VI

ENVIRONMENTAL CONSIDERATIONS

A. INTRODUCTION

The commercial development of any new source of energy inevitably will have an impact on the environment, and coal liquefaction will be no exception.[1] Although liquefaction technology is still in an evolutionary stage, a considerable effort already has been expended to appraise the various aspects of problems related to environmental impact on a commercial scale. Although this work is incomplete and is subject to considerable controversy, it is the purpose of this Panel to summarize the current situation, to examine the ongoing program, and to draw conclusions concerning the extent and adequacy of present research and development effort on environmental problems.*

B. COAL MINING

Coal mining, with attendant beneficiation, is properly a subject distinct from coal liquefaction and has been reviewed in depth by another Panel of the Committee.[2] However, since liquefaction plants in many cases will be located at the mine mouth, the plant and its supporting mines may well be regarded as an integral system. It therefore is appropriate at this point to touch upon the major considerations related to mining.

A review of environmental problems associated with coal mining may be simplified by considering the major mining areas separately. In the Appalachian and Eastern Interior Regions (east of the Mississippi), mining practices are well established and growth by expansion of these activities can be carried out with minimum uncertainty. The required practices to achieve proper working conditions and permissible solid, liquid, and gaseous effluents are well defined.[3,4] In most cases, a favorable socio-economic impact should result.

In contrast, mining in the West (Fort Union, Powder River, and Four Corners Regions) is relatively recent, and many environmental concerns

*Readers who wish to pursue the question in greater depth are referred to the references cited; however, a study by Hittman Associates, Inc. (1975) provides an excellent background analysis of this rather complex subject.

exist. The following potentially adverse impacts of a major new industry have been cited:[5]

1. Possible disturbance of limited supplies of water (both at the surface and in subterraneous aquifers) resulting in contamination by leaching or outright loss

2. Possible inability to restore and revegetate mined-out areas because of the arid or semi-arid climate

3. Potential adverse socioeconomic and human-value effects resulting from sudden industrial population of small, previously stable agricultural communities (e.g., Gillette, Wyoming)

4. Potential destruction of wilderness areas and scenic locations (a classic example is the recently ended struggle over the siting of a major mine complex and power station at Kaiparowits, Utah, in which the involved utility companies, after a 12-year, $10-million endeavor to gain approvals and permits, abandoned the effort because of continuing adverse pressure by environmentalist groups despite approval of the project by local citizenry who welcomed the potential economic benefits[6,7])

The result of these and other environmental concerns has been an enforced moratorium for more than a year on plans for coal mining from federal leases in the West. This injunction presumably was lifted[8] with the formation of a new leasing policy by the U.S. Department of the Interior.[9] Mining now can proceed at selected western locations, but as of August 4, 1976, a new and more stringent coal leasing law was passed by Congress, overriding the veto of President Ford.

ERDA has recognized the potential environmental problems associated with large-scale mining and synfuel manufacture in remote locations; a Synfuels Environmental Advisory Board will be created with state participation to ensure that commercial projects are environmentally sound in design, construction, and operation.[10]

C. LIQUEFACTION PLANT DISCHARGES

Since coal is a friable solid containing diverse mineral compounds and heteroatoms (nitrogen, oxygen, and sulfur) in addition to carbon and hydrogen, coal liquefaction and gasification processes tend to generate, in addition to the desired hydrocarbonaceous products, a variety of potential pollutants such as fugitive dust, contaminated water, traces and major quantities of minerals (some of which may be hazardous), and complex liquid and gaseous compounds containing the heteroatoms. Thus, the costs of avoiding water, air, and land pollution from coal liquefaction are significantly greater than those associated with petroleum refining. Present estimates suggest that currently available techniques for pollution control are applicable but that meeting the environmental quality control standards that may be adopted in the 1980s could account for 15 to 25 percent of the total liquefaction plant cost.

Detailed projections of the potential solid, liquid, and gaseous pollutants from many of the liquefaction processes have been made[11-16] and will be summarized below.

