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Possible Future Environmental Issues for Fossil Fuel Technologies

Final Report

Published - July 1979

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Prepared For:
U.S. Department of Energy
Assistant Secretary for Energy Technology
Division of Planning and Systems Engineering

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Final Report

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FOREWORD

As the United States moves towards the goal of reducing dependence on imported petroleum, new energy sources and new energy technologies will assume an increasingly important role in our energy future. The Office of Fossil Energy Programs, U.S. Department of Energy, is responsible for the development of technologies that will provide new sources of liquid and gaseous fuels and technologies that will increase the efficiency of direct coal combustion.

The purpose of this study was to identify environmental issues that may affect the implementation of the technologies being developed. Attention is focused on possible future regulatory actions, including both strengthening and relaxing current standards, the probabilities of their occurrence and their impacts. The effect of future actions associated with existing legislation or regulations was explicitly excluded from the purview of the report since these issues have been dealt with elsewhere.

Both the level of environmental impacts attributable to new technologies and the degree of environmental acceptability these technologies will receive in the future are highly uncertain, and the conclusions of this study should be judged accordingly. It should also be noted that this is one of the first studies to be conducted addressing the issues in question. We believe a considerable amount of information is presented, and hope that it will be of interest.

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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.

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GLOSSARY OF ABBREVIATIONS

AQCR	-	Air quality control region
BAT	-	Best available technology
RACT	-	Best available control technology
BART	-	Best available retrofit technology
BATEA	-	Best available technology economically achievable
BPCT	-	Best practicable control technology
CAA	-	Clean Air Act
CWP	-	Coal workers pnueumoconeosis
FIR	-	Environmental impact report
EIS	-	Environmental impact statement
EPA	-	Environmental Protection Agency
FBC	-	Fluidized bed combustion
FWPCA	-	Federal Water Pollution Control Act
ICRP	-	International Commission on Radiological Protection
LAER	-	Lowest achievable emission rate
LNG	-	Liquefied natural gas
MHD	-	Magnetohydrodynamics
NAAQS	-	National ambient air quality standard
NEPA	-	National Environmental Policy Act
NESHAPs	-	National emission standards for hazardous air pollutants
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
TSCA	-	Toxic Substances Control Act
TSD	-	Treatment, storage and disposal
TSP	-	Total suspended particulates
TWA	-	Time-weighted average

EXECUTIVE SUMMARY

Introduction

The work reported here was carried out for the Department of Energy's Office of Fossil Energy to identify and assess 15 to 20 major environmental issues that are likely to affect the implementation of fossil energy technologies between 1985 and 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; and true and modified in situ oil shale retorting. Environmental analysis of these technologies included, in addition to the main processing steps, the complete fuel cycle from resource extraction to end use.

A comprehensive survey of the environmental community, including environmental groups, researchers, and regulatory agencies, was carried out in parallel with an analysis of the technologies to identify important future environmental issues. Each of the final 16 issues selected by the project staff has the following common attributes: consensus of the environmental community that the issue is important; it is a likely candidate for future regulatory action; it deals with a major environmental aspect of fossil energy development.

The analyses of the 16 major issues address their environmental problem areas, current regulatory status, and the impact of future regulations. These analyses are followed by estimations of the time frame in which regulatory actions might occur and the likelihood of their occurrence. Finally, a more general discussion of the impact of environmental regulatory action on fossil energy development is presented.

Method of Approach

The general approach to identifying candidate issues for future environmental regulatory action was divided into three 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, federal agency, and federal and state regulator attitudes and goals. The second component provided a review of legislative and regulatory status at the federal and state levels. The third component generated candidate issues via a detailed environmental examination of the technologies independent of any environmental policy and regulatory bias. Finally, a panel system was used to screen the issues so that they could be ranked according to the seriousness of their environmental impacts.

Major environmental issues associated with the implementation of fossil fuel technologies were selected from the candidate issues by an expert-based panel. These issues were examined to determine the adequacy of existing regulations. Possible future regulatory actions were described based on the nature and degree of adequacy of current regulations, and on the technical feasibility of implementing such actions. Potential effects of these future regulatory actions on the implementation of fossil fuel technologies were reviewed. The environmental issues for which major regulatory actions are likely are listed in Table 1.

Results

The 16 environmental issues listed in Table 1 are identified as those most likely for future regulatory actions that may significantly impact the implementation of fossil fuel technologies. The main features of, and the possible regulatory actions associated with, each of the 16 issues are as follows:

TABLE 1. MAJOR ENVIRONMENTAL ISSUES

1. Disposal of solid waste from coal conversion and combustion technologies.
2. Water consumption 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), safety and environmental factors.
10. Underground coal mining - health and safety.
11. Fugitive emissions from coal gasification and liquefaction - health and safety.
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.

1. Disposal of Solid Waste from Coal Conversion and Combustion

Technologies. The conversion 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 techniques to reduce leachability of toxic substances in solid waste.

2. Water Consumption by 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 will probably 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 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. It is within this process that increased public scrutiny and local and state regulations and policy attitudes are developed. 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. A number of current federal regulations affect siting indirectly by effectively prohibiting certain 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 release of carbon dioxide (CO_2) to the atmosphere. 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. Possible actions include: the requirement of more efficient use of fossil fuels; the requirement to re-establish forests in order to balance CO_2 "sinks" and "sources" to previous levels; the simple limitation of coal combustion/conversion as a source of energy; international agreements on long range energy policy and goals; increased emphasis on alternatives to fossil fuels in the

National Environmental Policy Act (NEPA) process, and global controls or "levies" on fossil fuel use to offset predicted long term climatic impacts.

5. Emission of Polycyclic Organic Matter (POM). POM primarily resulting from combustion, coal hydrogenation, petroleum catalytic cracking and the transportation and processing of petroleum will continue to be among the most important of possible occupational and environmental impacts attributed to fossil fuel technologies. The difficulty in quantifying the various constituents of POM qualify it as a candidate for further research and regulatory development. Future regulatory action may include: imposing national emission standards for hazardous air pollutants (NESHAPS), new source performance standards (NSPS), national ambient air quality standards (NAAQS), and PSD, to protect the air, water, land, and human health; 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. Five issues have been identified concerning OCS development: acquisition of an OCS lease, water/oil contamination, air pollution (NO_x , SO_x and hydrocarbons), aesthetics, and the socioeconomic issues related to the need for onshore facilities. The major issue however, is identified as the acquisition of an OCS lease. In order to obtain this lease it will be necessary to provide preventive measures to manage the remaining four issues. 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 all fossil fuels and are found in all solid, liquid, and gaseous effluent streams, as well as in the products in some cases. The increasing use of coal will magnify the problem. Long term low level exposure of man and his surroundings to these trace elements will have uncertain health effects. Possible future actions include: imposing emission and ambient air standards (NESHAPS, NAAQS, NSPS, and PSD) for certain trace elements; promulgating receiving-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 organics and inorganics. These toxics and 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), Safety and Environmental Factors. An increase in the importation of LNG will result in extensive controversy

regarding the safety and 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 - Health and Safety. 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 pneumoconiosis (CWP) or black lung. 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 - Health and Safety. 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 involving 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). 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 projects locate. Rapid growth resulting from these projects 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 these states to enact legislation imposing siting or other restrictions on energy projects. Programs aimed at improving quality of life aspects of boomtowns may also be developed under pressure from unions and environmentalists. State laws and local ordinances may be established to maintain stable growth. Guidelines on revenue sharing and subsidies will 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 and may cause both health and 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 Mining and Conversion of Coal.

Radioactivity in coal stems primarily from the natural decay series of radionuclides ^{238}U and ^{232}Th . Concentrations of these radionuclides vary widely from the national average of 1.8 ppm uranium and 4.7 ppm thorium. Biological exposures to ionizing radioactivity induce carcinogenic and mutagenic responses. Major potential regulatory candidates involve the emissions of ^{222}Rn (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), on solid wastes (RCRA), on 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 locations 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 the maintenance of original topography and high quality of water supply, and the preservation of local ecology and agricultural productivity. Possible future regulations may include: requirements for more complete recovery of coal; more stringent requirements for restoration; requirements to have special placement of overburden; and effluent standards for drainage.

Probabilities

The method employed to arrive at probabilities and time frames of occurrence was simple and straightforward. First, the legislative and regulatory background associated with each issue was examined to determine the time scale over which the issue has been addressed in the past. Also, existing legislation was examined to determine whether there were any built-in timetables for future action.

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, comprehensive of regulation, 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 a high probability of regulation 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 not have a significant probability of being regulated before 1990, or perhaps later.

Cumulative probabilities were assigned for regulatory activity taking place with respect to each issue as a function of time--the three years 1985, 1990,

and 2000 were chosen to represent the near, medium, and long-term. The probabilities are expressed semi-quantitatively as low, medium, or high. Occasionally, it appeared so likely that a particular regulatory action would take place that the probability was assessed as nearly certain.

The probabilities of future regulatory action estimated using the procedure described above are summarized in Table 2 for each of the 16 major environmental issues. Chapter 4 should be consulted for the specific type of regulatory actions contemplated for these issues.

Discussion

The detailed environmental review of the key fossil energy technologies contemplated for development and application between now and the year 2000 identified specific technology targets and critical candidates for future regulatory action. The resulting major issues that were summarized in the previous section display several aspects that are of interest.

First, these issues span all technologies and modules--that is, they represent a broad approach to the future fossil 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 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 specific issues represent departures from the classical environmental issues which have received the most attention from public and regulatory bodies in the past, for example, the CO₂ greenhouse effect, fine particulates as opposed to total suspended particulates, groundwater as opposed to surface water, water allocation as well as quality, effective

TABLE 2. PROBABILITIES OF FUTURE REGULATORY ACTION
FOR 16 MAJOR ENVIRONMENTAL ISSUES

ISSUE	Probabilities		
	1985	1990	2000
1. Coal Conversion Solid Wastes	Medium	High	Certain
2. Coal and Oil Shale Water Consumption	High	Certain	--
3. Facility Siting	High	Certain	--
4. CO ₂ Greenhouse Effect	Low	Low	Medium
5. POM Emission	High	Certain	--
6. OCS Development	Low	Low	Medium
7. Trace Element Emissions	Medium	High	--
8. Groundwater Contamination	Medium	High	--
9. LNG Safety and Environmental Factors	High	--	--
10. Underground Coal Mining Health and Safety	Low	Medium	--
11. Coal Conversion Fugitive Emissions - Health & Safety	High	--	--
12. Boomtown Effects	High	--	--
13. Fine Particulate Emissions	Low	Medium	High
14. Coal Conversion Radioactivity Emissions	Medium	High	Certain
15. NO _x Emissions	Medium	High	--
16. Surface Mining Land Disturbances	Low	Medium	High

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 multimedia 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 facilities 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 CO₂ issue and proposals for its resolution all depend on work in progress. The same applies to toxics, trace metals, NO_x and groundwater quality issues.

Possible forms of regulatory action have been discussed for each of the 16 major issues. The specific regulatory forms and levels 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 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 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 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 CO₂ 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 CO₂ 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 insure 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 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 the impact of extant laws and regulations, that the impact of possible future environmental regulations upon the fossil fuel technologies should be evaluated.

1. INTRODUCTION

The work reported here was carried out for the Department of Energy's Office of Fossil Energy to identify and assess 15 to 20 major environmental issues that are likely to affect the implementation of fossil energy technologies between 1985 and 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; and true and modified in situ oil shale retorting. 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, it was considered 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 16 by the Flow Resources Corporation (FRC) project staff, using a panel system. This system also solicited a wide range of view points, with panel members' expertise ranging from environmental law to engineering.

The final list of 16 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 fossil energy development.

The following chapters contain: descriptions of the methods used for identifying candidate issues and selecting the final list of 16 issues; analyses of the major issues, including their regulatory status and the implications of future regulations; estimations of the time frame for future regulatory actions and the likelihood of their occurrence; and finally a discussion of the impacts of environmental regulatory activities on the implementation of fossil 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.

This document is designed to assist DOE personnel who are planning the research, development, demonstration and commercialization of fossil 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 candidate 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 regulatory status at the federal level. The third component generated candidate issues via a detailed environmental examination of the 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

2.1.1 Procedure

2.1.1.1 Citizen Groups and Federal Agencies

Leading environmental and citizen groups were contacted regarding potential interaction between their future environmental objectives and fossil energy technology research and development (R&D) and implementation. Groups contacted included the Environmental Policy Center, Friends of the Earth, Isaac 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.

2.1.1.2 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 fossil energy technology R&D and its application. The states were first categorized into three levels of priority. The highest level included states where environmental action is likely to have a significant impact on fossil 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 fossil fuel resources; (2) the likelihood that the resources will be exploited and developed; and (3) the magnitude of the state's existing fossil fuel industry. Alaska, for example, was assigned to the highest priority level because it has large fossil fuel 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 coal combustion and conversion facilities. Several representative consumer states were contacted regarding their anticipated environmental regulations for fossil energy facilities. These states are listed in Table 2-1.

2.1.2 Results

2.1.2.1 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

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

Arizona¹
Illinois
Indiana
Kentucky
Louisiana
New Jersey
New Mexico¹
North Carolina
Ohio
Tennessee
Virginia

Consumer States

Florida
Massachusetts
Minnesota
New York
Washington

¹Includes Navajo Lands.

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 decay products of 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 NO₂ 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.

2.1.2.2 States

Producer states such as Alaska, North Dakota, and other relatively unexploited rural states with large energy reserves are beginning to take a more cautious, conservative approach to energy resource development. They do not want to see

their energy resources haphazardly exploited. On the other hand, states that have had a longer history of energy development, such as Texas and Louisiana, have a "full-speed-ahead" attitude toward energy development. The latter states are primarily interested in economic development, with environmental factors being a secondary concern. These states are reacting to federal standards rather than taking the initiative themselves.

