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.

<u>In this regard, special concerns with coal liquefaction plants are the Potential environmental hazards from low levels of hydrocarbon and trace element emissions</u>. 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, <u>it is important that as much information as possible concerning the degree of these health risks be generated at pilot or demonstration plant phases</u>. (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 <u>in coal liquefaction plants are often not directly related to economic benefits</u>. 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]

[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. <u>In this situation economic incentives for environmental compliance by private industry can be short-circuited</u>.

<u>Environmental Standards</u>

<u>Some critical environmental standard and enforcement programs are proposed but not now in place</u>. 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 (<u>Fed. Reg</u>. 1979), but final standards have been indefinitely delayed. If issued, <u>proposed standards may require monitoring and maintenance programs (Fed.</u>

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 applicable to coal liquefaction, areas where new standards may be especially important for coal liquefaction plants include:

- Hydrocarbon monitoring;
- Design and maintenance standards for pipes and fittings operating with high pressure and high flow streams containing entrained solids;
- High pressure let-down valve designs where solids are entrained in liquid streams; and
- Vent/flare combustor systems handling entrained solids.

Much of the emphasis in plant design has focused on plant efficiency and performance. Important health and safety research such as fault free analysis and failure mode and effect analysis, for example, have not yet been applied despite the potential hazards in a coal liquefaction plant.[1]

4.3 PUBLIC PERCEPTIONS

The perceptions and attitudes of the public toward coal liquefaction have the potential for influencing such institutional concerns as site selection, environmental standards, and the pace of development. Based on recent indicators, at least three important concerns are evident:

- The general public appears to be relatively uninformed about synthetic fuels;
- No consensus exists about the potential severity of environmental and human health impacts; perceptions range from very optimistic to very pessimistic; and

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[1]Fault free analysis and failure mode and effect analysis are systems approaches to improving safety which have been applied in such critical areas as nuclear power plants, space programs, and offshore oil platforms.

- The lack of credible information available about the impacts from coal liquefaction makes the resolution of policy conflicts more difficult.

Public opinion toward synfuels development has received little attention to date. However, based on results from a 1980 national survey, the public appears relatively uninformed about synthetic fuels. Only 37 percent of those polled knew what synthetic fuels were; 15 percent defined them incorrectly, and 42 percent said that they didn't know anything about synthetic fuels (U.S., CEQ 1980). However, few respondents (9 percent) opposed support for synfuels, in contrast to the 33 percent who ranked nuclear power as the lowest priority.

Siting of industrial facilities, including energy conversion plants, has become increasingly difficult, in part because of public reactions to the potential risks. Thus, proposals to locate synthetic fuel plants close to towns can also expect public resistance. The extent of this resistance is uncertain and certainly subject to change--for example, as more is learned about health risks.[1]

In the case of the SRC II Demonstration Plant, some parties-at-interest to the development believe that the public is being used in an experiment to evaluate the environmental acceptability of the plant. This perspective is expressed in a letter from an

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[1]As an example of public concerns associated with the 'Rc II plant in West Virginia, twenty-five letters were received from state residents on a draft EIS; three letters were supportive, three were neutral, and nineteen were strongly opposed (compiled from U.S., DOE, 1981a).

industrial hygienist representing the Monongahela Alliance for Community Protection:

> The most shocking part of the EIS is its clear implication that the demonstration plant is intended as a health experiment in which the workers and residents of the region are to be the guinea pigs (Becker 1981).

Public concerns are likely to intensify if visible upsets, such as fires, flaring, spills, or strong odors, occur in the synfuels demonstration program. Such upsets are expected to occur more frequently during this demonstration phase than at the mature industry stage. Thus, constructing demonstration plants in proximity to population centers may increase public opposition to synthetic fuels commercialization (see also Section 3.3).

As shown in Table 4-2, public perceptions regarding the severity of environmental and human health impacts from synthetic fuels show a considerable range. For example, some groups believe that large emissions of air pollutants from these plants will degrade the quality of air and damage crop yields. At the other extreme, some believe that air quality will be relatively unaffected by the plant. Similarly, public perceptions of water quality impacts range from the very optimistic (assuming zero discharge of pollutants) to very pessimistic (discharges will cause fish kills and overall degradation of water quality). For water availability, the differences in perspective stem in large part from controversy over the extent and the appropriate use of existing water supplies. Another issue is concern over the potential human health risks from the synthetic fuels industry. Although some groups are worried about the carcinogenic effects of synfuel development, others

TABLE 4-2: RANGE OF PUBLIC PERCEPTIONS OF SYNTHETIC FUELS INDUSTRY

Pessimistic or Opponents of Development		Optimistic or Proponents of Development	
Perception	Source	Perception	Source
Air			
Air quality will be degraded and be unpleasant	U.S., DOE 1981b Robbins 1980	Air quality will be largely unaffected	U.S., DOE 1981b
Air pollution will severely affect agriculture	Parfit 1980		
Water			
Water pollution will result in fish kills and degradation of water quality	U.S., DOE 1981b	Zero discharge of pollutants will eliminate water pollution	U.S., DOE 1981b U.S., EPA 1979
Water consumption will seriously affect existing water users in arid areas (e.g., western Colorado)		Plenty of water is available for all projected synthetic fuel development	U.S., GAO 1979
Health			
Carcinogens threat will make areas undesirable or uninhabitable	U.S., DOE 1981b	Health is protected by EPA, OSHA, and industry activities	U.S., [illegible] 1981b

believe that industry controls as well as regulations by the Occupational Safety and Health Administration and EPA will provide adequate protection.