1. Water Management

Most coal liquefaction plants are net consumers of water; hence, zero waste-water discharge can be achieved by recycling the water after treatment involving dephenolization, steam stripping, biological treatment, and thermal sterilization. Such treatment is expensive and consumes energy, which increases plant cost and reduces thermal efficiency. The practice is economically attractive only in areas where water resources are limited or effluent water pollution standards are extremely restrictive. The 40,000-ton-per-day Fischer-Tropsch plant now under construction in South Africa is designed for zero waste-water discharge.[17]

Where water supplies are plentiful, the total water requirements and the total waste water generated by a typical coal liquefaction plant are approximately equivalent to those associated with an oil refinery of the same capacity. Typically, 4 to 8 barrels of water are used per barrel of product (FOE)* depending on the extent of waste-water reuse. Waste water is mainly cooling tower water, boiler water, and process water blowdown, which may contain high concentrations of dissolved solids and soluble organic compounds before purification treatment.

Water requirements can be reduced by cooling with air fin-tube heat exchangers; when half of the cooling water duty is taken by air-cooled heat exchangers, the loss in thermal efficiency has been estimated to be 1.5 percentage points for a large coal conversion plant[18] as a result of increased power consumption and reduced ability to approach minimum condensation temperatures.

2. Gaseous Effluent

A major discharge from liquefaction plants is the air from the cooling towers, which may contain volatile materials stripped from the cooling water. Individual petroleum refinery towers in Los Angeles have been reported to emit from 3 to 1,500 pounds of hydrocarbons per day.[19] Similar problems can be expected for coal liquefaction plants, particularly if treated water from the process is used as cooling tower makeup.

In some coal conversion processes, other major gaseous effluents are produced in coal drying and in steam and power generation. Particulate

*The heating value of a barrel of fuel oil is typically 6 million Btu per barrel. "Fuel oil equivalent" (FOE) is a term used to express conveniently the amount of coal-derived fuels (gas, liquid, or solid) on a common thermal basis.

removal and, possibly, SO_2 and NO_x removal will be required to produce acceptable effluent gas quality.

3. Solids Discharge

The mineral matter in U.S. coals, expressed as ash content, typically varies from 5 to 15 percent. Coal liquefaction plants, like coal-fired power plants and coal gasification plants, will be required to dispose of these residue solids in an environmentally acceptable manner. In the majority of cases, the ash will be in an oxidized state as derived from hydrogen or power generation; hence, disposal means now employed by large utility stations probably will be applicable. Such means include land fill and conversion to pozzolanic cement, a finely ground hydraulic cement produced by mixing, without subsequent heating, lime and burned-out coal ash.[20]

Other solid effluents in minor quantities may include spent catalysts, sludge from flue-gas desulfurization treatment, and sludge from evaporated aqueous process condensates, which may be high in halogens and soluble organic materials. These materials are usually not inert under ambient conditions and may require special treatment before disposal.

4. Trace Elements

The number of trace elements in coal is much greater than that in petroleum; some 38 elements (other than carbon, hydrogen, and oxygen) have been identified in widely varying concentrations.[21] The fate of these elements in the liquefaction processes is not clearly understood; some are volatile, others associate with the liquid in hydrogenation processes, and the remainder with the solid residue or ash.

Much additional work is required to establish both the distribution of these materials during processing and their environmental impact after processing. It is particularly important to identify those elements that may ultimately appear in the liquid product and to determine that they will have no adverse impact when the liquid is used.

5. Appraisal of Emissions Impact: Current Status

The major aggregate impacts of multiplant synthetic industries on various sections of the country have been estimated in a 1975 draft Environmental Statement by ERDA and the Department of the Interior. For most of the developing liquefaction processes, complete data on emissions have not been obtained. To a considerable degree, however, it appears that technology exists for proper control of the identified pollutants.