Western states are generally more conservation oriented and, as a whole, have more comprehensive resource management programs, especially regarding water. Laws such as the Endangered Species Act, Wild and Scenic Rivers Act, and area classification and best available control technology (BACT) regulations of the CAA Amendments will, in some cases, affect energy development.

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 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 facilities 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 facilities 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 moratorium 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.

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 rain 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 Energy Office, in a 1978 act, was granted authority to coordinate all energy projects. Hence, the Energy 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 Fossil Energy Development

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

2.2.1 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 of fossil energy development.

2.2.1.1 National Environmental Policy Act (NEPA)

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.

2.2.1.2 Clean Air Act (CAA) of 1970 and Subsequent 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.

2.2.1.3 Federal Water Pollution Control Act (FWPCA) of 1972

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.

2.2.1.4 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.

2.2.1.5 Safe Drinking Water Act (SDWA)

The SDWA was enacted primarily to protect public health. The act provides for the promulgation of national primary and secondary 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.

2.2.1.6 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.

2.2.2 Acts Dealing With Water Use and Water Pollution

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

The Marine Protection, Research, and Sanctuaries Act 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 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 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.

2.2.2.2 Acts Governing Construction and Operations Affecting Water

The Ports and Waterways Safety Act of 1972 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 which will affect shipping of fossil energy resources 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 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.

2.2.2.3 Miscellaneous Acts Affecting Water

The Federal Non-Nuclear Energy Research and Development Act provides for the development and commercialization 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 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.

2.2.3 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.

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

The Fish and Wildlife Coordination Act, the Endangered Species Act and the Migratory Bird Conservation Act 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, The Estuaries Protection Act, the Wilderness Act and the National Historic Preservation Act 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.

2.2.5 Acts Dealing With Safety and Health (Other Than OSHA)

The Federal Coal Mine Health and Safety Act 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 extremely 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.

2.2.6 Other Acts That May Affect Energy Development

The objective of the Toxic Substances Control Act (TSCA) 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. This act 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 are acts that help coordinate energy technology R&D and its application. The acts provide for the development of efficient, reliable energy sources, keeping in mind any adverse environmental effects that those sources might have. The impact these acts may have 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.

2.3 Technical Analysis

2.3.1 Issue Identification

The objective of the technical analysis was to recognize significant possible environmental impacts resulting from future energy development. This process was initiated by reviewing the 10 major fossil fuel technologies which may contribute significantly to fossil fuel energy development beyond 1985. Each of the 10 technologies was divided into 7 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 10 technologies considered in this process were:

1. Oil recovery and processing
2. Gas recovery and processing
3. Coal liquefaction
4. Coal surface gasification
5. Direct coal combustion
6. Advanced power systems
7. Magnetohydrodynamics
8. Surface oil shale retorting
9. True and modified in situ oil shale conversion
10. In situ coal gasification

The 7 modules of each technology and the submodules of one technology (oil) are shown in Figure 2-1. The complete list of all the submodules of the 10 technologies is included as Appendix A.

2.3.2 Ranking of Issues

All issues identified 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 system was based primarily on

Modules

Submodules

1. Surveying
2. Drilling

1. Pumping
2. Water-flooding
3. Enhanced recovery
 - thermal
 - chemical

1. Terminals
2. Tanker
3. Pipeline

1. Topping operation

1. Refining
 - Fuel Production
 - Petrochemical Feedstock

1. Barge
2. Pipeline
3. Rail
4. Truck

1. Transportation
2. Electricity
3. Industrial

Figure 2-1 MODULES AND SUBMODULES OF OIL RECOVERY AND PROCESSING

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
- General environmental

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 2-2. 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 a low priority number were eliminated from the candidate list.

TABLE 2-2. SCALES OF FACTORS USED IN PRIORITY ESTIMATION

CAUSE	DIMENSION	OBJECT
<p><u>Overall Magnitude of Impact</u></p> <p>Very Large</p> <p>Large</p> <p>Medium</p> <p>Small</p> <p>Very Small</p> <p><u>Control</u></p> <p>No Control Alternative Available</p> <p>Very Costly and Technically Uncertain</p> <p>Costly and Difficult to Control</p> <p>Can Be Controlled with a Reasonable Cost</p> <p>Very Easy to Avoid</p>	<p><u>Time Interval</u></p> <p>Irreversible</p> <p>Very Long Term (~10 years)</p> <p>Long Term (~1 year)</p> <p>Short Term (~1 day)</p> <p>Very Short Term</p> <p><u>Space</u></p> <p>Global</p> <p>Large Regional (e.g. NE U.S.)</p> <p>Regional (radius ~50 miles)</p> <p>Local (radius ~5 miles)</p> <p>Very Local</p>	<p><u>Nature of Receptor</u></p> <p>Human Health and Safety-Major</p> <p>Human Health and Safety-Minor</p> <p>Public Welfare-Major</p> <p>Public Welfare-Minor</p> <p>Aesthetic</p> <p><u>Extent of Receptor</u></p> <p>Very Large</p> <p>Large</p> <p>Medium</p> <p>Small</p> <p>Very Small</p>

2.3.3 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.

This process of issue identification, issue ranking, and generic issue identification was used to generate a list of 59 future regulatory candidates. This list is shown in Appendix B.

2.4 Discussion

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

In Table 2-3 are displayed the 59 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 7 of the technical issues (13, 14, 20, 24, 41, 47, and 54) coincide with 7 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

TABLE 2-3 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. Asphalt precursor emission from oil conversion
13. CO₂ 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, CO₂, H₂S, 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 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 powerline and underground cable
38. Land disturbance and subsidence caused by in situ coal gasification and in-site shale retorting
39. Health and safety associated with catalysts in oil conversion
40. Health and safety relevant to H₂S 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.

REGULATORY AND POLICY ISSUES

	Greenhouse Effect	Fuel Pipeline	Coal Liquid Conversions	Land Use	Water Use	Water Quality	Offshore Developments	Trace Metals	Visibility	Nitrogen Oxides	Ground Water Quality	Solid Waste Disposal	PSD Regulations	End Use Efficiency	Boomtown Effects	Protection of Wildlife	Accidents	LNG Activities
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□ SAME ISSUE ● DIRECT RELATIONSHIP
○ INDIRECT RELATIONSHIP BLANK=NO RELATIONSHIP

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.

2.4.2 Relationships of Technical Issues to Fossil Fuel Technologies

Table 2-4 displays jointly the technically derived generic issues (rows) versus the 10 major 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 (3,4,13,14,19,21,35,42,47 and 55).

Conversely, a technology which is directly related to many of the critical issues can be expected to be more critical technology. Coal gasification and liquefaction have this distinction, in that order.

T E C H N O L O G Y

TABLE 2-4 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 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. Asphalt precursor emission from oil conversion
13. CO₂ 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, CO₂, H₂S, 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 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 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 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 H₂S 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.

	Oil	Gas	Liquefaction	Gasification	Combustion	Advanced Systems	MHD	In Situ Gas	Retort	In Situ	Shale
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● — Direct Relationship
 ○ — Indirect Relationship
 Blank — No Relationship

3. SELECTION OF MAJOR ISSUES

3.1 Method of Approach

Candidate environmental issues associated with the implementation of fossil fuel 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 list of 15 to 20 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 59 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 extant regulations adequate to accomplish the goals identified in the policy/regulatory survey. From this standpoint, all but 1 of the 59 issues were candidates for future regulatory action.

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

FIGURE 3-1, METHOD OF APPROACH FOR SELECTING
MAJOR ENVIRONMENTAL ISSUES

TABLE 3-1 PANEL EVALUATION OF CANDIDATE ISSUES

TECHNICAL ISSUES	Technology	(1)	(2)	(3)
		Adequacy of Regulations ¹	Technical Feasibility of Reducing the Level of Impact ²	Potential Impact of Regulation on Technology ³
1. Siting of LNG facilities	1 Gas	●	○	●
2. Water availability for slurry line	2 Coal	●	○	●
3. Siting of coal-related facilities	3 Coal	●	○	●
4. Land required for solid waste disposal (coal)	4 Coal	●	○	●
5. Water required for coal conversion	5 Coal	●	○	●
6. Land required for disposal of spent shale	6 Shale	●	○	●
7. Water required for retorting, upgrading of shale oil and disposal of solid waste	7 Shale	●	○	●
8. Land required for the construction of slurry pipeline	8 Coal	●	○	●
9. Hydrocarbon emission from oil transportation, conversions and end use	9 Oil	○	○	○
10. Sulfur plant tail gas emission from oil refineries, gas processing, coal liquefaction and gasification and oil shale	10 All	○	○	○
11. Particulate emission (fine particles) from burning coal, oil and shale oil	11 All	○	○	○
12. Asphalt precursor emission from oil conversion	12 Oil	○	○	○
13. CO ₂ greenhouse effect related to fossil fuel combustion	13 All	○	○	○
14. NO _x emission from burning all kinds of fossil fuel	14 All	○	○	○
15. CO emission (mobile source)	15 Oil	○	○	○
16. SO _x emission from burning coal, shale oil, and oil	16 All	○	○	○
17. Radioactive gas emission caused by nuclear fracturing	17 All	○	○	○
18. Particulate emission/surface mining	18 Coal	○	○	○
19. PAH emission caused by all technologies burning coal	19 Coal	○	○	○
20. Trace elements emission resulting from coal combustion	20 Coal	○	○	○
21. Emission of radioactive material (mining and converting coal)	21 Coal	○	○	○
22. Air pollutant emission through fissures and cracks in in situ coal gasification and in situ shale retorting (CO, CO ₂ , H ₂ S, HCN, COS)	22 Coal & Shale	○	○	○
23. Surface and underground water contamination by oil water formed in the oil pretreatment and conversion processes	23 Oil	○	○	○
24. Water/oil spill (tanker accidents)	24 Oil	○	○	○
25. Aquifer contamination by injected chemicals in secondary and tertiary recovery of oil and gas	25 Oil & Gas	○	○	○
26. Radioactive contamination of groundwater (nuclear fracturing)	26 Oil & Gas	○	○	○
27. Acid mine drainage (coal, surface and underground)	27 Coal	○	○	○
28. Leaching of solid waste resulting from coal combustion (especially for MHD because of the high salt content)	28 Coal	○	○	○
29. Contamination of surface water by organic condensate	29 Coal	○	○	○
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	30 Coal	○	○	○
31. Leaching of solid waste in surface retorting of shale	31 Shale	○	○	○
32. Land/oil spill in the process of exploration, extraction and transportation of oil	32 Oil	○	○	○
33. Subsidence caused by extraction of oil and gas	33 Oil & Gas	○	○	○
34. Impact of pipeline (especially in Arctic)	34 Oil & Gas	○	○	○
35. Land disturbance and reclamation by surface mining of coal and shale	35 Oil & Shale	○	○	○
36. Subsidence caused by over extraction of groundwater for slurry lines	36 Coal	○	○	○
37. Land impact caused by powerline and underground cable	37 All	○	○	○
38. Land disturbance and subsidence caused by in situ coal gasification and in situ shale retorting	38 Coal & Shale	○	○	○
39. Health and safety associated with catalysts in oil conversion	39 Oil	○	○	○
40. Health and safety relevant to H ₂ S mercaptan and chemicals in gas conversion	40 Gas	○	○	○
41. LNG explosion	41 Gas	○	○	○
42. Health and safety associated with deep mining of coal	42 Coal	○	○	○
43. High voltage impact of transmission line	43 All	○	○	○
44. Health and safety of workers in a MHD plant exposed to magnetic field, high pressure boiler, potassium salt, and toxin in slag	44 Coal	○	○	○
45. Radioactivity associated with nuclear fracturing of shale, coal (occupational hazard to workers)	45 Coal & Shale	○	○	○
46. Socioeconomic impact of land use for mining and energy extraction	46 All	○	○	○
47. Boomtown associated with coal mining, in situ coal gasification, shale retorting	47 All	○	○	○
48. High pressure/high temperature-imposed occupational hazards (coal gasification and liquefaction processes)	48 Coal	○	○	○
49. Fugitive emission in coal gasification and liquefaction processes impose occupational and public health problems (including refinery of liquefied syncrude)	49 Coal	○	○	○
50. Health and safety problems associated with end use of coal liquids	50 Coal	○	○	○
51. Waste water generated in coal gasification and liquefaction	51 Coal	○	○	○
52. Impact of solid waste generated in coal gasification and liquefaction (radioactivity, trace elements, site selection)	52 Coal	○	○	○
53. Polycyclic organic matter emission from coal gasification and liquefaction	53 Coal	○	○	○
54. OCS oil and gas drilling, leasing and impacts	54 Oil & Gas	○	○	○
55. Groundwater aquifer and surface water contamination from surface mining of coal in West (other than acid mine drainage)	55 Coal	○	○	○
56. Onshore development related to offshore oil recovery, especially in sensitive coastal areas (pipeline, refineries, petrochemical plants, etc.)	56 Oil	○	○	○
57. Subsidence associated with advanced underground coal mining techniques (longwall and shortwall mining)	57 Coal	○	○	○
58. Brine disposal from recovery of natural gas from geopressure zones	58 Gas	○	○	○
59. Water discharge from dewatering coal slurry.	59 Coal	○	○	○

¹ Regulations ² Technical Feasibility ³ Technical Impacts

● Inadequate ● Next to impossible ● Large

○ Incomplete ● Difficult ● Medium

○ Adequate ○ Feasible ○ Minor

- (6) Land required for disposal of spent shale
- (13) CO₂ 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 four in number (10,16,37 and 43).

The result of the panel's consideration of these criteria for the 59 technical issues is displayed in Table 3-2, where 16 issues are identified as those likely to have the greatest significance for fossil energy development.

3.2.1 Interrelationships of Major Issues

Many of the 16 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 coal conversion and combustion technologies.
2. Water consumption 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), safety and environmental factors.
10. Underground coal mining - health and safety.
11. Fugitive emissions from coal gasification and liquefaction - health and safety.
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.

