Air Resources

From an air quality perspective, synthetic fuel development will have the greatest impact in the Eastern and Rocky Mountain Coal Provinces. Rugged terrain and existing air quality regulations may make it difficult to site in some air quality control regions in the Eastern Province (Table 3-3). For example, several of the major coal producing areas of Kentucky and Tennessee are currently classified as nonattainment areas. In the West, existing air quality is excellent in the Northern Great Plains and good in most of the Rocky Mountain Region. However, complex topography and the numerous Class I PSD areas could constrain some developments in the Rocky Mountain Province (Univ. of Okla., S&PP 1981).

Water Resources and Aquatic Ecosystems

Synthetic fuel development will impact stream and riparian ecosystems in several ways:

- Consumption of between 3,500 to 5,900 AFY of water (for a 50,000 bbl/day plant), depending on the location and design;[1]
- Continuous and intermittent discharges of wastewater, which can degrade water quality and amplify stream flow variations;
- Water pollution from synfuel plants due to accidents and floods, and spills from product transport;
- Dissolved solids and sediment loading due to runoff from surface mines; and
- Acid mine drainage from surface and underground mines, especially in the East.

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[1]Although coal liquefaction facilities consume significant quantities of water, on a per-Btu basis they consume 3 to 4 times less water than power plants (see Ballard et al. 1980).

TABLE 3-3: AIR QUALITY CHARACTERISTICS AND PROBLEMS

Province	Existing Quality (No. of PSD Class I areas)[a]	Meteorological Pollution Potential (days)[b]	Terrain	Implications
Eastern	Numerous nonattainment areas; Some Class I PSD areas (7)	High 30-40	Rugged (plume impaction	Sensitive to siting in industrial and rural areas
Interior	Numerous nonattainment areas; Some Class I PSD areas (5)	High 20-40	Flat to rolling hills	Sensitive to siting in industrial areas
Rocky Mountain	Nonattainment areas in central cities; Numerous Class I PSD areas (46	Moderate (0-20 potential pollution days)	Very rugged (plume impaction) potential stagnation	Very sensitive to siting; potential limitations to big levels of development
Northern Great Plains	Some attainment areas; Some Class I PSD areas (9	Low (0- 0)	Flat	Fewer air quality limits to development
Gulf Coast	Nonattainment areas in central cities; Few Class I PSD areas (1)	Low (0- 0	Flat	Limitations to development in some industrial areas

[a]PSD Class I areas within 300 miles of coal deposits; compiled from Garvey et al. 1978.

[b]Total number of forecast days of high meteorological potential for air pollution (U.S., DOE 1979).

Degradation of floodplain productivity and wildlife habitat as well as aquatic habitat could accrue from these changes. The extent of that degradation, however, will be critically dependent on site-specific conditions. Also, these impacts and issues are highly uncertain and controversial because such changes are difficult to quantify and are usually the cumulative result of many human activities.

As indicated in Tables 3-2 and 3-4, from a water availability perspective, the Eastern Region is more suitable than other regions for synthetic fuel development. Water is more abundant there although conflicts over appropriate use are emerging (Ballard et al. 1980). In the West the lack of precipitation causes water availability problems--most severe in the Colorado River Basin and in parts of the Northern Great Plains Region. From a water quality perspective, however, eastern locations are already receiving a great range of industrial and municipal discharges. In these locations, water quality may be least suitable for receiving discharges from coal liquefaction plants.

Terrestrial Ecosystems

The large coal requirements for a synfuels industry can lead to substantial land impacts, especially those associated with mining. A midrange estimate for the area of mined lands disturbed for coal liquefaction can be obtained by disaggregating coal supply to eight national coal supply regions and utilizing estimates of land area disturbed by surface mining based on average regional coal deposit characteristics (see Table 3-5). This results in a production