New Source Performance Standards (NSPS) for coal liquefaction have not yet been proposed by EPA; efforts in this area will begin after the promulgation of NSPS for gasification. It is to be hoped that such standards, when they do emerge, comply with the objectives of Section 111 of the Clean Air Act--i.e., to reflect the best degree of demonstrated control, taking cost into consideration.[22] As pointed out by Rubin and McMichael,[23] waste-water standards and air-quality standards may profoundly influence the design, economics, and siting of coal conversion facilities.

D. OCCUPATIONAL EXPOSURE

1. Noise

Mining, mechanical conveying, and size reduction of coal are particularly noisy operations, and careful shielding design is needed to reduce noise to the levels required by the Occupational Safety and Health Act (OSHA). The remainder of the coal liquefaction plant is comparable in noise generation to oil refineries and should create no unusual problems.

2. Health

A recent EPA Study[24] based largely on coke-oven emissions suggests that over 200 potentially hazardous compounds may be produced by the coal liquefaction processes under development. In particular, the problem of carcinogenic effects on humans engaged in coal combustion and distillation has been observed for over 200 years.

Specific studies of the carcinogenic properties of synthetic liquid fuels were carried out by the National Cancer Institute in the 1950s. Oils from the Bergius (coal hydrogenation) process were found to be potent in generating cancer in mice both by cutaneous application and by injection. In contrast, the essentially aliphatic Fischer-Tropsch oils did not produce skin cancer; however, liver degeneration was noted in animals exposed to Fischer oils and liquors.[25]

Confirmation of these Bergius oil findings with human beings (as well as mice) occurred during the 7-year operating program of a 300-ton-per-day coal hydrogenation plant by Union Carbide at Institute, West Virginia, during the 1950s. The operations established that cutaneous contact with the higher-boiling-point fractions of hydrogenated oil, by either accidental wetting or droplet "fall out" from vapors and fumes, could greatly enhance the potential for skin cancer. An appropriate industrial hygiene, health education, and medical inspection program was adopted and carried out.[26-29]

Experience in the steel industry has established that the lung cancer mortality rate for those employees who work on the top of slot-type coke ovens ("lid men") is 10 times greater than that of other steel mill workers.[30] This is clearly related to the inhalation of coke-oven fumes that escape from the oven charging ports during the cyclic process. In contrast, coal liquefaction and gasification processes are continuous operations wherein uncontrolled emissions will not occur in normal operation.

The Union Carbide work and many other independent studies have identified polynuclear (4- and 5-ring) aromatic hydrocarbons (variously referred to as PAH and PNA) as primary sources of carcinogenic hydrocarbons.* Benzo(a) pyrene, benzo-(a) anthracene, and benzo-(c) phenanthrene are established carcinogens in coal oil fractions,[26-29] aromatic petroleum fractions,[31,32] and shale oils.[25] These materials have an atmospheric boiling point of 315 to 540 °C; lower-boiling-point fractions from the same oils apparently had less or no carcinogenicity in repetitive cutaneous applications.[32]

Available data on the carcinogenicity of products from processes currently under development are limited. Samples of solvent refined coal (SRC), solvent, and heavy hydrogenated SRC prepared from Pittsburgh seam coal at the ERDA Cresap pilot plant in 1970 were tested in cutaneous applications with mice at Kettering Laboratory. As compared to benzo-(a) pyrene, a solution of SRC was weakly carcinogenic, and the hydro bottoms and solvent were moderately potent.

The hygienic practices and medical surveillance employed by most organizations now engaged in liquefaction process development fully reflect the Union Carbide experiences. Similar practices are employed on a commercial scale by SASOL, with a reported complete absence of carcinogenic reaction by the workmen. The basic principle involved is the avoidance of prolonged contact with the potential carcinogenic materials; this requires bathing at the end of a workday, laundering work clothes each day, and inspection to establish the complete removal of carcinogens.