1. Disposal of solid waste from coal conversion and combustion technologies

1. Water co. shale conve
2. Siting of coal con
3. The CO₂ greenhouse effect
4. Polycyclic organic matter (POM)
5. Outer continental shelf (OCS)
6. Trace element
7. Groundwater contamination
8. Liquefied Natural Gas, safety, and environmental factors
9. Underground coal mining - health and safety
10. Fugitive emissions from coal gasification and liquefaction health and safety
11. Boomtown effect
12. Fine particulate emissions from coal, oil and shale technologies
13. Radioactivity emissions from the mining and conversion of coal
14. NO_x emissions
15. Land disturbance from surface mining
- 16.

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3.2.2 Legislative Status of Major Issues

In Table 3-4 are displayed the final 16 major environmental issues (rows), along with the 29 environmentally related laws which potentially could enable regulations for their control. Thirteen of the 16 issues have significant coverage from at least one law (1,2,3,5,6,7,8,10,11,13,14,15 and 16).

Nevertheless, many of 13 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 13 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 CO₂ 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.

TABLE 3-4 EXISTING REGULATIONS ASSOCIATED WITH THE MAJOR ISSUES

- Significant Coverage
- ◐ Moderate Coverage
- Negligible Coverage

Blank - No Coverage

		6 Major Acts			Water Use Acts			HQ Acts			Land Use Acts			H & S			Miscellaneous														
		National Environmental Policy Act (NEPA)	Clean Air Act (CAA)	Resource Conser. & Recovery Act	Fed. Water Poll. Cont. Act	Safe Drinking Water Act	Occupational Safety and Health Act (OSHA)	Marine Prot. Teas & Sanct. Act	Fed. Nonnuclear Energy R&D Act	Rivers & Harbors Act	Water Resources Planning Act	Fish & Wildlife Coordination Act	Wild & Scenic Rivers Act	Estuaries Protection Act	Ports & Waterways Safety Act	Deepwater Port Act	Outer Continental Shelf (OCS) Act	Wilderness Act	Fed. Land Policy & Manag. Act	Surface Mining Cont. & Recla. 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 Enviro. Pesticide Cont. Act	Noise Control Act	Supply & Enviro. Coord. Act	
1.	Disposal of solid waste from coal conversion and combustion technologies	◐		●	◐	◐		○				○	○	○				○	●	○	○	○	○	○							
2.	Water consumption by coal and oil shale conversion technologies	◐			◐	○			◐		●	○	◐	○				○			○	○	○	○							
3.	Siting of coal conversion facilities	◐	●	●	◐	◐		○	○		○	◐	◐	◐				◐	◐		◐	◐	○	◐					○		
4.	The CO ₂ - greenhouse effect	◐	◐																												
5.	Polycyclic organic matter (POM)	◐	●	●	●	●	●	○	○		○	○		○													●			○	
6.	Outer continental shelf (OCS) oil development	◐		○	◐		○	◐						○	○	○	●		○		●	○				○					
7.	Trace element	◐	●	●	●	●	●	○						○							○		○			○		●			○
8.	Groundwater contamination	◐		○	●	●		○	○		○	○	○	○				○		◐	○	○									
9.	Liquefied natural gas (LNG), safety and environmental factors	◐	○		○		◐	○		○				○	○	○		○				○	○	○	○		○				
10.	Underground coal mining - health and safety	○					●																		●						
11.	Fugitive emissions from coal gasification and liquefaction - health and safety	◐	●				●																							○	
12.	Boomtown effects	◐	○		○																										
13.	Fine particulate emissions from coal, oil and oil shale technologies	◐	●				●															○			●					○	
14.	Radioactivity emissions from the mining and conversion of coal	◐	◐	●	◐	●	◐	○	○			○	○	○						○					●		○			○	
15.	NO _x emissions	◐	●				○																							○	
16.	Land disturbance from surface mining	◐		◐	◐	◐				○	○								◐	●										○	

3.3 Analysis of Issues

Each of the 16 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, and the impact on fossil energy development of likely future regulations.

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.

Thus, 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.

3.3.1 Disposal of Solid Wastes From Coal Conversion and Combustion Technologies

3.3.1.1 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).

<u>Facility</u>	<u>Solid Waste (tons/yr)</u>
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 3.3.14).

3.3.1.2 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.

3.3.1.3 Regulatory Status

Several laws currently in effect could apply to solid waste disposal from coal conversion plants. These acts are listed below, along with brief discussions of their implications for coal conversion.

Resource Conservation and Recovery Act. Solid wastes from coal conversion technologies are likely to be declared hazardous under the criteria set forth in RCRA regulations. Once these wastes are declared hazardous the relatively strict waste disposal procedures of RCRA will have to be followed. RCRA will also limit solid waste disposal to methods and areas such that ground and surface waters will not be contaminated.

Surface Mining Control and Reclamation Act of 1977. This act 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.

Safe Drinking Water Act. 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.

Federal Water Pollution Control Act. 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 and the Natural Historic Preservation Act 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.

3.3.1.4 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 activities will be concentrated. Greater problems may be encountered in the more densely populated eastern states where disposal sites will be limited. The extension of present solid waste regulations to coal conversion wastes and the adoption of new regulations should evolve at a moderate pace as more conversion technologies are employed.

3.3.2 Water Consumption by Coal and Oil Shale Conversion Technologies

3.3.2.1 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(e) 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:

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.

3.3.2.2 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.

3.3.2.3 Regulatory Status

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.

Several pieces of legislation in which the Congress has exercised some jurisdiction over water resources are:

- Water Resources Planning Act
- Fish and Wildlife Coordination Act
- Wild and Scenic Rivers Act
- FWPCA

It seems likely that resolution of the problem will rest with the states which must have the power to establish systems of priorities for water allocation.

3.3.2.4 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.

3.3.3 Siting of Coal Conversion Facilities

3.3.3.1 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.

3.3.3.2 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.

3.3.3.3 Regulatory Status

Again, 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. Limits siting in areas where endangered species would be further imperiled.

Fish and Wildlife Coordination Act. Affects the development of water resources for energy conversion.

FWPCA. Limits areas in which wastewater can be discharged.

RCRA. The availability of sites for the disposal 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. Provides for the establishment of bird sanctuaries.

The National Historical Preservation Act. 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 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.

3.3.3.4 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. 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.

3.3.4 The Carbon Dioxide Greenhouse Effect

3.3.4.1 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 CO₂ 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 consume 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.

3.3.4.2 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 .

3.3.4.3 Regulatory Status

NEPA requires the appropriate project agency to provide detailed environmental impact statements for every major federal action significantly affecting the quality of the human environment. The Department of Energy Organization Act requires DOE to conduct a comprehensive program of research and development on the environmental effects of energy technologies. However, there is no specific regulatory action on CO₂ emissions at the present time.

3.3.4.4 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 CO₂ greenhouse effect will probably become a major issue in dealing with fossil fuel energy development. Although CO₂ 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 CO₂ emissions from fossil fuel combustion could cause climatic changes, there might be regulatory action on CO₂ emissions. Possible actions include: the requirement of more efficient use of fossil fuel; the requirement to reestablish forests to help balance CO₂ sources and sinks; the simple limitation of coal combustion/conversion as a source of energy; international agreements on long range energy policy and goals; 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 these possible regulatory actions would limit or slow down the development and implementation of fossil fuel energy technologies.

3.3.5 Emission of Polycyclic Organic Matter (POM)

3.3.5.1 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).

3.3.5.2 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.

3.3.5.3 Regulatory Status

POM is covered in general terms under the CAA of 1977 (Hazardous Air Pollutants), OSHA, and TSCA. However, there have been no regulations placed specifically on POM due to the difficulty in quantifying the various constituents. Neither have the states specifically regulated POM. Most states have implemented or are in the process of implementing state controls on carcinogens. These laws do not specifically mention POM but act as enabling legislation so that when evidence accumulates on the carcinogenic effect of POM, air, water and industrial health and safety controls can be established. The Air Quality Division in Utah indicates that emission limitations on POM will be set in the future. For the most part, states are waiting for data to accumulate before setting specific controls on POM emissions.

3.3.5.4 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.

3.3.6 Impacts of Outer Continental Shelf Oil Development (OCS)

3.3.6.1 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 facilities 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-

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- 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.

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.

3.3.6.2 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.

3.3.6.3 Regulatory Status

The FWPCA Amendments of 1972, Sections 301 and 304, contain provisions relating to the effluents from extraction of offshore petroleum and natural gas. The Environmental Protection Agency (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 accidental spillage through additional training in prevention practices.

The FWPCA, the Coastal Dumping Law, and the Coastal Management Bill 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 jurisdiction 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 as air quality and water quality impacts prior to OCS leasing.

Other acts that could affect OCS operations are:

- The CAA of 1970, with subsequent amendments
- The Marine Protection Research and Sanctuaries Act
- The Ports and Waterways Safety Act
- The Endangered Species Act
- OSHA
- The Coastal Zone Management Act

3.3.6.4 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).

The impacts of rising costs and environmental pressures, as well as the surplus of oil incident to the West Coast as a result of the Alaskan Pipeline, may impede OCS development and even prevent it in certain areas altogether (Shell Oil Company, 1973).

The states have jurisdiction 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 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. 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 is permitted and often encouraged, but with reasonable environmental constraints.

3.3.7 Emission of Trace Elements

3.3.7.1 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, fluorine, 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 facilities should contribute significant trace element emissions by the year 2000.

Under the extraction module, 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.

3.3.7.2 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.

3.3.7.3 Regulatory Status

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

Indirectly, trace element air emissions are controlled under Section 60.42 of the CAA, which states that no owner . . . "shall discharge into the atmosphere particulate matter which is in excess of 0.10 pounds per million Btu heat input on a maximum 2-hour average." This section is an NSPS for fossil-fuel steam generators. Also, the national ambient air quality standards (NAAQS) for particulates would indirectly affect trace element air emissions.

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 3-5).

Section 141.11 under the SDWA establishes maximum contaminant levels for inorganic chemicals which include arsenic, barium, cadmium, chromium, lead, mercury, selenium, and fluoride (See Table 3-6).

The Surface Mining Control and Reclamation Act indirectly affects trace element water emissions by strengthening regulations involving acid and alkaline mine drainage.

TABLE 3-5. WATER QUALITY CRITERIA

<u>Element</u>	<u>Surface Water (mg/l)</u>	<u>Irrigation Water (mg/l)</u>
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 3-6. SAFE DRINKING WATER LEVELS

<u>Element</u>	<u>Maximum Level (mg/l)</u>
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)

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 stringent 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 3-7. 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 3-8.

TABLE 3-7. ARIZONA TRACE ELEMENT STANDARDS FOR
COLD AND WARM WATER FISHERIES

<u>Element</u>	<u>Limiting Concentrations (mg/l)</u>
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 3-8. COLORADO AMBIENT AIR QUALITY STANDARDS
FOR TRACE ELEMENTS

<u>Element</u>	<u>ppm</u>	<u>mg/m3</u>
Arsenic	-	0.5
Barium	-	0.5
Beryllium	-	0.002
Bromine	0.1	0.7
Cadmium	-	0.05
Copper fume	-	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 forms but alkyl)	-	0.05
Molybdenum (soluble compounds)	-	5
(insoluble compounds)	-	10
Nickel	-	1
Selenium	-	0.2
Silicon	-	10
Silver	-	0.1
Tellurium	-	0.1
Thallium	-	0.1
Tin	-	0.1
Tungsten (soluble)	-	1
Tungsten (insoluble)	-	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 ($5 \mu\text{g}/\text{m}^3$).

Texas has a 24-hour ambient air quality standard of $0.01 \mu\text{g}/\text{m}^3$ 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.

3.3.7.4 Possible Future Regulatory Actions and Their Impacts

Currently under the CAA there are NESHAPs which include beryllium and mercury air emissions from certain stationary sources. Coal-fired power plants are not currently listed under NESHAPs, but future NESHAPs standards could include beryllium, mercury, cadmium, arsenic, and other 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. The timing on many of these future regulations could be very near term,

especially those applicable to coal pretreatment and coal-fired power plants. The regulations dealing with coal gasification, liquefaction, and related coal technologies will probably evolve in the 1980s as commercialization proceeds.

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.

3.3.8 Groundwater Contamination

3.3.8.1 Description of Issue

The problem of groundwater contamination will become an important consideration in the commercialization 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 Uinta Basins of Utah, Wyoming, and Colorado contain the richest, most accessible oil shale deposits, and the Green, White, 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 even 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).

3.3.8.2 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.

3.3.8.3 Regulatory Status

Groundwater can eventually impact a surface water source, so the regulations for surface water quality apply to these technologies.

NEPA would require an environmental impact statement for all in situ coal gasification and in situ and surface oil shale retorting operations carried out on federal land. This legislation requires that a detailed study be done to show what possible impacts these technologies would have on surrounding ecological systems.

RCRA sets controls for the handling of hazardous substances in solid waste. Currently spent catalysts, scrubber sludges and processed oil shale are not regulated, however.

WPCA has water quality criteria which list recommended allowable concentrations of some trace elements in irrigation and surface water (see Table 3-5). Phenols, weak organic acids, and the tar fractions are considered hazardous substances, and depending upon the quantities discharged, these substances may be subject to NPDES. NPDES requires that certain effluent guidelines be met (such as pretreatment standards) in order to qualify for a permit to discharge these pollutants. In the case of in situ discharges into groundwater, these pollutant identities and quantities may be difficult to determine.

SDWA under Section 141.11 has set standards for maximum contaminant levels of some trace elements (see Table 3-6). Along with the trace element levels, there is a total dissolved solids content standard of 500 mg/l permissible in drinking water.

The Federal Non-Nuclear Energy Research and Development Act provides that the EPA will evaluate these coal and oil shale technologies as to their energy conservation and environmental protection measures. In conjunction with this act, the Water Resources Planning Act provides that the Water Resources Council and the River Basin Commissions throughout the nation assess the water

resource requirements and water supply availability for these technologies. The allocation of water to various agricultural and industrial users would be governed under the Water Resources Planning Act.