TABLE 3-4: WATER RESOURCES AND AQUATIC ECOSYSTEMS: CHARACTERISTICS AND PROBLEMS

Province	Ecosystem Types	Existing Primary Stresses	Coal Liquefaction Effects	Implications (primary problems)
Eastern	Mid and low altitude lakes; primarily continuous flowing streams and rivers	Eutrophication; acidification; siltation; organic and inorganic pollution	Discharges to receiving stream; water consumption; potential groundwater pollution; spills	Sensitive to incremental organic and inorganic pollution; additional impoundments (water quality)
Interior	Low altitude lakes; primarily continuous flow streams	Eutrophication, acidification, siltation	Discharges to receiving streams; water consumption; potential groundwater pollution; spills	Sensit[illegible] to [illegible]l organic inorganic [illegible]ution (water [illegible]lity)
Rocky Mountain	High altitude lakes; continuous and intermittent stream types	Siltation; some pollution; impoundments	Water consumption; potential ground water pollution; spills	Sensitive to stream flow reduction (water availability and habitat modification)
Northern Great Plains	Continuous and intermittent streams	Siltation; eutrophication	Water consumption; potential groundwater pollution; spills	Sensitive to additional biological oxygen demand; local stream flow reduction (water availability)
Gulf Coast	Coastal lagoons, marshes; estuaries; broad rivers and flood plains	Drainage; filling; eutrophication	Water consumption; potential groundwater pollution; spills	Sensitive to population growth and habitat modification; pollution (water quality habitat modification)

TABLE 3-5: ANNUAL PATTERN OF LAND USE FOR COAL SURFACE MINING PROJECTED IN 1985

Supply Region	Regional P report ion of Total U.S. Surface Mining Production[a]	Proportion of Coal Surface Mined Within Each Region (%)	Surface Area Disturbed (acres per million tons production)
Northern Appalachia	12	47	127
Central Appalachia	13	31	214
Southern Appalachia	2	57	125
Eastern Interior	16	48	160
Central and Gulf Coast	9	98	107
Northern Great Plains	40	100	21
Rocky Mountains	1	38	102
Southwest	7	98	52
	100		
U.S. Average (production weighted)		62	98

Source: Based on data in U.S., DOE 1979.

[a]Projected total U.S. coal production of 1,080 tpd by 1985; 671 tons are surface mined (U.S., DOE 1979).

weighted U.S. average of 98 acres disturbed per million tons of coal produced by surface mining. Thus, a two million bbl/day synfuel industry utilizing 300 million tons of coal a year (with 62 percent surface mined) would disturb about 850 square miles from surface mining over a 30 year period.[1] Note this figure does not

[1]The projected patterns are based On a major use for coal as an industrial and boiler fuel; thus, it may be biased against Interior and Appalachian coal, which is most suitable for direct processes (see Section 3.1) . A shift to using greater proportions of Appalachian and Interior coals would favor underground mining and might reduce the extent of surface disturbance. This reduction would be counterbalanced to some extent by larger areas disturbed per ton of coal supplied from surface mines in the Interior and Appalachian regions (Table 3-5).

include surface disturbances from underground mining, such as coal cleaning areas, storage or subsidence effects.

In addition to mining, terrestrial ecosystems are modified by transportation, processing facilities, solid waste disposal, and by urban growth associated with increased industrialization. Impacts from coal liquefaction activities are related to the degree that modifications to terrestrial environments can be assimilated or “absorbed” by the ecosystem. In areas with rich soils and moderate-to-high rainfall such as the Gulf Coast, Interior, and Eastern provinces, regrowth of vegetation occurs comparatively rapidly following a disturbance such as surface mining. However, some characteristics of the Eastern Province such as complex topography, make restoration of environmental features difficult and contribute to reclamation problems. Table 3-6 identifies some general characteristics of terrestrial ecosystems in the major coal producing regions where coal liquefaction may occur.

Based on the existing patterns of communities and stresses, the Gulf Coast terrestrial ecosystems appear able to absorb mining impacts substantially, and regrowth of dominant plant species is quite rapid. In the Eastern sections of the Gulf Coast Lignite Province, for example, forest areas act as an additional buffer, providing capacity for significant local and regional development.