E. COMMUNITY EXPOSURE

Concern has been expressed about the risk to adjacent communities that may arise from synthetic fuel manufacture.[33] Coal liquefaction and gasification, like petroleum refining and most modern chemical processes, are carried out in continuous, closed systems so that uncontrolled emissions to the atmosphere will not occur in a well-designed commercial plant during normal operation.

Based on present knowledge of processes and emissions, the Panel sees no reason for the potential exposure of a community to environmental hazards from an adjoining coal liquefaction plant to exceed that from other existing controlled industrial operations. This position is supported by extended operations of a commercial coal gasification plant (15 years) in Scotland and a commercial coal liquefaction plant (20 years) in South Africa without apparent adverse impact on adjoining communities.

F. CONSUMER EXPOSURE

The available data are insufficient to permit categoric definition of the potential risks that the consumer of coal liquids might encounter

*Such materials are now believed to be mutagenic as well.

in ordinary use. Available evidence suggests that:

1. Fischer-Tropsch oils, regardless of boiling range, are free of polynuclear aromatic hydrocarbons and are, in the main, straight chain paraffins and olefins. As such, these liquids would be expected to be no more hazardous in handling than petroleum stocks. This conclusion is supported by extended commercial experience by SASOL.

2. Gasoline fractions from coal liquefaction, after finishing hydrogenation operations, should be essentially indistinguishable from highly aromatic petroleum products of the same boiling range.

3. Distillate fuel oils (boiling between 205 and 540 °C) produced in coal hydrogenation (and coal pyrolysis) will contain relatively high concentrations of polynuclear aromatics and nitrogen compounds. Because of these higher concentrations, they probably will be more carcinogenic than typical petroleum fractions in the same boiling range. Precautions will be required in handling and containment to avoid fume inhalation or prolonged cutaneous contact.

4. Heavy hydrogenated residual fuels and SRC also will require special precautions to avoid prolonged contact. Inhalation risks are reduced by the low vapor pressure of these high-molecular-weight products.

The lighter distillate oils boiling in the No. 1-No. 2 fuel oil range (205 to 425 °C) may be used for domestic heating. It is probable that these oils are mildly carcinogenic; as a result, the consumer will be required to observe reasonable hygienic practices. There appears to be little additional hazard over petroleum stocks introduced by use of these coal-based oils if repeated and prolonged cutaneous contact is avoided.

C. COMBUSTION CHARACTERISTICS

The development of liquid fuel from coal is being pursued to:

1. Convert high-sulfur coal into environmentally acceptable boiler fuel for use in fossil-fuel-fired boilers

2. Convert coal into environmentally acceptable gas turbine fuel for "peakers" and combined-cycle systems

3. Convert coal into environmentally acceptable transportation fuels such as diesel fuel and gasoline

The urgency to achieve the first objective is high in view of existing boiler emission regulations, which have been imposed by EPA and local authorities and which require early compliance by hundreds of boilers now burning high-sulfur coal or imported fuel oils. The urgency to achieve the second objective is only slightly less since many combined cycle systems are already in the design or construction stage (particularly on the West Coast). Production of transportation fuels from coal is a relatively longer range objective (except where these materials are by-products from operations to produce heavier fuels).

1. Liquid Boiler Fuels

Table 15 gives NSPS for steam generation equipment as promulgated by EPA under the Clean Air Act Amendments of 1971 as well those of San Bernardino and Los Angeles Counties, which are among the many urban areas that have established more severe standards. The objective of a number of processes described in Chapter IV of this report is to produce by mild hydrogenation a relatively low-cost heavy fuel that will burn in compliance with these emission standards. SRC (PAMCO), H-Coal, Synthoil, and Gulf CCL are examples of these processes.