The Fish and Wildlife Coordination Act provides that any public or private agency which has a project using or controlling water resources must estimate the wildlife and aquatic life benefits or losses from that project. Also, the Wild and Scenic Rivers Act provides that the free-flowing conditions and water quality of certain rivers be protected. The Endangered Species Act also protects endangered and threatened species of fish life which could be affected by change in water quality. All of these acts could apply to the coal and oil shale technologies depending upon facility location and water resource requirements.

Most states have regulations which allow water discharge into a well only when it doesn't 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.

3.3.8.4 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.

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.

3.3.9 Liquefied Natural Gas (LNG), Safety and Environmental Factors

3.3.9.1 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).

3.3.9.2 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.

3.3.9.3 Regulatory Status

There is no current specific federal legislation regarding LNG import quotas or terminal siting. The Department of Energy Organization Act 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 as amended in 1976 applies to LNG after the gas 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 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 Estuaries Protection Act 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.

3.3.9.4 Possible Future Regulatory Actions and Their Impacts

Currently, there is congressional subcommittee legislation which 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.

3.3.10 Underground Coal Mining - Health and Safety

3.3.10.1 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 prevalent 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 rheumatoid 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 of 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.

3.3.10.2 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 ^{222}Rn in the mine atmosphere is most effectively controlled through adequate ventilation.

3.3.10.3 Regulatory Status

The Federal Mine Health and Safety Act of 1977 was established to promulgate health and safety standards for the protection of miners. The act requires that each operator of a coal or other mine complies with such standards, provides assistance to the states in the development and enforcement of effective state mine health and safety programs, improves and expands research and development and training programs aimed at preventing mine-related accidents and diseases, establishes interim mandatory health and safety standards, and directs the Secretaries of Labor and of Health, Education and Welfare to develop and promulgate improved mandatory health and safety standards.

Interim safety standards limit the average concentration of respirable dust in the mine atmosphere during each shift to 3.0 mg/m^3 , effective on the date of the act, and to 2.0 mg/m^3 , effective 3 years after the date of enactment.

Approved respirators are required to be available whenever persons are exposed to respirable dust in excess of these concentrations. Medical surveillance requirements are also discussed.

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 $<5\% \text{ SiO}_2$) - 2.4 mg/m^3
Coal dust (respirable fraction $>5\% \text{ SiO}_2$) - 10 mg/m^3

Pennsylvania, West Virginia 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, ventilation and handling of explosives. These state laws are used in conjunction with federal law to regulate the health and safety of underground coal mining.

3.3.10.4 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 in a few years 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.

3.3.11 Fugitive Emissions From Coal Gasification and Liquefaction - Health and Safety

3.3.11.1 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, nitro-samines), 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.

H₂S may be formed in high concentrations in the immediate vicinity of H₂S-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 facilities 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 gasification 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., benzantracene, benzo[a]pyrene, etc.) are established skin carcinogens, and less well established respiratory or general carcinogens.

The multifactorial toxic hazards of the above compounds 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).

3.3.11.2 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. Continuous 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.

3.2.11.3 Regulatory Status

Certain compounds released as fugitive emissions from coal conversion plants are specifically regulated by OSHA. These are SO_2 , H_2S , CS_2 , NH_3 , HCN , trace elements, CO , and certain hydrocarbons (including PAHs). Regulations covering trace elements and PAHs are discussed separately under each of those individual issues. The National Institute of Occupational Safety and Health (NIOSH) has also recommended standards for many of these (NIOSH, 1978):

- SO₂ (sulfur dioxide) - OSHA standard is 5 ppm time-weighted average (TWA); NIOSH recommends .5 ppm TWA.
- H₂S (hydrogen sulfide) - OSHA standard is 20 ppm ceiling, 50 ppm/10 minute peak; NIOSH recommends 10 ppm/10 minute ceiling.
- CS₂ (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.
- HCN (hydrogen cyanide) - OSHA standard is 10ppm TWA; NIOSH recommends 5ppm/10 minute ceiling.
- NH₃ (ammonia) - OSHA standard is 50 ppm TWA; NIOSH recommends 5 ppm/10 minute ceiling.
- Heterocyclic Nitrogen Compounds (pyridine) - OSHA standard is 5 ppm TWA.
- CO (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

Most states do not have fugitive emission standards for coal gasification and liquefaction facilities. Illinois and Kentucky are in the process of writing guidelines for fugitive emission levels 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.

3.3.11.4 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 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 achievable 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.

3.3.12 Boomtown Effects

3.3.12.1 Description of Issue

Construction and operation of a fossil 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 and regasification plants. 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.).

Appalachia - coal mines and associated processes.

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

The impacts expected due to rapid growth from fossil 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).

3.3.12.2 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 communities 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).

3.3.12.3 Regulatory Status

The issue of boomtowns resulting from fossil energy projects is not regulated by any specific piece of federal legislation. NEPA, however, does require an EIS to be prepared on any major federal action that affects the quality of the human environment. Proposed energy projects must therefore submit such a document which would include a discussion of potential rapid growth problems and possible mitigating actions.

Congress is likely to pass the Energy Impact Assistance Act, which provides for both planning and economic assistance to communities faced with energy-related growth problems.

A few of the western states have already had to cope with boomtowns. Two states, North Dakota and Wyoming, will be used as examples of how some states are reacting to the problems.

In 1975, North Dakota passed a state siting law requiring 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 Beulah 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.

In 1975, Wyoming passed the Industrial Development Information and Siting Act. The 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.

3.3.12.4 Possible Future Regulatory Actions and Their Impacts

Boomtowns resulting from fossil 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 communities 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 established to maintain stable growth.

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

3.3.13.1 Description of Issue

Fine particulates are generally defined as particles with a size less than 5 μm 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 technologies 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 $5 \mu\text{m}$ 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 compounds must be evaluated when considering particulate health effects.

Most particulates smaller than $5 \mu\text{m}$ 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 bronchitis, 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).

3.3.13.2 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 precipitator, although capable of removing small particulates, is only effective in a narrow range of electric resistivity; at

both high and low resistivities, control efficiency 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.

3.3.13.3 Regulatory Status

Particulates are regulated under the CAA, the Federal Mine Safety and Health Act of 1977, and OSHA standards. The standards under the CAA are not specific for fine particulates, however, since they do not take into account particle size.

Ambient air quality standards for particulates have been established under the CAA:

	<u>Primary ($\mu\text{g}/\text{m}^3$)</u>	<u>Secondary ($\mu\text{g}/\text{m}^3$)</u>
Annual Geometric Mean	75	60
24-hour Concentration	260	150

Also under the CAA, PSD areas designated Class I or II are limited to the following increases in particulate concentrations:

	<u>Class I ($\mu\text{g}/\text{m}^3$)</u>	<u>Class II ($\mu\text{g}/\text{m}^3$)</u>
Annual Geometric Mean	5	19
24-Hour Maximum	10	37

The EPA has not yet published NSPS for coal conversion plants. Standards do exist for specific components of coal conversion plants, however, such as fossil fuel-fired steam generators and coal preparation plants:

- Fossil-fueled steam generators - .1 lb/10⁶ Btu, 20 percent opacity.
- Coal preparation plants - .07 g/dscm for thermal driers, .04 g/dscm for pneumatic coal cleaning equipment, opacity 20 percent from all operations, opacity 10 percent for pneumatic coal cleaning equipment.
- The CAA Amendments of 1977 require new coal-fired steam generators coming on line after 1983 to achieve a particulate emission rate of 0.05 lb/10⁶ Btu.

The EPA published its Emission Offset Policy in the December 21, 1976 Federal Register for new sources in areas having ambient air quality worse than the NAAQS. No new sources emitting more than 100 tons per year of particulates will be allowed to locate in areas having air quality worse than the primary ambient air quality standards, unless existing sources reduce their emissions by an equivalent amount. Where only secondary ambient air quality standards are exceeded, no major source will be allowed in the area, unless the state can demonstrate eventual compliance with the standards despite the new source. The EPA Offset Policy was reinforced by the CAA Amendments of 1977.

Although no states have particulate emission standards specifically for emissions from coal and oil shale technologies, most states do have ambient air quality standards for total suspended particulates. Many of the states have opted for more stringent standards than those required by federal law.

Only one state that was surveyed, Indiana, has an ambient standard that takes into account the size of the particles. This standard is for respirable dust in the range of 0.5 to 6.0 microns in diameter, and specifies a maximum ground level concentration of 50 $\mu\text{g}/\text{m}^3$ for 1 hour.

3.3.13.4 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 particulates. 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 currently 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.

3.3.14 Emissions of Radioactivity From the Mining and Conversion of Coal

3.3.14.1 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 ^{238}U and ^{232}Th (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 pyrite 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 underground mining; emissions of alpha-emitting particulates from conventional combustion (e.g., ^{238}U , ^{234}U , ^{239}Th , ^{226}Ra , ^{210}Po , ^{232}Th , ^{228}Th), ^{222}Rn emanation from ^{226}Ra with progeny buildup (^{210}Po , ^{210}Pb), and groundwater contamination from ash and residue disposal from coal conversion activities. For the gasification of low rank uraniferous lignites there may be some concern for the pass-through of ^{222}Rn into the product gas.

The impacts upon which protection criteria are developed for ionizing radiation are carcinogenic and mutagenic biological 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 congenital 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. The following are estimates of the quantification of such risks for certain tissues for which quantitative estimates are available. (ICRP, 1977)

<u>Tissue</u>	<u>Risk Manifestation</u>	<u>(Effect/Dose)¹</u>
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

¹ The number of abnormal manifestations in the population per dose equivalent (rem) to the population.

*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.

Generally, fatality risks on the order of 1.10^{-5} to 1.10^{-6} are considered acceptable; they are crudely on the order of 100 mrem whole-body exposure per year to members of the general population.

3.3.14.2 Probable Solutions

For underground 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 economical 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.

3.3.14.3 Regulatory Status

The federal government currently has no regulation regarding the health effects of radioactivity emissions from coal utilization, although there is enabling legislation under the CAA Amendments of 1977 (Section 122) and under Section 3001a of RCRA. Under RCRA there are proposed regulations to classify waste as hazardous which contains greater than 5 pCi/g ^{226}Ra , (this corresponds to ash from raw coal with concentrations of about 2 ppm uranium assuming secular equilibrium and 10 percent ash).

The maximum ambient concentrations allowable for facilities licensed by the U.S. Nuclear Regulatory Commission (NRC) are presented in Table 3-9. 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 3-10.

TABLE 3-9 U.S. NUCLEAR REGULATORY COMMISSION
MAXIMUM PERMISSIBLE CONCENTRATIONS

Maximum Permissible Concentration (uCi/m³)¹

<u>Radionuclide</u>	<u>Air</u>	<u>Water</u>
²³⁸ U	3×10^{-10}	4×10^{-5}
²³⁴ U	4×10^{-12}	3×10^{-5}
²³⁴ Th	1×10^{-9}	2×10^{-5}
²³² Th	1×10^{-12}	2×10^{-6}
²³⁰ Th	8×10^{-14}	2×10^{-6}
²²⁸ Th	2×10^{-13}	7×10^{-6}
²²⁸ Ra	1×10^{-12}	3×10^{-5}
²²⁶ Ra	2×10^{-12}	3×10^{-8}
²²⁴ Ra	2×10^{-11}	2×10^{-6}
²²² Rn	3×10^{-9}	---
²¹⁰ Po	7×10^{-12}	7×10^{-7}
²¹⁰ Bi	2×10^{-10}	4×10^{-5}
²¹⁰ Pb	4×10^{-12}	1×10^{-7}
U - natural	2×10^{-12}	2×10^{-5}
Th - natural	1×10^{-12}	1×10^{-6}

¹10 CFR 20 Appendix B. The lowest level for soluble or insoluble form is included.

TABLE 3-10 MAXIMUM RADIOACTIVITY LEVELS ALLOWABLE IN
COMMUNITY WATER SUPPLIES (41 FR 28402)

Radioactivity	Regulation
^{226}Ra , ^{228}Ra	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 ^3H 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
^3H ,	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

3.3.14.4 Possible Future Regulatory Actions and Their Impacts

Possible candidate future regulations are described below:

<u>Nuclide</u>	<u>Type of Standard</u>
^{222}Rn	Ambient Air/Emission Standard
^{222}Rn	Gasification Product Gas
^{226}Ra	Solid Residue (ash)/Ambient Air Standard
$^{228}\text{U}/^{234}\text{U}$	Ambient Air/Emission Standard
^{210}Po	Ambient Air/Emission Standard
^{210}Pb	Ambient Air/Emission Standard
alpha activity	Surface/Groundwater Standard

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 effectively 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,

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 - ^{226}Ra classification of radiological wastes under RCRA could force preferential development of coal resources with ^{238}U levels below approximately 2 ppm in order to avoid the ash disposal licensing requirements which such an ash would require. However, the regulation 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.

3.3.15 Emissions of Nitrogen Oxides

3.3.15.1 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.

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 of nitrosamines--a potential carcinogen. NO_x , thus plays a major role in the whole set of air pollution problems.

3.3.15.2 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.

3.3.15.3 Regulatory Status

The CAA Amendments of 1977 add to the intent of the original act by providing specific mechanisms and regulations designed to control NO_x emissions from stationary mobile sources and by authorizing EPA to establish a short term NAAQS for NO_2 . The nonattainment plan provisions have immediate impacts on fossil fuel technologies. Under these provisions, revised State Implementation Plans (SIPs) governing 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 LAER technology.

The major impact of these amendments is from the PSD regulations. 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 NSPS) on new or modified sources on a case-by-case, source-by-source basis.

The CAA Amendments of 1977 give 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 traveled 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 transportation dynamics will likely influence the emission, location, and site concentration requirements of NO_x -emitting fossil fuel facilities.