In contrast, the arid and semiarid regions of the Rocky Mountains have a slower regrowth, and animal species are less buffered by dense forest stands in many areas. Thus, Rocky Mountain

TABLE 3-6: TERRESTRIAL ECOSYSTEMS: CHARACTERISTICS AND PROBLEMS

Province	Ecosystem Types	Existing Primary Stresses	Coal Liquefaction Effects	Implications (problem importance)
Eastern	Pine forest; maple, oak, hickory forests; agricultural lands	Urban growth, mining	Increased mining; industrial growth; localized deforestation	Numerous stresses; ecosystems somewhat resilient (ecosystems can absorb some coal liquefaction development)
Interior	Oak-hickory forest; grasslands; agricultural lands; pine forests	Urban growth; mining; agriculture	Increased mining; industrial growth; localized grassland and crop removal	
Rocky Mountain	Subalpine forest; ponderosa pine forest; sagebrush grassland	Urban growth; mining; recreational activities; and local land conversion	Increased mining; industrial growth locally near required transportation corridors; local deforestation	Numerous stresses; some ecosystems relatively fragile (ecosystem can absorb relatively little development
Northern Great Plains	Grassland; cropland; riparian deciduous trees; pine forests	Agricultural development	Increased mining; industrial growth	Comparatively few stresses, ecosystems resilient (ecosystem can absorb substantial development)
Gulf Coast	Grassland; cropland; pine forests	Urban growth; agriculture; industrial development	Increased mining; industrial growth	Numerous stresses but ecosystems resilient (ecosystems can absorb substantial development)

terrestrial ecosystems are more sensitive to direct disturbances than Gulf Coast or Eastern ecosystems.

Linkage Between Air, Water, and Land Resources: Acid Rain

Synthetic fuel facilities produce NO_x and SO_x, and these pollutants in combination with moisture in the air form nitric acid and sulfuric acid--acid rain. Particles containing sulfate, nitrate, and chlorides can also settle from the air without atmospheric moisture. These particles can then acidify soils, streams, and lakes. Although acid rain has been a problem associated primarily with the Northeast, it is now spreading to the Southeast and perhaps even to the West. In all these regions, 10 to 50 percent of the acid deposition may be dry (Kerr 1981). The possible damage in reduced productivity and loss of species over the long term is highly uncertain with present knowledge, but may be very significant (U.S., EPA, ORD 1980). Multiple coal liquefaction plants could contribute to a significant proportion of the NO_x and SO_x emissions as measured against 1975 levels of emission (Table 3-7).

Even in regions where existing air pollution levels are low, such as the Rocky Mountains and Northern Great Plains, localized acidification has been measured. Although both the levels of development and potential impact in western regions are uncertain, possible elevated levels of sulfur and nitrogen oxides (as illustrated in Table 3-7) raise concerns in the Rocky Mountain and Northern Great Plains Region because of plant species known to be sensitive to acidification, including pines and wheat (U.S., EPA, ORD 1980; White *et al*. 1979). Thus, acid rain and dry deposition

TABLE 3-7: EXAMPLES OF POTENTIAL CONTRIBUTORS TO ACID RAIN (thousands of tpy)

	A Local Case		A Regional Case	
	260,000 bbl/day in Henderson Co. Kentucky[a]		One million bbl/day Liquefaction in Montana, North Dakota, and Wyoming	
Conditions	SO_2	NO_x	SO_2	NO_x
1975-1976 Emission Level	266	57	1,123	339
Synfuel Plants[b]	50	74	110	110
Percent Increase	23%	130%	10%	*32%*

[a]See Enoch 1980.

[b]Note range of emissions among regions reflects different coal composition and technology combinations.

stemming, in part, from synthetic fuels development are likely to remain an ecological issue and to increase in importance as an agricultural issue.

Overall Ecological Characteristics

Finally, there are unique and special values associated with the wilderness character of some areas--particularly the Rocky Mountain region--which could be changed by large scale synfuels development. A desire to preserve the "Big Sky Country" and the "wide open spaces" is expressed by citizens across the U.S. Coal mines, liquefaction plants, and other energy facilities, along with the added population increases would:

- Change local land use patterns;
- Degrade air quality, including visibility;

- Increase water consumption;
- Lower water quality; and
- Increase pressures for recreational space (White et al. 1979).

In combination, these modifications would alter the unique and special features of some western locations.

Incrementally, changes brought about by development are small; for example, the amount of land used by direct development of mines and liquefaction facilities would in most cases be between 0.05 and 1.0 percent of the land area of any one county with coal resources under projected ranges of potential development (White et al. 1979). Thus, in many cases, changes are more likely to be perceived impacts than measured ones. Exceptions to this may occur where facilities would be concentrated around the major coal development communities such as Gillette, Wyoming, and Farmington, New Mexico.