Table 15 New Source Performance Standards for Steam Generation Equipment Promulgated by EPA and San Bernardino/Los Angeles Counties

Maximum Emission	EPA	Los Angeles/ San Bernardino[a]
SO_2, lb/MM Btu liberated	0.80 (1.20)[c]	0.020
NO_x[b] lb/MM Btu liberated	0.30 (0.70)[c]	0.014
Particulates, lb/MM Btu liberated	0.10 (0.10)[c]	0.001

[a]Calculated for a 1,000 MW boiler. Applicable to all new power sources (boiler, gas turbine, etc.) in the following units: SO_2-200 lb/hr, NO_x-140 lb/hr, particulates-10 lb/hr.
[b]Expressed as NO_2.
[c]For solid fuel.

Heavy fuels produced by mild hydrogenation from coal are unlike residual petroleum fuels in that they are relatively deficient in hydrogen (thus enhancing possibilities for soot production) and relatively rich in nitrogen. Combustion tests are necessary to confirm compliance with emission standards even when fuel inspections show that sulfur and particulate contents are acceptable.

Limited small-scale firing tests have been reported using samples of heavy fuels made from Eastern high-sulfur coals. Fuel inspections and primary combustion results are given in Table 16. These tests were carried out by different experimenters in differing test equipment; thus, the results may not reflect the fuel properties alone. In each test, decreasing excess air reduced NO_x but increased soot production. In the SRC test (Illinois coal), two-stage firing (with a total of 20 percent excess air) reduced the NO_x level to 58 percent of the value reported above without significant particulate emission.

Table 16 Composition of Coal-Derived Fuels and Resulting Combustion Emissions

	Fuel and Coal Source			
	SRC	SRC	Synthoil	Gulf CCL
	Pgh. No. 8	Ill. No. 6	Ky. No. 11	Pgh. No. 8
Fuel Analysis	(Percent)			
C	87.0	87.30	87.9	89.00
H	05.8	05.84	08.9	09.44
N	01.9	01.87	00.4	00.50
O	04.6	04.21	--	--
S	00.7	00.66	00.5	--
Ash	<0.1	00.12	01.5	00.13
HV Btu/lb	15,200	15,800 (est.)	17,500 (est.)	18,000 (est.)
At 20 Percent Excess Air				
NO_x as equiv. % of fuel Nitrogen	23	38	16	45
Approx. lb NO_x/MM Btu	0.94	1.30	0.12	0.41
Particulates lb/MM Btu	0.17	--	0.53	--

While these results are not sufficient to meet EPA emission requirements for liquids, they do suggest that SRC and heavy fuel oils might be burned commercially in compliance with EPA standards (assuming that fuel sulfur content and particulate content are sufficiently low) by extension of the present firing practices used in existing boilers designed for heavy fuel oil (i.e., two-stage combustion, recirculated flue gases, and stratified firing patterns). However, it must be recognized that such techniques have achieved only limited success when applied to coal combustion in full-scale tests. It also should be recognized that the coal-based heavy fuels, because of their asphaltene content, are incompatible with most heavy petroleum fuel oils. Thus, in commercial practice, a boiler must be equipped with dual fuel systems or, alternatively, be in a position to rely completely on one source of fuel oil.

In the event that these coal-based heavy fuels do not prove to be commercially acceptable, additional hydrogenation can be employed to improve their combustion characteristics (at an added cost). It is not clear at this point whether this would be more economically achieved by increasing the severity of the initial production conditions or by adding a subsequent hydrorefining operation.

2. Gas Turbine Fuels

Gas turbines are of considerable interest to the utility industry because of their low capital requirement per kilowatt of generating capacity and the potential high efficiency of combined cycles. Accordingly, the manufacture of acceptable gas turbine fuel from coal is receiving serious study.

By virtue of the intense combustion conditions and the subsequent contact between flue gas and turbine blades, it is important that gas turbine fuels be essentially solids-free and clean burning at elevated temperatures and that complete combustion occur with low NO_x and SO_2 emissions. The NSPS for gas turbines have not yet been issued by EPA, but a few regional authorities have issued standards.