The extent of these differences in public perceptions may be narrowed if better information about the likely impacts of coal liquefaction is provided. Most information on coal liquefaction is restricted to technical literature; thus, it may be important to disseminate it in other forms to a larger public. Just as important is the need for information to be generated by groups which have some credibility with the public. Studies should be conducted by individuals and groups who are perceived as competent and have no stake in the industry's development (Section 4.4). Better quality and use of information, of course, does not mean that conflicting public perceptions will be resolved. However, it can provide a focus for policy conflicts and narrow the range of disagreement.

4.4 ENVIRONMENTAL RESEARCH PROGRAMS

The environmental research programs for coal liquefaction are planned and sponsored largely by the U.S. Environmental Protection Agency (U.S., ORD, DEMI, EPA 1979; U.S., EPA, IERL 1980) and by the Office of Environment in the U.S. Department of Energy (U.S., DOE, Asst. Sec. for Fossil Energy and Asst. Sec. for Environment 1980). Other branches of government (e.g., the National Institute of Occupational Safety and Health) in coordination with these two lead agencies and private research programs (such as those sponsored by the Electric Power Research Institute) also have active research programs to characterize environmental and health risks (Males 1980). However, several deficiencies in the existing research program can be identified. These inadequacies are of three types:

- Gaps in technical research programs;
- Gaps in social impact and policy research; and
- Deficiencies in research program organization.

Technical Research Gaps

There are a number of scientific and technical unknowns concerning coal liquefaction that have been identified throughout this report. While most of these questions cannot be resolved until demonstration or pioneer commercial plants are operated, others could be, but are not being, addressed now. Table 4-3 identifies some of these important information gaps. For example, although development programs have been initiated for refining and upgrading coal liquids, with the exception of tests on combustion in stationary sources, little effort has been made to environmentally test coal derived liquids or liquid mixtures used for transportation purposes. A review of health and environmental research programs, especially related to risks from upsets or emergencies and product end-use, is needed to determine whether they are adequate to provide timely information if synfuels are commercialized.

Social and Policy Research Gaps

Most of the current research on synthetic fuels focuses on the physical characteristics of the technologies and the physical/biological effects of their pollutants. However, of potentially

TABLE 4-3: SELECTED TECHNICAL INFORMATION GAPS

Area	Concern	Problem	Implications
Products: Light and medium weight liquids toxicity	Presence of benzene, and other trace chemicals	These chemicals are known to cause leukemia and induce liver tumors. Current research focuses on skin cancer and bacterial mutagenesis.	Composition of products known but environmental significance ambiguous. Indicates need for wider range of carcinogen testing methods.
Process Emissions: Emissions of "reduced" sulfur compounds	Hydrogen sulfide, carbonyl sulfide, carbon disulfide	Neurotoxic agents in low concentrations; implicated in reproductive disorders	Emission and exposure levels expected to be low, but problem potentially important from fugitive or accidental emissions.
Safety system: Controlled combustion systems	Little data available on actual design. Toxic mixture will be introduced into the system.	Failure in performance of controlled combustor could result in intermittent releases of toxic compounds.	Alternative design choices, performance criteria and testing and monitoring procedures need to be developed.
End use: Gasoline and Diesel fuel use	Particulate, nitrogen and sulfur emissions; effects on catalytic converters	Fractions of coal derived naphtha mixtures in product markets is uncertain; environmental impact uncertain and untested.	Better environmental information on fuel characteristics and end-uses needs to be developed.

equal importance are “softer” research needs that address the social impacts of a major synfuels program and the policy of institutional mechanisms that influence, or can be used to influence, environmental choices. Examples of research questions in this area are:

(1) What are the current public attitudes and concerns and how are they being addressed by the synfuels demonstration program?

(2) What is the range of potential changes in public attitudes toward regulation and how might these changes affect synfuel development?

(3) What factors will influence the choices of technology, location, and rate of synfuel development, and how will these influence short- and long-term environmental impacts?

(4) Have siting laws or other institutional factors made a significant effect on where facility sites are planned? How have institutional, factors affected social, economic, and environmental trade-offs?

Research Program Organization

As identified in the previous section, there is widespread but divergent public concern with the environmental and human health risks associated with synfuel development. While the widely divergent opinions may not ever be completely resolvable, the situation could be improved with more reliable and credible impact information. This requires that research and monitoring programs not only be scientifically and technically sound, but also:

- The research program must involve a diversity of interests in its planning and its review;
- Impact assessments must include site-specific components to directly inform those who may be affected;
- The studies must be funded and carried out by parties who do not have a vested interest in the technology.