The broader ecological issue is not that ambient air concentrations will exceed standards, that water will become polluted, or that coal mines will preempt ranchland; rather, the issue is multifaceted and based on values and perceptions stemming from the combination of changes brought about by industrial and urban development in any area.

Many western areas are viewed as the only pristine areas left, and coal development will locally change that. The potential for that change in social and ecological character is a major source of conflict.

3.3 LOCAL FACTORS AFFECTING ENVIRONMENTAL IMPACTS

Within regions, several site-specific factors can influence the kind and extent of environmental impacts. Table 3-8 identifies several factors affecting air, water, solid waste, ecological, and public perception impacts. For example, locating a plant in an elevated area can reduce local air quality problems because the pollutants will be dispersed over a wider area and diminish plume impaction on terrain. Avoiding areas of critical habitat and flood plains can help to reduce ecological problems and the chances for water pollution. Thus, locational differences of just a few miles may be very important in preserving environmental values.

TABLE 3-8: LOCAL FACTORS AFFECTING ENVIRONMENTAL IMPACTS

Environmental Impact Category	Locational Factors
Air Quality	Dispersion potential Proximity to nonattainment area Proximity to PSD Class I area Elevated terrain
Water Quality	Proximity to flood plain Proximity to water-quality limited streams Aquifer characteristics
Solid Waste	Proximity to flood plain Presence of porous soils (sand, sandstone, loam)
Ecology	Presence of critical habitat for endangered species Presence of wildlife refuges Presence of breeding habitat Wetlands and riparian habitat
Perception	Proximity to towns and cities Proximity to archaeological sites Public perceptions of development

An increasingly important factor in industrial development is public reaction to a facility. For example, the visibility of a facility and the plume from its stacks are often regarded as negative aesthetic and environmental impacts. This apparently is the case for the Morgantown SRC-II demonstration plant, which would be easily seen from the University of West Virginia campus. Many residents of Morgantown consider the high visibility of the plant and fear of adverse impacts as changing the character of the area from a small university town to an industrial city (see also Section 4.3). An alternative location just a few miles away could have avoided this problem.

Table 3-9 indicates the proximity to population centers of five coal liquefaction demonstration or commercial facilities at an advanced planning stage. Three of the facilities are within 4 miles of towns with populations of 20,000 or more. The other two facilities, although located near small towns, are 10 to 25 miles from larger population centers.

Although these local factors can be very important to the environment, they are usually less important to developers than economic factors. Table 3-10 identifies the initial criteria used by developers to select sites for two demonstration plants. As indicated, important economic factors affecting plant location are:

- Proximity to the coal resource;
- Proximity to transportation systems (for example, navigable rivers) ;
- Availability of water supply and receiving water for discharges; and

TABLE 3-9: SURVEY OF SITES SELECTED FOR COAL LIQUEFACTION PROJECTS AT ADVANCED STAGE[a]

Plant Description	Status	Location	Distance to Nearest City of 20,000 or more (miles)	Families Displaced at Site	Distance to Nearest Town (population size)
SRC-I Demonstration 6000 tpd	Draft EIS filed	Newman, Davies Co., Kentucky	Owensboro (10)	24	0.0 to 0.6 miles to Newman (400)[b]
SRC-II Demonstration	Final EIS filed	Ft. Martin, West Virginia	Morgantown (4)	10[c]	4 miles to Morgantown (71,000)
W.R. Grace Mobil Methanol-to-Gasoline 28,900	Preliminary design	Baskett, Kentucky	Henderson (3)	NA	1 mile to Baskett (25O)*
Tri-State Synthetic Fuels Project 30,668 tpd Lurgi-Fischer-Tropsch	Preliminary design	Henderson, Henderson Co., Kentucky	Henderson (3)	NA	3 miles to Henderson (23,000)
H-coal 23,000 tpd	Preliminary design	Breckinridge Co., Kentucky	Owensboro (25)	NA	6 miles to Cloverport (1,208)

NA = not available

*Kentucky Dept. of Commerce.

[a] Advanced stage indicates that permitting, or environmental impact statement process, or site acquisition has been initiated.