The emission figures cited in Table 15 for Los Angeles and San Bernardino Counties translate into a 120-MW combined cycle unit burning distillate oil of the following specifications:

Sulfur	0.08 percent maximum
Nitrogen	0.01 percent maximum
Ash	10 ppm maximum

Additional properties that make a premium turbine fuel are a hydrogen content in excess of 12 percent and an aromatic content of less than 35 percent, both of which assist in obtaining complete combustion.

Distillate oils produced by catalytic hydrogenation of coal have nitrogen contents that vary inversely with their boiling point.[34] A typical distillate in the turbine fuel boiling range would contain 0.31 percent nitrogen as compared with a petroleum stock that would contain 0.01 percent nitrogen.[35] Thus, it is apparent that the production of acceptable turbine fuels from coal will require secondary processing over specific catalysts to approach the desired nitrogen level. While this probably will add significantly to the costs of these fuels, experimental verification of this point is needed. Alternatively, it may be possible to alter the turbine combustion operation (e.g., by water injection) to tolerate fuels of higher nitrogen content, but again, experimental verification is required.

Summarized in Table 17 are data of interest on emissions from a gas turbine operating with an 1,800 °C combustor outlet temperature. The proposed EPA emission limit for oil-fired units is 70 ppm NO_2. These data suggest that methanol from coal would be an ideal turbine fuel and this probably is also true of Fischer-Tropsch distillates that are free of nitrogen, sulfur, and particulates. These two fuels are generally considered to be more expensive than distillates from coal hydrogenation; however, this may not be the case if intensive secondary processing of oils from coal hydrogenation is required. Methanol and Fischer-Tropsch liquids have the added advantage that their manufacture has been demonstrated completely on a commercial scale.

Table 17 Emission from a Gas Turbine[36]

Fuel	Emissions, ppm NO_2	CO^a
Methanol	20	15
400 Btu Gas (CH_4+ N_2)	40	48
Natural Gas	60	70
No. 2 Fuel Oil, 80 ppm N	95	20
No. 2 Fuel Oil, 0.2% N	138	20

[a]Dry volumetric basis.

3. Transportation Fuels

Little information is available on the gasoline and diesel fuel fractions that can be produced from coal; however, it is reasonable to expect that environmentally acceptable products can be produced if a sufficiently severe secondary treatment is employed. Primary distillates from coal hydrogenation in the gasoline range (C_5 to 205 °C) average about 0.08 to 0.10 percent nitrogen; this will be reduced to less than 1 ppm if reforming is used to produce a finished gasoline. It is interesting to note that, despite the low chemical nitrogen contents of the fuel now employed, transportation is the source of nearly half of the total U.S. NO_x emissions.[37] This is the result of atmospheric nitrogen fixation caused by high combustion temperatures in internal-combustion engines.

H. RESEARCH AND DEVELOPMENT--NEEDS AND ACTIVITIES

1. Needs

It is apparent from the foregoing discussion that, for each liquefaction process of potential commercial interest, an extensive environment-oriented research and development effort must be completed to:

a. Detect, characterize, and develop control technology for the process effluents that may have adverse health or environmental impact

b. Establish the hazards associated with the process operation and its products and develop appropriate control technology

c. Test the utilization of the products under simulated commercial conditions and develop such modifications to the liquefaction process or the fuel-consuming equipment as may be necessary to achieve acceptable combustion performance and emissions

2. Establishment of New Source Performance Standards

Under the authority of the 1970 Clean Air Act Amendments and the 1972 Federal Water Pollution Control Act Amendments, the EPA will issue NSPS for coal liquefaction processes. It is essential to recognize that coal and petroleum have different processing characteristics and that coal liquefaction products and petroleum stocks have different properties. Because of the costs that may result from forcing coal processing and coal liquids to conform to standards established for petroleum, the Panel recommends that the merits of each proposed standard for coal liquefaction plants and coal liquid utilization be thoroughly examined and debated before promulgation.