By reacting with hydrocarbons, nitrogen oxides cause the formation of oxidants in the ambient air. These oxidants contribute significantly to the formation of secondary particulates by oxidizing NO_x , SO_x , and organic compounds. These synergistic effects will influence the PSD regulations for NO_x . The CAA

Amendments of 1977 do not require an increment approach (e.g., area classification) for NO_x identical to the SO_2 /TSP approach, but only equivalent protection. The ultimate PSD regulations for NO_x , as well as hydrocarbons and oxidants, may take a considerably different form, taking into consideration these synergistic effects.

Most states contacted have adopted the CAA ambient air quality standard of $100 \mu\text{g}/\text{m}^3$ (0.05 ppm). California has a strict short-term standard of 0.25 ppm measured over 1 hour. North Dakota also has a short-term standard of $200 \mu\text{g}/\text{m}^3$ (0.10 ppm) maximum 1 hour concentration not to be exceeded over 1 percent of the time over any 3-month period.

3.3.15.4 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 NO_x 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.

3.3.16 Land Disturbances From Surface Mining

3.3.16.1 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.

3.3.16.2 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.

3.3.16.3 Regulatory Status

The Surface Mining Control and Reclamation Act of 1977, administered by the Office of Surface Mining Reclamation and Enforcement of the Department of Interior, has the major impact on surface mining. It requires that a permit application should include, among other things, a determination of the probable hydrological consequences of the mining and reclamation operations, both on and off the mine sites, in the pre-mining planning. 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 and better uses." Additionally, all operators of coal mining operations shall pay to the Secretary of the Interior a reclamation fee. The fund shall be used to protect the public from adverse effects of coal mining practices.

The Corps of Engineers, authorized by Section 404 of the FWPCA Amendments, has promulgated regulations concerning placement of dredge and fill material in navigable streams or their tributaries. This regulation can affect surface mining which frequently involves diversion of streams through soil slippage or sedimentation; however, the 404 Program has been only partially implemented, and only coal mining that would affect tidal waters and waters involved in interstate or international commerce is currently regulated.

Through authorization of the NPDES, the FWPCA Amendments require EPA to set effluent standards. The current limitations are set for pH, suspended solids, total iron, dissolved iron, acidity, alkalinity, and manganese in the mine discharge. As more attention focuses on the potential hazards of discharging large quantities of trace elements and aromatics to the environment, it is very likely that the discharge limitations will become more stringent in the near future.

Section 1003 of the RCRA of 1976 requires EPA to regulate the treatment, storage, transportation, and disposal of hazardous wastes. There is a mining study underway to determine if mining residuals, such as overburden, are hazardous. Special placement of hazardous waste is required to protect groundwaters. Because large amounts of overburden are involved in the surface mining process, the outcome of this report could have tremendous effect on surface mining.

Additional environmental safeguards are provided by the Coal Leasing Act Amendments of 1976, and Section 102 of NEPA (1969). Authorized by this legislation, the Department of Interior and EPA both require detailed environmental analysis before federal coal land can be leased or mining permits can be issued. Thirty-eight states have state laws to regulate surface mining and they are relatively less stringent than federal regulations.

The Federal Surface Mining Control and Reclamation Act requires the states to control the adverse effects of surface mining. Some states such as Pennsylvania and Wyoming already have strict reclamation requirements 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, and 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.

Other laws covering this issue are: Water Resources Planning Act, Fish and Wildlife Coordination Act, Wilderness Act, Federal Land Policy and Management Act, and Endangered Species Act.

3.3.16.4 Possible Future Regulatory Actions and Their Impacts

Possible future regulations are:

- Requirement for more efficient or complete recovery of coal in order to minimize extent and degree of impact.
- More stringent requirements for restoration, including prohibition of surface mining in certain topographically, ecologically, or hydrologically sensitive regions.
- Requirement to have special placement of overburden or to have special mining/restoration technologies in certain regions by declaring certain mining residuals as hazardous.
- Setting of effluent standards for more toxic substances in the effluent and drainage under the FWPCA.
- Allocation of groundwater may lead to constraints in surface mining/restoration practices, including nonavailability of restoration water.
- Restriction on mining/restoration practices to maintain the availability and quality of drinking water supplies (i.e., tie to SDWA). Detailed hydrological surveys will be required to avoid contaminating underground aquifers.

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.

4. PROBABILITIES OF FUTURE ENVIRONMENTAL REGULATORY ACTION

In the previous chapter, possible future regulatory actions were proposed for each of 16 major environmental issues. Those actions were proposed on the basis of regulatory authority established under existing legislation, as well as the perceived need for additional legislation to deal with major environmental problem areas. Although it was implied in the discussion of those actions that they were likely to take place sometime in the future, no attempt was made to indicate the time frame in which the actions might occur or to estimate their likelihood of occurrence. In this chapter, those questions are addressed.

The method employed to arrive at probabilities and time frames of occurrence was simple and straightforward. First, the legislative and regulatory background associated with each issue was examined to determine the time scale over which the 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.

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 a high probability of regulation 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 not have a significant probability of being regulated before 1990, or perhaps later.

Cumulative probabilities were assigned for regulatory activity taking place with respect to each issue as a function of time--the three years 1985, 1990, and 2000 were chosen to represent the near, medium, and long-term. The probabilities are expressed semi-quantitatively as low, medium, or high. For purposes of quantitative interpretation, these terms can be interpreted as the ranges 0 to 0.33, 0.33 to 0.67, and 0.67 to 1.0, respectively. Occasionally, it appeared so likely that a particular regulatory action would take place that the probability was assessed as nearly certain (close to 1.0).

Because the estimation of probabilities was based on an extrapolation of current trends, it was considered desirable to examine the likely changes in probability that would occur if there were a change in the regulatory climate. In particular, two different scenarios were addressed. In the first there is increasing public pressure for stronger environmental protection measures than exist at present. This pressure reflects a society in which environmental quality goals are emphasized, sometimes at the expense of economic growth and productivity. In the second scenario there is a primary emphasis on economic growth and the attendant growth in domestic energy supply. Environmental goals, while still seen as important, would be less strongly emphasized than at present and would not be allowed to significantly reduce productivity.

4.1 Disposal of Solid Wastes from Coal Conversion and Combustion Technologies

4.1.1 Legislative/Regulatory History

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 terrestrial 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/g and if it is not source, special nuclear or by-product material as defined by the Atomic Energy Act of 1954, as amended.

4.1.2 Estimation of Probabilities

The major regulatory action of interest resulting from RCRA is the identification of coal conversion solid wastes, or one or more of their constituents, 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. 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 there is at least a medium probability that coal conversion wastes will come under hazardous waste regulation by 1985, increasing to high by 1990 as more coal conversion technologies are commercialized. It is virtually certain that at least some types of coal conversion wastes will be regulated by 2000.

4.1.3 Changes in Probabilities

An increased emphasis on economic growth in the future would bring about pressure for increased coal production and use to meet national electricity and fuel requirements. This pressure would most likely postpone action on classifying coal wastes as hazardous. The probability of action would be low through the 1980's, increasing to medium by 2000.

An increased emphasis on environmental protection would increase the probability of regulatory action to high in 1985, and almost certain in 1990, due to the fact that environmental interests would strongly focus on coal conversion activities.

4.1.4 Discussion

As the coal conversion industry grows, the generation of solid wastes will become a highly visible issue, both because of the large quantity of wastes generated and because of the toxic materials they contain. Examples of such materials are trace elements, radioactive elements, cyanide, phenols, toxic and carcinogenic organics, and so on. Even if EPA does not declare such wastes hazardous, some of the energy-producing states may do so as part of their hazardous waste management programs.

The main impact of such action is an increase in the costs of waste disposal due to special handling, storage, and disposal requirements. Siting problems could also arise for conversion facilities due to the lack of suitable disposal sites in some areas.

4.2 Water Consumption by Coal and Oil Shale Conversion Technologies

4.2.1 Legislative/Regulatory History

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 additional impoundments to mitigate seasonal variations, and promoting inter-basin transfers.

4.2.2 Estimation of Probabilities

There is a high probability that actions will take place in the key western energy-producing states by 1985 that will limit the availability of water for energy development. This likelihood will increase to near certainty by 1990 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.

4.2.3 Changes in Probabilities

If the United States were to place priority on economic growth and the parallel requirement for accelerated energy development, there would be considerable pressure on the states to allocate more water for this purpose. It seems likely that the states would resist such pressures, but the net effect, backed by intensive litigation, would be to delay implementation of some of the actions discussed above. The probability would be reduced to medium by 1985, increasing to high by 1990, and near certainty by 2000.

If environmental protection were to be emphasized more than at present, state water actions would be accelerated and would take place with virtual certainty by 1985.

4.2.4 Discussion

Because water is a key component of coal and oil shale conversion, future state decisions on water allocation will be major factors in the timing and location of fossil energy development. Although the federal government will have some influence in this area, the states will be the primary actors, unless there is a complete turnaround in federal water policy. Because of the extreme importance of water resources to the economic and social well-being of the western states and the increasing demands that will be placed on them, there will be considerable activity at the state level for the foreseeable future.

4.3 Siting of Coal Conversion Facilities

4.3.1 Legislative/Regulatory History

Although there are no federal laws that address the siting of conversion facilities directly, there are several that affect siting in an indirect

way. Furthermore, several 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.

The key federal laws affecting siting of energy conversion facilities are the CAA Amendments of 1977 (See Appendix C), NEPA (1969), FWPCA (1972) and Amendments (1977), RCRA (1976), and the Federal Land Policy and Management Act of 1976. In addition, two major coal resource states, Wyoming and North Dakota, passed comprehensive industrial-facility siting acts in 1975.

4.3.2 Estimation of Probabilities

The estimation of probabilities 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.

There is a high probability that substantial increases in the costs and delay time (relative to the present) due to siting problems will occur by 1985, and a near certainty that they will occur by 1990. However, after that time there is medium chance 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.

4.3.3 Changes in Probabilities

Under societal conditions which favor rapid economic growth, there is only a small chance that siting procedures would cause increased costs and delay by 1985, and a large probability that siting procedures would subsequently become more efficient by 1990.

If there were greater emphasis on environmental protection, it is nearly certain that costs and delays would increase by 1985. There would still be pressures for streamlining the siting process, resulting in a small probability of reducing costs and delays by 1990, increasing to medium by 2000.

4.3.4 Discussion

The assignment of probabilities presented above is based on continuation of current trends at least to 1985. Even if societal attitudes toward economic growth and environmental protection change in the near future, it would be difficult to reverse the processes that affect siting before that time. They would be either accelerated or retarded. 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 Carbon Dioxide - Greenhouse Effect

4.4.1 Legislative/Regulatory History

The scientific community began to show interest in the CO₂-greenhouse effect in the early 1950's. The Mauna Loa Observatory and the station at the South Pole started to record ambient CO₂ concentrations in 1957. The steady increase in the annual average atmospheric CO₂ concentrations was well recognized in the 1960's. Intensive research on the storage and exchange mechanisms, mathematical modeling, and the possible effects of CO₂ was initiated immediately after this finding. The U.S. Government has shown a marked interest in the CO₂ issue since 1972. Major government and institutionally-funded research projects have been conducted since then. Currently there is no regulation of CO₂ 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 CO₂ effects.

At the present time, there are great uncertainties involved in the following major aspects of the problem associated with the CO₂-greenhouse effect:

- The causes of the steady increase of atmospheric CO₂.
- The storage and exchange mechanisms of oceans, forests and humus that can affect the atmospheric CO₂ 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 CO₂ emission, it is not likely there will be any regulation of CO₂ 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 CO_2 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 CO_2 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 CO_2 in the atmosphere will increase to 400 ppm by the year² 2000 and to 800 ppm by 2040.
- Ambient CO_2 concentrations of 500-1000 ppm are frequently² found in urban areas. The environmental effects due to an increasing CO_2 concentration are expected to occur on a meso scale² or synoptic scale before they happen globally.
- Removal of CO_2 from flue gases does not appear feasible. Possible measures to reduce CO_2 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.

4.4.2 Estimation of Probabilities

Should there be enough information accumulated to show that CO_2 emission from fossil fuel combustion could cause climate changes, there might be regulatory actions on CO_2 emissions. Possible future actions may include the following:

- (1) Increased emphasis on alternatives to fossil fuels in the NEPA process.
- (2) The requirement of more efficient usage of fossil fuels.
- (3) The requirement of reestablishing forests to rebalance CO_2 sources and sinks.

- (4) Regulations, similar to the Energy Supply and Environmental Coordinate Act of 1974 (ESECA) are promulgated to give the Department of Energy the authority to order certain fossil burning facilities to convert to nonfossil energy sources.
- (5) Regulations promulgated to site power plants and other major fossil burning facilities away from urban areas to avoid locally high CO₂ concentration.

All the possible regulatory actions listed above, with the exception of the last, may occur if sufficient information were accumulated to indicate that CO₂ emissions from fossil fuel combustion could cause climatic changes that would lead to adverse consequences, and if international agreements were reached on limiting the use of fossil fuel as a source of energy.

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, international agreements on limiting CO₂ emission would be difficult to achieve without noticeable evidence of adverse impacts. Therefore, the chance of having the aforementioned regulatory actions (3) and (4) would be small before 1990 and would be small to medium by the year 2000. The probability of having regulatory actions (1) and (2), which may slow down the growth rate of fossil fuel use to some extent, would be small in 1985, small to medium in 1990, and medium in 2000.

Since the environmental impacts are expected to occur on a meso scale before they happen globally, and international agreement may not be needed, regulation (5) could occur earlier than the first four. The probability of having this action would be small to medium in 1985 and 1990, and somewhere between medium and high in 2000.