[b] When expanded t. commercial size, plant border would be across the railroad tracks from downtown Newman.

[c] Estimated from number of residences within site boundaries.

TABLE 3-10: INITIAL SITE REQUIREMENTS SPECIFIED FOR COAL LIQUEFACTION DEMONSTRATION PLANTS

Requirement	SRC I Demonstration Plant	SRC II Demonstration Plant
Coal Supply	Not specified	"Large reserves close"
Transportation	Navigable river; rail contiguous or nearby	Rail, highway, and barge access
Land (acres)	800 to 1,000 "suitable shape" and topography	1,300
Water (gallons per minute)	16,000	15,000 to 80,000[a]
Services	Not specified	Labor market adequate
Other	Ash disposal site (at least half of the site above 100 yr. flood elevation)	40 megawatts electricity supply

Source: Compiled from U.S., DOE 1981a, 1981b.

[a]Range reflects choices of consumptive use for closed cooling (15,000) or once-through cooling (80,000).

- Proximity to adequate housing and public services for workforces and their families.

The importance of water and access to transportation corridors is indicated by the fact that all five proposed demonstration and commercial scale liquefaction plants (i.e., the five identified in Table 3-9) have been sited adjacent to navigable rivers. However, this also means that most coal liquefaction plants are sited partially or entirely on wetlands and floodplains. This can result in damage to wetlands habitat, water pollution from flooding, and failure to consider elevated terrain locations.

In an attempt to determine the most important considerations for siting a facility to convert coal to synthetic fuel, the Oak Ridge National Laboratory (Berry et al. 1978) used a panel of experts to generate a set of siting criteria (Table 3-11). The proximity of required raw resources (high-sulfur coal and water) and air quality were considered most important. The priority concern for air quality was to site conversion plants in areas not designated by the EPA as Air Quality Maintenance Areas--regions in which future air-quality degradation will be carefully monitored by regulatory agencies.

A number of siting analyses have been conducted which, together, have taken into consideration a wide variety of factors--resource availability, environmental impacts, production capabilities, availability of transportation, institutional and legal barriers, and prior commitment of the resources. Three studies (by the U.S. Geological Survey, the Bureau of Mines, and SRI International) used somewhat different criteria but identified 120 counties in common as potentially suitable for siting coal gasification and indirect liquefaction facilities (Hagler, Bailly 1980). In the Southern U.S., for example, eight Kentucky counties (Henderson, Hopkins, McLean, Muhlenberg, Ohio, Pike, Union, and Webster) and two New Mexico counties (McKinley and San Juan) were included. In addition, an ORNL analysis of the southeastern region of the U.S.

TABLE 3-11: SITING CRITERIA FOR A COAL CONVERSION FACILITY

Variable (order of relative Importance)	Category or Value	Compatability[a] Index
Water availability	Adjacent to stream with 7-day/10-year low flow >194 Mgd	10
	Adjacent to stream which could have 7-day/10-year low flow >194 Mgd if additional regulation were imposed	4
	Adjacent to Great Lakes	8
	Adjacent to Atlantic Ocean or Gulf of Mexico	
AQMA	Not an AQMA	10
	Partially an AQMA	5
	Entirely an AQMA	
Accessibility of high-sulfur coal (>1.9% S)	Values represent calculations from gravity model using tonnage of high-sulfur coal	
	Highest value	10
	Lowest value	1
	>100 miles from high-sulfur coal reserve	
Barge accessibility	Adjacent to channel of >9 ft. depth	b
Seismic activity	Activity level I (lowest risk)	10
	Activity level II	5
	Activity level III (highest risk)	0
Rail accessibility	Adjacent to medium- or heavy-duty railroad	10
	Not adjacent to medium- or heavy-duty railroad	0
Accessibility of low-sulfur coal (<1.9% S)	Values represent calculations from gravity model using tonnage of low-sulfur coal	
	Highest value	10
	Lowest value	1
	>100 miles from low-sulfur coal reserve	6
Population density	90-100% of county has >500 inhabitants per square mile	0
	80-90%	2
	70-80%	3
	60-70%	4
	50-60%	5
	40-50%	6
	30-40%	7
	20-30%	8
	10-20%	9
	0-10%	10-9

Mgd = thousand gallons per day AQMA = Air Quality Maintenance Area

= excluded from consideration as potential candidate counties

Source: Berry et al. 1978, p. B-23.