3. Research and Development Activities

Current research and development activities related to environmental problems (including the impact of coal liquefaction) are very extensive and involve many departments of the government. Some of the agencies and activities focused specifically on coal conversion are described below.

a. Council on Environmental Quality

The Council on Environmental Quality (CEQ) was created in the Executive Office of the President under the National Environmental Policy Act of 1969 (NEPA). The duties of the CEQ include:[38] (1) conducting investigations, studies, research, and analyses relating to ecological systems and environmental quality; (2) reporting at least once each year to the President on the state and condition of the environment; and (3) utilizing, to the fullest extent possible, the sources, facilities, and information of public and private agencies in order to avoid duplication of effort and expense.

Subsequently, the Environmental Quality Improvement Act of 1970 and the NEPA Amendment of 1970 created the Office of Environmental Quality with the chairman of the CEQ as Director of the Office. As amended, the CEQ responsibilities include: (1) coordinating federal programs related to environmental quality, (2) determining the need for new policies and programs for dealing with environmental problems not being adequately addressed, and (3) initiating research and analysis where necessary. CEQ is directed to evaluate ERDA programs and report immediately the probable environmental consequences of trends in the development and application of energy technologies.

The role of the CEQ to date appears primarily to have been one of overseeing and annually reporting trends and activities related to the national and global environment rather than one of actively coordinating ongoing environmental research and development. In addition, under NEPA, the CEQ oversees implementation of the Act, including the process of preparing Environmental Impact Statements. The CEQ receives all Environmental Impact Statements as prepared by the appropriate federal agency, verifies that proper procedures have been followed, and maintains up-to-date records.

The CEQ advises that two reports which relate to coal liquefaction are in preparation and scheduled for publication in 1977. The first of these is entitled "CEQ Assessment of Environmental Problems and Conservation in Energy R&D," and among other subjects, the relative roles of ERDA and EPA will be examined. The subject of the second report (being prepared by Energy Resources Company of Cambridge, Massachusetts) is the problems and research needs of coal-based conversion processes.

b. U.S. Environmental Protection Agency

In addition to its functions of formulating, promulgating, and enforcing standards related to the control of environmental pollution and emission of hazardous materials, the EPA carries on a research and development program in pursuit of technological controls of all forms of pollution. Further, the EPA has a considerable responsibility for coordinating interagency effort on environmental research and development.

In November 1974, an interagency working group, chaired by the CEQ, published at the behest of the Office of Management and Budget a major federal research and development program related to the environmental aspects of energy use. This program is presented in two reports: The Gage report[39] dealing with evironmental control technology for energy systems and the Muir/King report[40] dealing with health and environmental effects of energy use.

In mid-1975, the EPA formed an Advanced Fossil Fuel Sector Group (AFFSG) to coordinate efforts and maintain relations and information exchange among the many federal agencies and the private groups specifically involved in developing and regulating new fossil fuel sources. EPA's 1975 expenditures for energy research and development were $90 million; $100 million was budgeted for 1976. A considerable portion of this funding is "passed through" to other agencies for specialized research and development in implementation of the Gage and Muir/King programs.

The initial activities of the AFFSG have been concerned primarily with the information, technology, and activities related to first-generation gasification plants. Tentative NSPS are in preparation for these developed processes. Items for current and future consideration are second-generation gasification, shale oil production, and coal liquefaction.

The EPA "in-house" research center at Research Triangle Park, North Carolina, is primarily responsible for health effects research; the Cincinnati, Ohio, facility is the center for pollution control technology and engineering research; the Corvallis, Oregon, center is for ecological systems research; and the Las Vegas, Nevada, center is for monitoring systems.

EPA plans are presented in the document, "Environmental Problems and Research and Development Program."[41] It is apparent that some duplication of ERDA effort may occur since plans to build small coal liquefaction and gasification units at the Research Triangle Park center to support control technology development are outlined.