4.4.3 Changes in Probabilities

Although the impacts of the CO₂-greenhouse effect will be noticeable in 2000, and enough scientific information should be accumulated in the 1990's, the long-term net effects may still be uncertain. Speculation that a warmer earth might be a more desirable place to live may be used in justifying the "wait and see" position. If society becomes less concerned about environmental considerations than at present, the chance of having any regulation would be small before 1990, and the chance of having regulatory action in the year 2000 would be small to medium. If society becomes more concerned about environmental quality than at present, the chance of having any regulation, with the exception of action (5), before 1990 will be about the same as that under the current regulatory climate and social context, mainly because of the strong demand for fossil fuels and the lack of sufficiently convincing evidence of future adverse effects. However, as the consequences of climatic change become noticeable, it is very likely that all the aforementioned regulatory actions will take place in the year 2000. Since the urban or regional impacts are likely to be noticeable earlier than global effects, the probability of having action (5) would be medium in 1985 and high in 1990 and 2000.

4.4.4 Discussion of Probability and Issue Implications

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 CO₂ emissions, large non-CO₂-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 CO₂ content of the atmosphere.

4.5 Polycyclic Organic Matter

4.5.1 Legislative/Regulatory History

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.

4.5.2 Estimation of Probabilities

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

The probability that POM will specifically be regulated under the CAA by 1985 is almost certain. 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 large probability that by 1985 some types will be classified as toxic pollutants and will be subject to the regulations as prescribed in the FWPCA.

By 1985, there is a medium probability that the SDWA will regulate the discharge of POM into aquifers. To date, little information has been gathered

concerning POM as a contaminant of aquifers. There is a high probability that by 1990, this information will be known, and that regulations would apply and require that some kind of control technology 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, thus RCRA standards should apply (high probability) by 1985, and certainly apply by 1990.

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)anthracene, and 3-methylcholanthrene. One can predict with near certainty that by 1985 POM will be strictly regulated by OSHA.

4.5.3 Changes in Probability

The probability of changes in the regulatory climate surrounding POM seems highly unlikely, regardless of whether society becomes more concerned with environmental quality or with economic growth. The issue of major concern confronting POM is its relationship to carcinogenesis. Presently, in a society where many products seem to cause cancer, it is doubtful that such concerns would be affected by general environmental or economic trends. Thus, if society should become more oriented toward either environmental quality or economic growth, it is unlikely that any changes in legislation or regulatory action will occur.

4.5.4 Discussion

Preliminary studies have determined various constituents of POM to be carcinogenic. EPA and other regulatory agencies are currently accumulating information necessary to fully assess the health impact of POM. There is a high probability that regulatory action will occur between 1985 and 1990. This requirement for regulatory action will be based primarily on public health concerns.

4.6 Outer Continental Shelf

4.6.1 Legislative/Regulatory History

The Outer Continental Shelf Lands Act of 1953 (OSC), with 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 coastal 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 (which requires operators filing exploration and development plans in each case to certify that the activity is consistent with the State Coastal Zone Management Act), and the Marine Sanctuaries Act (setting aside sections of the ocean as marine sanctuaries) represents legislation which will add to the already strong lobby for environmentalists.

4.6.2 Estimated Probabilities

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 a low probability 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.

4.6.3 Changes in Probability

Should society become more concerned with the environmental quality, the above legislation will be strictly enforced. This would be done by an increased emphasis on NEPA, such as development of a thorough environmental impact statement evaluating the location and design of total offshore drilling (including crude oil/gas transport to shore), as well as onshore facilities. Under these conditions, it appears unlikely that any gas and oil production will take place.

On the contrary, if society becomes more concerned with economic growth, there is a high probability that the regulations would be relaxed, weakening considerably the lobby of the environmentalists. This would most likely occur only under drastic conditions. For example, if high levels of oil imports threatened an economic depression, it would become increasingly necessary to develop OCS.

4.6.4 Discussion

The major problem associated with OCS will continue to be the acquisition of an OCS lease. Presently, OCS development is well regulated, therefore, it is doubtful that any future regulatory or legislative action will be enacted. However, it is quite likely that the present regulations could be tightened or relaxed depending upon societal concerns. Should society become more concerned about environmental quality as opposed to economic growth, present regulations would be strictly enforced. However, if the reverse should occur, a relaxation in present regulations would be observed.

4.7 Trace Elements

4.7.1 Legislative/Regulatory History

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.

Section 1910.1000 of OSHA (1970) regulates worker exposure to many trace elements and their compounds.

Presently, there are water quality criteria establishing limits for 13 trace element concentrations for both surface and irrigation water which could be incorporated into FWPCA (1972).

Section 141.11 of SDWA (1974) established maximum contaminant levels for inorganic chemicals which include arsenic, beryllium, cadmium, chromium, lead, mercury, selenium, and fluoride.

The Surface Mining Control and Reclamation Act of 1977 indirectly affects trace element water emissions by strengthening regulations involving acid and alkaline mine drainage.

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 Act 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.

4.7.2 Estimation of Probabilities

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. Currently, there are standards for beryllium and mercury for some stationary sources, not including coal-fired power plants. 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. There is a medium probability, given these two strong legislative bases and increased coal consumption, that some action may occur by 1985 concerning trace element pollution for direct coal combustion. There is a high probability that it will occur by 1990.

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. There is a medium probability that some regulatory action will occur affecting coal gasification facilities by 1985. Coal liquefaction and oil shale retorting will probably not be commercially developed before 1985; therefore, the probability of regulatory action by 1990 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.

4.7.3 Changes in Probabilities

The increased use of coal coupled with greater societal concern over environmental issues would result in greater pressure to promulgate regulations dealing with trace element pollution from fossil energy technologies. This pressure would result in a high probability of regulatory action by 1985.

A greater emphasis on economic growth, including the development of domestic energy resources to displace imported petroleum, would result in pressures to reduce restrictions on the expanded use of coal and oil shale. Therefore, the probability of significant new regulatory action on trace element pollution would be small through the 1980's, increasing to medium by 2000. The direct coal combustion technologies will first realize the effects of trace element regulatory action. As the fossil fuel technologies develop into the 1980's, these regulations will take effect.

4.7.4 Discussion

Current federal legislation lays the basis for future regulations regarding trace element pollution from fossil fuel technologies. The awareness of the hazardous health effects of trace elements is evident in emerging regulations (NESHAPS for beryllium and mercury). The Clean Water and Air Acts will incorporate trace element regulations as more knowledge accumulates on health and welfare effects. Relatively new legislation, such as RCRA and TSCA, will also regulate solid waste disposal techniques and product/by-product handling and distribution.

The direct coal combustion technologies will first realize the effects of trace elements regulatory action. As the fossil fuel technologies develop in the 1980's, these regulations will take effect.

4.8 Groundwater Contamination

4.8.1 Legislative/Regulatory History

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, methoxychlor, toxaphene, and two chlorophenoxy 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 $0.10 \mu\text{g/l}$ (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.

4.8.2 Estimation of Probabilities

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. There is a medium probability for regulations concerning trace elements and organics which would be applicable to these technologies by 1985. Through further pilot plant testing, much more will become known about the various specific pollutants and their pathways into aquifers and groundwater systems, leading to a high probability of regulation by 1990.

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, there is a low probability 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 the in situ processes, and there is a low probability that action would occur before 1990.

4.8.3 Changes in Probabilities

Although the specific effluent limitations for trace elements and organic compounds associated with the in situ coal and oil shale technologies cannot now be established, many of the trace elements and some of the organics are included in the list of 65 toxics under the FWPCA. In a future society where the emphasis is on economic growth, it is possible that some of the toxic standards could be relaxed, and there would be only a low probability of further regulations applying to in situ technologies by 1985 or 1990.

In a society more concerned about environmental quality than at present, protection of groundwater supplies is likely to become a major issue. Therefore, the probability of further regulatory action affecting in situ technologies would be high by 1985, continuing through 2000.

4.8.4 Discussion

The various probabilities of legislation for groundwater contamination will vary depending not only on the social and economic factors but also with the rate of development of the technology and the particular type of legislation. Currently, there are existing regulations for some trace elements and organics which could apply to future technologies (i.e., drinking water standards). There are also certain other trace elements and organic compounds being considered for regulation under SDWA and FWPCA. There is a medium to large probability that trace element and organic regulation action will occur by 1985. These pollutant specific types of regulations will precede regulations under RCRA and TSCA. Regulations concerning the latter two acts will develop as more is known about in situ coal and oil shale technologies. Pilot plants will yield more detailed information concerning specific pollutants, routes of the pollutants into the groundwater systems, solid wastes, and water resource requirements. As these technologies approach commercialization specific regulations will evolve, but this is not likely before the 1990's.

4.9 Liquefied Natural Gas; Safety and Environmental Factors

4.9.1 Legislative/Regulatory History

Currently, there is no specific direct federal legislation concerning LNG import quotas or siting of regasification facilities.

The Department of Energy Organization Act of 1977 delegated authority to the Federal Energy Regulatory Commission (FERC) concerning environmental safety issues for siting LNG facilities.

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's traffic and safety regulations are enforced by the U.S. Coast Guard.

The Coastal Zone Management Act of 1972 provided 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.

On the state level, California passed the LNG Terminal Act of 1977 which mandates that studies be done concerning regional energy shortages, siting factors, and safety matters concerning LNG terminals and regasification facilities. One of the main factors of this act is a population density consideration in the immediate area of the LNG facility.

4.9.2 Estimation of Probabilities

Recent Congressional subcommittee and Department of Transportation actions may lead to future federal legislation and regulations concerning LNG. During the 1978 Congressional session there was subcommittee legislation which would require the President to decide the amount of LNG imports for the next 10 years. Also, the proposed LNG Safety and Siting Act (S2273) would have developed minimum standards for siting, design, construction, and operation of LNG transportation, storage, and regasification facilities which would be similar in nature to the California LNG Terminal Act. The California act says that "population density shall not be greater than an average of 10 persons per square mile for a distance of 1 mile outside the perimeter of the site on which the offloading, regasification, and storage facilities for LNG will be

located." Also, the "population density shall be not greater than an average of 60 persons per square mile for a distance of 4 miles outside the perimeter of the site on which the offloading, regasification, and storage facilities for LNG will be located." Another important siting criterion is local seismic conditions. The Nuclear Regulatory Commission generally considers as not suitable sites located with 5 miles of a surface capable fault longer than 1,000 feet. A "capable" earthquake fault is defined as one with movement within the last 35,000 years or multiple movements within the last 500,000 years.

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.

There is a high probability that all of the proposed legislation and actions discussed above will be promulgated by 1985. 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.

4.9.3 Changes in Probabilities

Because of the importance of natural gas as a clean-burning fuel in all sectors of the economy, it would play a major role in any scenario of high economic growth. LNG would be seen as an important alternative source of natural gas as domestic fields declined in production. Therefore, there would be intensive lobbying for streamlined siting procedures for LNG facilities, and against new legislation that was seen as overly restrictive. Because of such opposition and because of the number of regulations already in existence, the probability of additional regulatory action would be small by 1985, perhaps increasing to medium by 1990.

In a future society more concerned about the environment than at present, the siting of LNG terminals would be a major issue in coastal regions. Although there would be opposition to such facilities on various grounds, it is doubtful that the probability of further legislative/regulatory action, already estimated to be high under present conditions, would increase significantly.

4.9.4 Discussion

The basis for much of the future legislative/regulatory action regarding LNG imports and site facilities already exists. There is existing state legislation and some enabling federal legislation. Supportive background material for future federal regulations lies within the Departments of Energy and Transportation. Already there are several subcommittees and review groups investigating all aspects of LNG. The present administration has established an "LNG Imports Review Group" which will study all major issues concerning LNG including regional/national dependence, contractual arrangements with foreign countries, contingency planning (in case of embargo), and siting criteria. The National Energy Plan calls for increased LNG imports; thus this should hasten the need for federal action. Based upon the fact that the legislative process is in motion concerning LNG, there is a large probability that by 1985 major federal action will occur.

4.10 Coal Mining - Health and Safety

4.10.1 Legislative/Regulatory History

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 Mine Safety and Health Act was enacted. This Act reflects changes in the 1969 Federal Coal Mine Health and Safety Act which are based upon the Federal Mine Safety and Health Amendments of 1977. The Act addressed the same topics as the 1969 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 respirable dust standard of 2.0 milligrams/m³ of air in the mine atmosphere during each work shift was left unchanged in the 1977 Act and is now considered final.

4.10.2 Estimation of Probabilities

There is a low probability 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 by 1985. It is more likely (medium probability) that this will occur by 1990. The revision of the standards will probably involve the 2 mg/m³ 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.

4.10.3 Changes in Probability

If society were to become more concerned about quality of life issues than at present, the probability of more stringent health regulations for coal mining by 1985 would still remain about the same. No matter what the social climate, long-term studies must first be completed in order to change the current health standards. Safety standards might be revised somewhat sooner under pressure from miners unions which would have more public support than at present. Unions would certainly demand better pay, shorter working hours, and probably more automated mining processes, and these changes could probably be pushed through by 1990.

If society were to emphasis economic growth rather than quality of life, the probability of tighter health and safety regulations within the next few years might be somewhat less. However, since human lives are at stake rather than just environment issues, improved health and safety measures would probably be slowed but not permanently blocked. By 1990 or 2000 at the latest there would probably be more stringent standards for coal mining. There is very little chance that the current regulations could be relaxed or eliminated since the existence of unsafe and unhealthful working conditions prior to the passage of the Federal Mine Safety and Health Act is well documented.

4.10.4 Discussion

There is some chance that the health and safety standards set by the 1977 Federal Coal Mine Safety and Health Act will be tightened by 1985 or at least by 1990, resulting in the respirable coal dust standard being revised downward. Also by that time, research may demonstrate the need for standards for

certain toxic substances in coal mines. New safety standards may be promulgated by 1990 or 2000 under pressure from miners unions and environmentalists and could result in more completely automated mining techniques. Quite probably unions will also demand higher wages and shorter working hours.

The impact of these future regulations upon the coal industry could be substantial. Many coal mine operators have already voiced the opinion that meeting the 2.0 mg/m³ standard will be difficult and expensive. If the standard is tightened even more, the effort and cost will be higher. The same is true for safety measures; the more complex they become, the higher the cost. The expense will, of course, result in increased coal prices. This probably will mean a delay in expansion of underground mining and thus a delay in the commercialization of new coal technologies such as gasification and liquefaction. There will be a shift toward the development of western coal reserves which can be surface mined and toward the development of in situ coal and oil shale processes in order to avoid the expense and problems associated with deep coal mining.