[a]10 = compatible; O = least compatible;

[b]Score equals number of miles of channel (maximum is 94.6)

included Sequoyah and Muskogee, Oklahoma; Bowie and Shelby, Texas; Marengo, Wilcox and Green, Alabama; and Stewart, Tennessee.

It is interesting to note that the results obtained by the various siting analyses frequently did not identify the areas where developments are actually being planned. In addition to sites identified in the siting studies, coal synfuel facilities are being planned in Florida, North Carolina, Arkansas, Louisiana, and in other areas within a given state other than those counties included in the siting analysis. In part this is because there are important institutional and social considerations that may affect where facilities are deployed. Among these are perceived economic gains from development and the willingness of some states to actively seek industrial development, while others may express hesitation. For example, Kentucky has actively participated in site acquisition to facilitate synfuel development, while some coal rich states, such as Colorado, have not been actively acquiring sites.

4.0 ARE OUR INSTITUTIONAL MECHANISMS ADEQUATE TO ENSURE ENVIRONMENTAL PROTECTION?

In addition to the technological and locational factors discussed previously, developing a large-scale coal liquefaction industry with adequate environmental safeguards requires institutional mechanisms for anticipating adverse impacts and implementing needed mitigation measures. Effectively managing synfuel development requires:

- Scientific information on physical, biological, and social effects of the coal liquefaction fuel cycle;

- Criteria for siting facilities in acceptable locations;
- A framework for choosing appropriate technologies and development schedules; and
- Criteria for acceptable or adequate operating procedures.

The following section addresses several issues indicating the difficulties in environmental management of synfuels development and areas where environmental management can be improved. These include:

- Environmental risks that are difficult to monitor and detect;
- Adequacy of environmental standards and compliance incentives;
- Effects of public perceptions; and
- Adequacy of environmental research programs.

4.1 MONITORING DIFFICULTIES

Environmental risks from synfuels will be difficult to measure and many could appear only after an extended time period, making it more difficult or impossible to reduce their impacts. This element of risk is associated with many technologies. For example, leaching from solid waste disposal areas can pollute groundwaters many years later--and once groundwater is polluted it is very difficult, if not impossible, to clean up.

In this regard, special concerns with coal liquefaction plants are the Potential environmental hazards from low levels of hydrocarbon and trace element emissions. Low levels of these pollutants are difficult to monitor, and their effects are difficult to detect. For example, no standards exist for monitoring polynuclear aromatic hydrocarbons and polynuclear aromatic amines. These chemicals present the greatest carcinogenic health risk to the general public and plant workers.

Four categories of difficulties in detecting these environmental risks are summarized in Table 4-1. These are:

(1) The diversity of pollutant sources makes frequent measurements costly and time consuming;

(2) Even low concentrations and limited exposure can produce adverse health effects because some chemicals have high toxicity;

TABLE 4-1: DIFFICULTY IN DETECTING ENVIRONMENTAL HAZARDS

Hazards Information Need	Monitoring Problems	Detection Limits	Delays In Detecting Problems
Toxic organics pollution levels	Number of process sources (i.e., air, water, and solid wastes stream) and variety of chemicals	Difficulty in detecting low concentrations and cumulative releases	Monitoring may be infrequent (every 6 months to a year)
Trace element pollution levels	Number of process sources and variety of elements	Low levels of some trace elements make monitoring difficult	Monitoring may be infrequent (every 6 months to a year)
Pathways to human exposure	Multiple pathways; seasonal and geographic variation	Detection and relating to source difficult	Effects from bioaccumulation may occur over long time periods
Disease Incidence	Large population size and geographic movement of population	Some effects are difficult to determine and relate to source	Up to 10 or more years latency for some diseases (i.e., cancer)

(3) Surveys and clinical tests rarely prove cause and effect relationships; and

(4) Long latency periods make disease measurements and effects prediction nearly impossible over the "short" term (up to 10 or more years).

