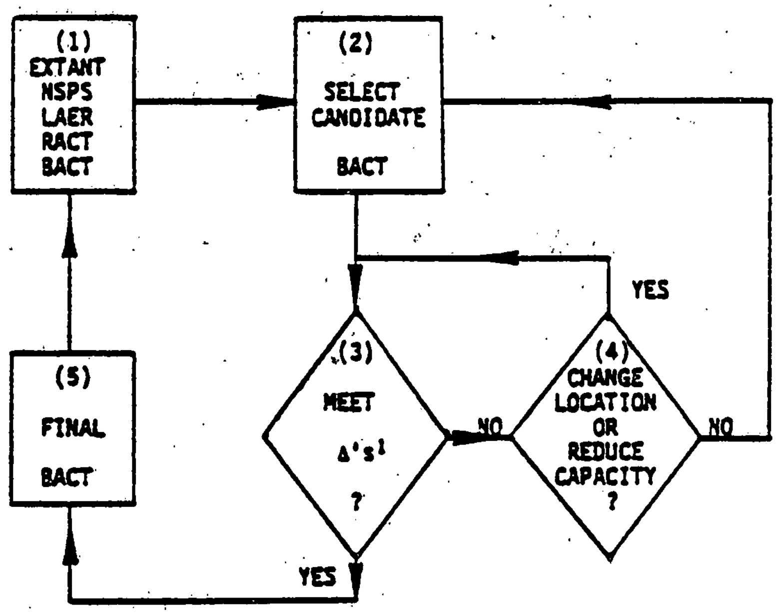

FIGURE C-1 BACT DECISION LOOP

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APPENDIX D

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