4.11 Fugitive Emissions from Coal Gasification and Liquefaction - Health and Safety

4.11.1 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 consensus 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 consensus 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, α -naphthylamine, β -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.

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 gasification 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.

4.11.2 Estimation of Probabilities

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. The probability that this type of regulatory activity may occur will increase to medium after 1990 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." There is therefore a high probability that some of these substances may be regulated under this carcinogen policy within the next few years (by 1985), 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 probability 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. Quantitative probabilities of such action cannot be estimated at present. It is more likely that states with a number of conversion facilities would be taking action on this issue.

4.11.3 Changes in Probabilities

Should environmental regulations appear to impede or excessively to delay the development of coal conversion technologies and at the same time, should

conversion processes be relied upon heavily for future energy supplies, it is possible to foresee legislative action temporarily exempting coal conversion facilities from some type of regulatory requirements. This may take the form of exemption from EIS preparation, exemption from specific regulations seen as "bottlenecks" to technology development, or relaxation of some types of emission or occupational exposure standards. It is expected that this would be a type of emergency action precipitated by a national crisis. It is not likely that such action would occur within the next 10-15 years, because other energy supplies are not exhausted and the conversion technologies are not yet at a stage of development where their production capabilities could sustain any significant portion of the national requirements.

An increasing societal emphasis on environmental protection would probably not change the probabilities discussed in the previous section. The regulatory procedures for addressing coal conversion health and safety problems are already underway, and additional public pressure is not likely to affect them to any great extent.

4.11.4 Discussion

At present, a number of health and safety issues relating to coal gasification and liquefaction have been identified. It is possible that additional health issues, as yet undetected, may develop and be identified as conversion technologies grow from the demonstration and pilot plant stages into commercial development. A number of existing health and safety and environmental regulations are currently in effect which pertain to coal conversion facilities, as do some proposed regulations. A number of ongoing research activities are being directed toward coal conversion health and safety issues. It is apparent that conversion technologies are receiving major research and regulatory attention from such agencies as NIOSH and EPA, and that health and safety controls will be of major concern as the technology itself develops.

4.12 Boomtown Effects

4.12.1 Legislative/Regulatory History

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. Generally, adverse impacts are regulated

through the use of permit conditions. The conditions address such issues as educational facilities, housing, utilities, and police and fire protection.

4.12.2 Estimation of Probabilities

There is a high probability that federal legislation dealing with boomtown effects will be passed by 1985. 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 without federal help.

4.12.3 Change in Probabilities

In a society more concerned about environmental and quality of life issues than at present, federal energy impact assistance legislation would almost certainly be passed by 1985, and it would probably be passed in its present form, including the provisions which allow states to veto federal approval of energy projects and which allow local officials to force an industry contribution to the impact aid program. Environmental groups would probably have

enough public support and lobbying power to force passage of the bill in spite of the energy industry's opposition. Also by 1985 and certainly by 1990, most impacted states will have passed their own legislation addressing permits and permit conditions for energy projects, siting restrictions, and alleviation of energy impacts in the absence of federal support.

In a society less concerned about environmental goals than at present, boomtown effects would still be a major concern since social as well as environmental issues are at stake. Energy impact assistance legislation would probably still be passed, possibly by 1985 and almost certainly by 1990. The two provisions of the recent bill opposed by the energy industry might be deleted since their passage would give states too much control over energy project siting in a growth-oriented society. However, the main objective of the bill, federal aid to alleviate energy impacts, would still be valid despite the emphasis on economic growth. States would also still need to develop their own programs and studies dealing with alleviation of energy impacts and would probably still draft their own legislation addressing siting restrictions and permits. However, the amount of control a state would have over energy facilities might be limited in a society where the emphasis was mainly on economic growth.

4.12.4 Discussion

It seems likely that energy impact assistance legislation which provides federal grants and loans to states impacted by energy development will be adopted as law within the next few years. Several controversial provisions of the recent bill giving states control over siting of energy facilities could be deleted before passage or could cause such legislation to be defeated. It seems almost certain that such federal legislation will be passed probably by 1985 and certainly by 1990. It also seems likely that most energy-impacted western states will draft their own legislation by 1985 or 1990 to take over where federal aid leaves off.

The predicted federal and state legislation could have a restrictive effect upon coal development. If the energy impact assistance legislation similar to the recent bill is passed, the provision dealing with state veto of energy projects could give states a great deal of control over energy siting. Restrictions on siting would result in higher costs and delays in commercialization of coal technologies. The provision of the bill which would have forced industry contributions to impact aid through permit conditions would also result in higher costs. State legislation such as that adopted by North Dakota and Wyoming would result in increased costs and delays as well because of permit condition clauses. Advanced planning and similar state or regional programs aimed at improving the quality of life in boomtowns also could cause siting restrictions, higher coal costs and time lags in energy development.

4.13 Fine Particulates from Coal, Oil, and Oil Shale Technologies

4.13.1 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 currently 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 com-

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 ($50 \mu\text{g}/\text{m}^3$ ground level concentration for a 60-minute period for a particulate size of $0.5\text{-}6.0\mu$).

4.13.2 Estimation of Probabilities

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 within 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 μm in diameter or smaller. Such a standard would encompass the fine particulates (less than 5 μm 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 CAAA. More stringent PSD regulations in the western Class I areas are a possibility. A quantitative probability and 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. Allowing identification of additional specific components of fine particulates and determination of their health effects, an increasing scale of probability (medium/high) may be assigned to the remaining time frame (1990 and 2000).

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.

4.13.3 Changes in Probabilities

The probabilities of future environmental regulatory action dealing with fine particulates will not be greatly sensitive to social trends to the extent that such action is geared toward the protection of human health, based on the known health effects of fine particulates. In a society more concerned with economic growth, such action would be welcomed because it would address only the specific pollutant known to affect health, rather than a broader class of pollutants (total suspended particulates). In a society more concerned about environmental protection, such action would be likely to be seen as more effective in protecting health and the environment than the present broad standards.

On the other hand, fine particulate standards that are designed to improve visibility or to achieve other nonhealth related goals would have a low probability of being promulgated in a future society more concerned with

economic growth. In a more environmentally oriented society, there would be increased pressure for protection of visibility, especially in pristine areas, and such standards would have a high probability of adoption by 1985.

4.13.4 Discussion

The adverse health effects of particulate matter are known to be associated with particulates of respirable size-less than 5μ in diameter. The regulatory framework within which fine particulates can be addressed is in place, and future revisions of the NAAQS for total suspended particulates may include particulate size specifications. Specific components such as lead or sulfates may also be addressed.

Revisions to the particulate NAAQS could result in more stringent controls being required for coal, oil, and oil shale technologies in order to reduce fine particulate emission to a level at which ambient standards can be met. Because traditional particulate control technologies (e.g., electrostatic precipitators, fabric filters) have lower efficiencies for removing small particles than for removing large particles, such control requirements could be difficult to meet.

4.14 Emission of Radioactivity from the Mining and Conversion of Coal

4.14.1 Legislative/Regulatory History

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 standards. 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 FWPCA as amended (1970). The NRC does not have any statutory authority to regulate radioactive emissions that result from fossil fuel activities. However, the CAAA 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 protection 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 under FWPCA, the Ocean Dumping Act, the Public Health Service Act, NEPA, and the CAA and amendments, as previously discussed. EPA has no enforcement responsibilities for radiation protection, other than those already assigned, such as for drinking water standards. Enforcement is generally carried out by NRC.

4.14.2 Estimation of Probabilities

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 ^{210}Pb . 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 will result in a medium probability that radioactivity standards, most likely in the form of NESHAPS, will be established by 1985. There is a high probability of this action occurring by 1990, and it is nearly certain to occur by 2000.

4.14.3 Changes in Probabilities

Under pressures for increased economic growth at the expense of environmental protection, the use of coal to displace imported oil would be strongly emphasized. Because of the difficulties already faced in expanding coal use, it seems likely that radiation standards would be deferred for a number of years. It is unlikely that any action would occur before 1990, and there is a medium probability that regulatory action would occur by 2000.

Increased public pressure for environmental protection at the expense of economic growth would result in a large probability of regulation of fossil energy radioactivity releases by 1985, and a near certainty that it would occur by 1990.

4.14.4 Discussion

The probability of regulatory action discussed above is based on the statutory authority of EPA to establish standards for radioactivity releases and the ongoing interest in this issue displayed by its Office of Radiation Programs.

The impact of a NESHAP for release of radioactivity would probably be to limit the use of certain coals, such as the high uranium-content lignites and subbituminous coals found in the western U.S. Additional controls beyond those currently required for stack gas cleanup are probably not feasible, and the removal of radionuclides from coal prior to combustion or conversion would be prohibitively expensive.

4.15 Nitrogen Oxides Emission

4.15.1 Legislative/Regulatory Background

The CAA 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 CAAA of 1977 require the administrator of EPA to promulgate a national primary ambient air quality standard for NO₂ 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 CAAA of 1977 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 CAAA of 1977 to conduct a study and to promulgate regulations that should become effective by 1980. The CAAA of 1977 does not require the PSD approach for NO_x 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 CAAA of 1977 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 CAAA of 1977 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 transportation 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 $100 \mu\text{g}/\text{m}^3$ (0.05 ppm) annual arithmetic average. Most states have adopted this federal standard. California has a strict short-term standard of $470 \mu\text{g}/\text{m}^3$ (0.25 ppm) measured over 1 hour.

North Dakota also has a short-term standards of $200 \mu\text{g}/\text{m}^3$ (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 $0.20 \text{ lb}/10^6 \text{ Btu}$ for gaseous fuel, $0.30 \text{ lb}/10^6 \text{ Btu}$ for liquid fuel and $0.7 \text{ lb}/10^6 \text{ Btu}$ for solid fuel.

4.15.2 Probabilities of Future 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. The probability

of having those regulations would be medium in 1985 and somewhere between medium and high in 1990. The probability would increase to somewhere between high and certain by the year 2000.

4.15.3 Changes in Probabilities

Additional regulatory actions are very sensitive to the regulatory climate mainly because the two difficulties, air quality predicting capability and having feasible emission control measures, may be overlooked by the strong public desirability of having the NO_x emissions reduced. If the society as a whole becomes more concerned about ambient air quality it is likely to call for more stringent controls on NO_x emission without adequate evidence to justify their necessity. Therefore, the probability of having additional action will be higher than that under the current regulatory climate. It may become medium to high in 1985, high in 1990, and almost certain in 2000. If the society becomes less concerned about environmental quality and the emphasis is on economic growth, the probability of having more stringent control on NO_x emission will be lower than that under the current regulatory climate. However, there is no possibility of having the current regulations relaxed because of the central role that NO_x plays in the whole set of air pollution problem. The probability of having the possible actions may become small to medium in 1985 and 1990 and medium to high in the year 2000.

4.15.4 Discussion

NO_x emissions play a central role in determining ambient air quality. Therefore, more stringent control regulations can be expected in the future. There will be great demand for more accurate methods to predict the impacts of NO_x emissions and more advanced emission control methods. Those possible regulations will have major impacts on the implementation and development of

areas with NO_x emitters, mobile or stationary. PSD regulations may restrict the future development and commercialization of fossil fuel technologies. These possible future regulatory actions on NO_x emissions may become so stringent that post-combustion reduction will be required.

4.16 Land Disturbances From Surface Mining

4.16.1 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.

4.16.2 Probabilities of Future Action

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.

Under the current regulatory climate, the probability of having some of those major regulatory actions by 1985 will be small, mainly because of the demand for coal and the low level of exposure of the impacts to the general public. The probability of having those major regulatory actions will increase to medium in 1990 and high in 2000. 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.

4.16.3 Changes in Probabilities

The future societal outlook regarding economic growth versus environmental protection will have a strong effect on surface mining regulations. Currently, the Surface Mining Control and Reclamation Act, as well as regulations developed under its authority, are the subject of controversy. Industry groups have attacked the regulations as being too restrictive and have claimed that they will significantly retard the growth in coal production from surface mining. Therefore, if society becomes more concerned about economic growth and domestic coal production is seen as a key component of that growth, there is a medium probability that some of the more stringent surface mining regulations would be relaxed by 1990.

In a society more concerned about environmental quality than at present, the probabilities of future action would not change significantly from those discussed above. The current set of regulations is likely to be seen as adequate for the near term, and pressures for additional regulation would probably not be brought to bear until surface coal mining began to expand appreciably. However, existing legislation such as NEPA and the Endangered Species Act could be expected to be invoked more frequently to protect areas considered to be particularly sensitive to the effects of surface mining.

4.16.4 Discussion

Technically, it may be difficult to reduce the toxic substances in mine effluent and drainage, to remove hazardous residuals from the overburden, to avoid contamination of groundwater aquifers and to develop special placement proceedings for overburden, yet these actions are likely to be required in the future and may have major impacts on the future of surface mining. They may aid in the reverse shift from surface mining to other advanced deep mining practices, just as the Coal Mine Health and Safety Act of 1969 has aided the shift from underground mining to surface mining. In addition, other environmental regulations, such as the EPA proposal to require SO₂ removal for all coal-fired boilers, regardless of coal sulfur content, could equally affect the future of surface mining, especially in the low-sulfur coal-bearing regions of the West.

5. DISCUSSION

5.1 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 fossil energy technologies between 1985 and 2000. As discussed elsewhere, this has been approached from two directions; by surveying environmental interests and state and federal policy and regulatory bodies, and by reviewing the environmental aspects of the major fossil 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 are listed in Table 5-1 below. 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 purposes 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 5-1. 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;

TABLE E-1. POLICY AND REGULATORY SURVEY RESULTS

<u>Generic Problems</u>	<u>Target Technologies</u>
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	
7. Visibility	<u>Specific Threats</u>
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

- (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 fossil fuel resource development threatens to degrade it.