Thus, managers of the synthetic fuels industry are likely to be inadequately informed about the chronic health risks to workers and the general public. Dramatic cases of overexposure most readily document adverse health effects; however, even these incidents often only provide information ten to twenty years after the initial exposure. If a synfuels industry is to become commercial, it is important that as much information as possible concerning the degree of these health risks be generated at pilot or demonstration plant phases. (Section 5 elaborates on the problem of increased environmental risks with rapid development schedules.)

4.2 ENVIRONMENTAL STANDARDS AND COMPLIANCE INCENTIVES

Several options exist for achieving environmental objectives:

- Economic incentives that encourage compliance with environmental standards;
- Government programs for regulation, monitoring, and enforcement that provide assurances for achieving standards; and
- Operator standards of performance based primarily on industry consensus.

Economic incentives exist where adverse environmental impacts are tied directly to increased production costs. Unfortunately, as with many industries, the economic incentives for meeting environmental objectives in coal liquefaction plants are often not directly related to economic benefits. To illustrate, coal liquefaction plants operating under normal conditions may have 99.8 percent removal of particulate in air emission stacks. Should a process upset occur one percent of the time, resulting in by-passing particulate removal equipment, total plant emission would increase 5-fold or more. However, product costs might typically only increase one percent or so reflecting lost production time. When economic incentives are not sufficient, then more overt management actions may be needed. Three management deficiencies for controlling adverse environmental effects have been identified. These are:

- Poor quality control of some government sponsored programs;
- The need for new environmental standards for some problem areas; and
- The need for industry consensus standards.

Each of these is discussed briefly below.

Construction Quality Control

An example of poor quality control can be found in reviews of construction practices for a coal liquefaction pilot plant in Kentucky, where deviations from accepted standards were found (U.S., DOE, Off. of Inspector General 1979) including: poor control of equipment and materials procurement; inadequate planning to permit effective maintenance during operation: and deficient weld inspections and recordkeeping.[1]

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[1]In contrast, a review by the General Accounting Office of the construction of the 250 tpd EDS pilot plant at Baytown, Texas, gave a favorable report (U.S., GAO 1981). As further evidence of the construction quality, the unit was brought on-stream with relatively little difficulty.

A range of factors contributed to these deficiencies (U.S., DOE, Off. of Inspector General 1979):

- The construction subcontractor did not have a quality control program;
- The construction contracts failed to specify quality assurances duties;
- Work supervisors had a lax and apathetic attitude toward construction safety; and
- Radiographic testing of high pressure piping was inadequate, in part because government oversight agency responsibility was deleted from DOE agreements.

Government participation in developing a coal liquefaction industry may shift responsibilities from developers and their subcontractors to the government supervisory program. In this situation economic incentives for environmental compliance by private industry can be short-circuited.

Environmental Standards

Some critical environmental standard and enforcement programs are proposed but not now in place. Perhaps the most critical to the coal liquefaction industry are proposed standards to control carcinogenic hydrocarbons. Information contributing to these standards is not based on coal liquefaction or even refinery experience, but rather is based on studies at selected chemical plants (Us., EPA, Research Triangle Park 1981). Draft generic standards describing monitoring and maintenance to control fugitive airborne carcinogens were issued in October 1979 (Fed. Reg. 1979), but final standards have been indefinitely delayed. If issued, proposed standards may require monitoring and maintenance programs (Fed.

Req. *1979)* but procedures and mechanisms to ensure compliance have not been determined.

The difficulties imposed for coal liquefaction by the absence of standards are four-fold:

- It is not possible to assess the potential carcinogenic risk, or evaluate the other health risks from coal liquefaction facilities;
- There is no basis to evaluate plant design or monitoring programs;
- There is no assurance that the public is protected from operators that may fail to meet established standards; and
- Assurances of enforcement or liability are not established through any formal means.

Industry Consensus Standards

Because of the broad range of safety and environmental concerns, it may be difficult to develop comprehensive government programs to regulate all environmental and safety concerns of a coal liquefaction industry. The development of adequate construction and operator performance may be stimulated by industry consensus standards. For example, the American Society for Metals establishes material standards; the American Society for Testing and Materials specifies testing approaches; the American Society for Mechanical Engineers develops standards for equipment; and, in coordination with technical societies and industry, the American National Standards Institute develops standards for components and operating systems.

Although general standards have been developed for petroleum refineries and hydrocarbon processing facilities, many of which are