Status reports on EPA programs (1975 and 1976) are available and recognize the need for greater cooperation and coordination of EPA and ERDA efforts and for development of a coordinated program. Also expressed is a similar need for greater interaction between industry and EPA at the earliest possible point in a process development program.

c. U.S. Energy Research and Development Administration

In conjunction with the development of liquefaction processes, ERDA is carrying out (or subcontracting) additional programs devoted to resolution of environmental concerns (emissions, trace elements, occupational hazards, and product utilization characteristics). The process development units and pilot plants generally incorporate the best available technology for emissions control.

Gasification and liquefaction research at the ERDA Energy Research Centers (in Pittsburgh, Pennsylvania; Morgantown, West Virginia; Grand Forks, North Dakota; and Laramie, Wyoming) is funded through the ERDA Office of Fossil Energy. Programs and design philosophy with regard to the resolution of environmental concerns are under the supervision of that Office.

ERDA assigns work under contract to the national laboratories whereever the research needs fit the available specialized expertise. Current environmental work planned at Oak Ridge is a balanced program plan prepared for the ERDA Division of Biomedical and Environmental Research (DBER). The environmental program includes characterization of effluent streams, biomedical research on toxicological properties, and development of quick methods for determining the potential presence of pollutants.

The ERDA Office of Environment and Safety serves the ERDA Administrator in an advisory capacity with regard to the adequacy of the provisions for environmental control and safety in all ERDA projects. In addition, the Office contracts for additional research and development when deemed necessary; the Oak Ridge program of the DBER is under this Office.

d. Other Agencies

According to the plans set forth in the Gage and Muir/King reports,[39,40] reseach and development work related to the environmental aspects of coal liquefaction may also be under way at other agencies such as the Federal Energy Administration; U.S. Department of the Interior; Bureau of Indian Affairs; National Science Foundation; U.S. Geological Survey; National Aeronautics and Space Administration; National Institute of Occupational Safety and Health; Department of Housing and Urban Development; Department of Commerce; Tennessee Valley Authority; U.S. Department of Agriculture; National Oceanic and Atmospheric Administration; and the U.S. Department of Health, Education and Welfare. This Panel has not attempted to determine the extent of such efforts or the degree to which they complement, supplement, or duplicate other work sponsored by ERDA, EPA, or industry.

I. RECOMMENDATIONS

This Panel believes that a long-range environmental research program, effectively integrated with the evolving coal liquefaction technologies, is essential if the ultimate commercialization of these technologies is to be carried out on an environmentally sound basis. The Gage[39] and the Muir/King report[40] represent an excellent initial program of environmental research that should be revised as necessary to reflect the needs revealed by the liquefaction process research and development.

If such a long-range program is to be successful, improved cooperation between industry, EPA, ERDA, and the other agencies involved is essential. Responsibility for coordination of effort, for elimination of duplication, and for maintenance of a high level of research quality should be assigned to some "neutral" executive office; as understood by this Panel, such responsibility already rests implicitly with CEQ.[38,42] The responsible office will require a sufficient staff of qualified professional people to carry out a continuing appraisal of the entire environmental program.

This Panel sees no reason why commercial coal liquefaction plants that incorporate the appropriate pollution control equipment and industrial hygiene practices and facilities will pose any unusual environmental hazards to employees or residents of adjacent communities. Accordingly, the Panel recommends accelerated development of promising new liquefaction technologies together with the associated environmental research and development.

This Panel is not aware of any document that presents a periodic review of the combined efforts of the environmental aspects of coal liquefaction; thus, it is not possible to appraise the status of resolution of known problems, to consider new problems that may arise, or to evaluate the need for changes in proposed emission standards. The Panel believes that a brief (25-30 page) overview of the progress, achievements, and outstanding problems should be prepared and issued at reasonable intervals for public persual. This function could best be carried out by the office responsible for program surveillance.

Because of the costs that may result from forcing coal processing and coal liquids to conform to standards established for petroleum, this Panel recommends that the merits of each proposed standard for coal liquefaction plants and coal liquid utilization be thoroughly examined and debated before promulgation.

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