5.2 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 5-2 shows the relationship between the technology modules (identified in a generic sense only) and the long range environmental goals by using the 16 major issues to connect environmental goals with important environmental effects of the modules. These major issues were summarized in Section 3.3. Several aspects of these results as displayed in Table 5-2 are of interest.

First, these issues span all technologies and modules--that is, they represent a broad approach to the future fossil 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 5-2. RELATIONSHIP BETWEEN LONG-TERM ENVIRONMENTAL GOALS AND FOSSIL ENERGY TECHNOLOGY MODULES

FUEL	TECHNOLOGY MODULE	LONG TERM PROTECTION OF					
		CLIMATE	WATER AVAILABILITY	WATER QUALITY	OPTIMUM LAND USE	HUMAN HEALTH	PRISTINE ENVIRONMENTS
OIL & GAS	EXPLORATION & EXTRACTION						• OCS
	CONVERSION & END USE	• CO ₂ Greenhouse Effect • Fine Particulates		• POM	• OCS (onshore facilities) • LNG	• POM • NO _x	• OCS • LNG
COAL	EXPLORATION & EXTRACTION		• Groundwater Contamination	• Solid Waste Disposal • Trace Elements • Groundwater Contamination • Land Disturbance • Radioactivity	• Solid Waste Disposal • Siting • Land Disturbance	• Solid Waste Disposal • Radioactivity • Trace Elements • Groundwater Contamination • Deep Mining - Health and Safety	• Solid Waste Disposal • Siting
	CONVERSION & 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 Particulates • POM • Trace Elements • Radioactivity • NO _x • Groundwater Contamination	• Boomtown • Solid Waste Disposal • Siting
SHALE OIL	EXPLORATION & EXTRACTION		• Groundwater Contamination	• Trace Elements • Groundwater Contamination • Land Disturbance	• Land Disturbance	• Groundwater Contamination	• Siting
	CONVERSION & END USE	• CO ₂ Greenhouse Effect • Fine Particulates	• Water Consumption • Groundwater Contamination	• Solid Waste Disposal • POM • Trace Elements • Groundwater Contamination • Land Disturbance	• Solid Waste Disposal • Siting • Land Disturbance (in situ)	• Solid Waste Disposal • POM • Trace Elements • Groundwater Contamination • Fugitive Emissions • Fine Particulates • NO _x	• Solid Waste Disposal • Siting • Boomtown

Third, most of these specific issues represent departures from the classical environmental issues which have received most attention from public and regulatory bodies in the past, for example, the CO₂ 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 facilities 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 CO₂ issue and proposals for its resolution all depend on work in progress. The same applies to toxics, trace metals, NO_x and groundwater quality issues.

5.3 Possible Impacts of Future Regulatory Actions

In previous sections we have identified 16 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 5-3 for the CAA as amended in 1977. (A brief analysis of the CAA leading up to Table 5-3 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 multimedia aspects become more important. It is apparent from Table 5-3 and the

TABLE 4-3. POSSIBLE MECHANISMS OF CAA IMPACT ON NEW AND EXISTING SOURCES¹

	(1) NSPS (Federal)	(2) RACT (Local)	(3) LAER (National)	(4) BACT (State)	(5) BART (State ²)	(6) OFFSET (Local)	MUST ALSO CONSIDER IMPACT ON (7), (8) and (9) IN ORDER TO IDENTIFY POSSIBLE ADDITIONAL RESTRICTIONS ON						
							(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
LOCATION PSD AREA	X			X	X		X	X	X	X	X	X	X
EXISTING SOURCES													
LOCATION NON-ATTAINMENT AREA		X			X ³		X			X		X	
LOCATION PSD AREA					X ³		X			X		X	

¹See Appendix C for discussion and definitions.

²EPA promulgates BART for fossil fuel generating plants with capacity greater than 750 megawatts.

³Applies 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 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

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 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 CO₂-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 CO₂ 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 5-3, that the impact of possible future environmental regulations upon the fossil fuel technologies should be evaluated.

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APPENDIX A

SUBMODULES OF THE MAJOR TECHNOLOGIES

1. OIL

1.1 Exploration

- 1.1.1 Surveying
- 1.1.2 Exploratory Drilling

1.2 Extraction (onshore-offshore)

- 1.2.1 Primary Recovery
- 1.2.1 Secondary Recovery
- 1.2.3 Tertiary or Enhanced Recovery
 - 1.2.3.1 Thermal
 - 1.2.3.2 Chemical

1.3 Pretreatment

- 1.3.1 Gas/Oil Separation Techniques

1.4 Transportation

- 1.4.1 Shipping/Receiving Terminals
- 1.4.2 Pipeline
- 1.4.3 Vehicular Transport (tanker, rail, car)

1.5 Conversion

- 1.5.1 Main Crude and Vacuum Distillation
- 1.5.2 Hydrotreating
- 1.5.3 Catalytic Reforming
- 1.5.4 Fluidized Catalytic Cracking
- 1.5.5 Alkylation
- 1.5.6 Hydrocracking
- 1.5.7 Lubricant Treating

1.6 Product Transportation

- 1.6.1 Shipping/Receiving Terminals
- 1.6.2 Pipeline
- 1.6.3 Vehicular Transport (tanker, rail car, truck)

1.7 End Use

- 1.7.1 Transportation Fuels
- 1.7.2 Electricity
- 1.7.3. Industrial
- 1.7.4 Residential

2. GAS

2.1 Exploration

- 2.1.1 Surveying
- 2.1.2 Exploratory Drilling

2.2 Extraction (onshore-offshore)

- 2.2.1 Primary Recovery
- 2.2.2 Non-nuclear Fracturing
- 2.2.3 Nuclear Fracturing

2.3 Pretreatment

- 2.3.1 Dehydration
- 2.3.2 Gas Purification

2.4 Transportation

- 2.4.1 Pipeline

2.5 Conversion

- 2.5.1 LPG and Natural Gasoline
- 2.5.2 Natural Gas and LNG

2.6 Transportation

- 2.6.1 Vehicular
- 2.6.2 Pipeline
- 2.6.3 Terminals and LNG Tankers

2.7 End Use

- 2.7.1 Residential
- 2.7.2 Electricity
- 2.7.3 Industrial

3. COAL LIQUEFACTION

3.1 Exploration

- 3.1.1. Surveying
- 3.1.2 Drilling

3.2. Extraction

- 3.2.1 Surface Mining
- 3.2.2. Underground Mining

3.3 Transportation

- 3.3.1 Conveyor
- 3.3.2 Truck
- 3.3.3 Rail

3.4 Pretreatment

- 3.4.1 Beneficiation
- 3.4.2 Slurrying

3.5 Conversion

3.5.1. Processing

- 3.5.1.1 Catalytic Hydrogenation
- 3.5.1.2 Solvent Extraction
- 3.5.1.3 Pyrolysis

3.5.2 Purification

- 3.5.2.1 Gas Treatment
- 3.5.2.2 Solid/Liquid Separation

3.6 Transportation

- 3.6.1 Shipping/Receiving Terminals
- 3.6.2 Pipeline
- 3.6.3 Vehicular (tanker, rail, truck)

3.7 End Use

- 3.7.1 Advanced Power Cycle
- 3.7.2 Industrial
- 3.7.3 Refinery Syncrude

4. COAL GASIFICATION

4.1 - 4.4 (same as 3.1 - 3.4)

4.5 Conversion

4.5.1 High Btu Gas

- 4.5.1.1 Gasification
- 4.5.1.2 Shift Conversion
- 4.5.1.3 Purification
- 4.5.1.4 Methanation

4.5.2 Low Btu Gas

4.5.2.1 Gasification

4.5.2.1 Purification

4.6 Transportation

4.6.1 Pipeline

4.7 End Use

4.7.1 Domestic heating (high Btu)

4.7.2 Advanced Power Cycle

4.7.3 Industrial (low Btu)

4.7.4 Synthesis Gas (low Btu, chemical feedstock)

5. COAL COMBUSTION

5.1 - 5.4 (same as 3.1 - 3.4)

6.5 Conversion

6.5.1 Conventional Combustion

6.5.2 Atmospheric Fluidized Bed

6.5.1.1 Combustion

6.5.1.2 Gas Purification

6.5.1.3 Solids Removal

6.5.3 Pressurized Fluidized Bed

6.5.2.1 Combustion

6.5.2.2 Gas Purification

6.5.2.3 Steam Generation

6.6 Transportation

6.6.1 Electrical Transmission

6.7 End Use

6.7.1 Lighting and Appliances

6.7.2 Machinery

6.7.3 Heating

7. MHD

7.1 - 7.4 (similar to 3.1 - 3.4)

7.5 Conversion

7.5.1 Coal Gasification

7.5.2 Seed Recycle (ionized gas)

7.5.3 Power Generation (electromagnetic induction)

- 7.5.4 Slag Separation
- 7.5.5 Seed Condensation and Regeneration
- 7.5.6 Steam Turbine-Power Generation
- 7.5.7 Solid Seed Extraction

7.6 Transportation

- 7.6.1 Electrical Transmission

7.7 End Use

- 7.7.1 Lighting and Appliances
- 7.7.2 Machinery
- 7.7.3 Heating

8. OIL SHALE

8.1 Exploration

- 8.1.1 Surveying
- 8.1.2 Drilling

8.2 Extraction

- 8.2.1 Surface Mining
- 8.2.2 Underground Mining

8.3 Transportation

- 8.3.1 Conveyor
- 8.3.2 Vehicular (rail, truck)

8.4 Pretreatment

- 8.4.1 Crushing and Screening

8.5 Conversion

8.5.1 Retorting

- 8.5.1.1 Direct Pyrolysis
- 8.5.1.2 Indirect Pyrolysis

8.5.2 Upgrading

- 8.5.2.1 Hydrotreating
- 8.5.2.2 Gas Purification
- 8.5.2.3 Distillation

8.6 Transportation

- 8.6.1 Pipeline
- 8.6.2 Vehicular (truck, rail)

8.7 End Use

- 8.7.1 Refinery Syncrude
- 8.7.2 Direct Combustion
- 8.7.3 Advanced Power Cycle

9. IN SITU OIL SHALE

9.1 Exploration

- 9.1.1 Surveying
- 9.1.2 Drilling

9.2 Extraction (N/A)

9.3 Transportation (N/A)

9.4 Pretreatment

- 9.4.1 Drilling
- 9.4.2 Fracturing (nuclear and non-nuclear)

9.5 Conversion

- 9.5.1 Retorting (in situ)
- 9.5.2 Upgrading
 - 9.5.2.1 Hydrotreating
 - 9.5.2.2 Gas Purification
 - 9.5.2.3 Distillation

9.6 Transportation

- 9.6.1 Pipeline
- 9.6.2 Vehicular (truck, rail)

9.7 End Use

- 9.7.1 Refinery Syncrude
- 9.7.2 Direct Combustion
- 9.7.3 Advanced Power Cycle

10. IN SITU COAL GASIFICATION

10.1 Exploration

- 10.1.1 Surveying
- 10.1.2 Drilling

10.2 Extraction (N/A)

10.3 Transportation (N/A)

10.4 Pretreatment

10.4.1 Drilling

10.4.2 Fracturing

10.5 Conversion (in situ)

10.5.1 Gasification (low-medium Btu Gas)

10.5.2 Purification

10.6 Transportation

10.6.1 Pipeline

10.7 End Use

10.7.1 Advanced Power Cycle

10.7.2 Industrial

10.7.3 Synthesis Gas

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 particles) from burning coal, oil and shale oil
12. Asphalt precursor emission from oil conversion
13. CO₂ greenhouse effect related to fossil fuel combustion
14. NO_x emission from burning all kinds of fossil fuel
15. CO_x 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, CO₂, H₂S, 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 in situ gasification of coal, in situ 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 H₂S, 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, 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 (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.

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 modified sources is displayed in Table C-1. Briefly, the situation is as follows:

TABLE C-1. POSSIBLE MECHANISMS OF CAA IMPACT ON NEW AND EXISTING SOURCES

	(1) NSPS (Federal)	(2) RACT (Local)	(3) LAER (National)	(4) BACT (State)	(5) BART (State) ¹	(6) OFFSET (Local)	MUST ALSO CONSIDER IMPACT ON (7), (8) and (9) IN ORDER TO IDENTIFY POSSIBLE ADDITIONAL RESTRICTIONS ON						
							(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 NONATTAINMENT AREA	X		X		X	X	X		X	X	X	X	X
LOCATION PSD AREA	X			X	X		X	X	X	X	X	X	X
EXISTING SOURCES													
LOCATION NONATTAINMENT AREA		X			X ²		X			X		X	
LOCATION PSD AREA					X ²		X			X		X	

¹EPA Promulgates BART for fossil fuel generating plants with capacity greater than 750 megawatts.

²Applies only to sources 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 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

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 independently of location. NSPS is the minimum performance control technology permitted on new or modified sources by the CAA, and is therefore a Federally specified emission standard, as indicated at the top of Column (1). 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.
- (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 at least as stringent as the NSPS.

*Postponable to December 31, 1987 for oxidants (O_x) and carbon monoxide (CO).

- (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 specified by the states, except that EPA promulgates BART requirements for fossil fuel generating plants with capacity greater than 750 megawatts.

*International parks, 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 and 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.

- (6) OFFSET - Emission offsets 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 offsets 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 offsets are available at a given calendar date in a given AQCR will depend both upon the rate of growth there, and upon the concentration reductions needed to attain the NAAQS. This can be evaluated for future years and it is important to do so. The magnitude of emission offsets 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 offsets (new sources)? If RACT and LAER are relatively stringent, then emission offsets may be essentially one-to-one. If RACT and LAER are relatively less stringent, then emission offsets may be greater than one-to-one. Depending upon relative costs of RACT, LAER and offsets, 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.
- (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 its 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. *

FIGURE C-1. BACT DECISION LOOP

*Local and distant PSD and distant NAAQS attainment requirements.