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?

<u>Research Program Organization</u>

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 <u>reliable</u> and <u>credible</u> 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.

Many of the current research programs do not meet these criteria. For example, biomedical research on the carcinogenity of synthetic fuels mixtures is primarily sponsored by the DOE and conducted through its national laboratories, which are viewed by some groups as proponents of synthetic fuel development.

5.0 WHAT ARE THE ENVIRONMENTAL RISKS OF AN ACCELERATED SYNFUELS COMMERCIALIZATION PROGRAM?

Although the technology for producing liquid fuels from coal was first demonstrated by Germany during the 1920's, coal liquefaction is still in an early state of development in this country; no commercial-scale plants exist or are under construction in the Us. A "crash" or "accelerated" commercialization program to reduce dependence on foreign oil will involve substantial technical, economic, and environmental risks.

Indirect coal liquefaction is closer to commercialization than direct processes. However, rapid deployment of indirect processes will require the use of currently commercial gasifiers such as Lurgi and Koppers-Totzek. More advanced technologies such as the Texaco coal gasifier and the pressurized Shell-Koppers and Winkler gasifiers are not yet in advanced pilot plant stages and need to go through the commercial module demonstration stage before commercialization.

Figure 5-1 illustrates the time required for the development of a commercial plant for two direct processes, EDS and H-Coal, under a "normal" development schedule as projected by the licensing firm (developers). Development is estimated to take 17 years for the

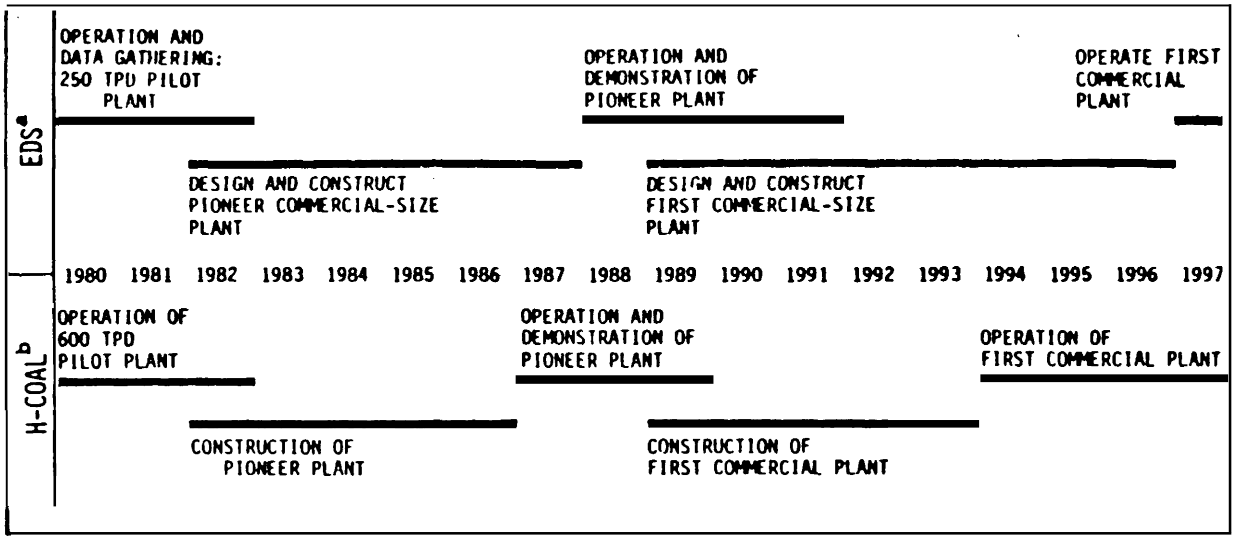


Figure 5-1: Time schedule for two direct coal liquefaction processes.

[a] Green 1980.

[b] Based on two years operation before construction of next unit, design and construction five-year time estimate from Rogers and Hill 1979.

Exxon Donor Solvent (EDS) process and 14 years for the H-Coal process. The EDS estimate includes 7 years for design and construction following operation of both a 250 tpd pilot plant and a pioneer commercial size unit. In contrast, it is estimated that the H-Coal process will require only a 5-year construction period; all design presumably takes place while gathering data from operating units. These estimates have assumed that the permitting process goes on concurrently with design. Because designing requires several years, it is the primary determinant in project schedules. However, if permitting is not concurrent, then an increase equivalent to permitting time for each step would be added to the timetables.

If coal synfuels are commercialized rapidly, it would require: (1) deploying indirect processes now utilizing Lurgi or Kopper-Totzek gasification and/or (2) by-passing some of the scale-up steps in the development of the newer gasification or direct process technologies. Both approaches, and especially the latter, may be unwise for technical and economic reasons. In addition, accelerated commercialization programs will contribute to increased environmental risks for four reasons:

- Technical risks from by-passing development steps;
- Difficulty in monitoring and detecting impacts;
- Regulatory lags; and
- Added impacts from rapid construction.

Each of these factors is briefly discussed below.

5.1 RISKS DUE TO TECHNICAL UNCERTAINTIES

The technical uncertainties in commercial plant performance have typically resulted in requirements for a bench-scale, pilot plant, pioneer plant, and commercial-scale plant development sequence. In the case of direct processes (see Section 2), this scale-up sequence is required primarily because of the inability to predict the flow of coal solids, semisolids, and entrained solids in a liquefaction plant. Thus, they must be tested for phases in a scale-up to commercial size. Any increase in the frequency of upsets or accidents (see Section 2.2) due to accelerated development programs could cause a major increase in air emissions and occupational health and safety risks. In the case of air emissions, neither the controlled combuster nor the vent/flare systems are designed with sulfur or particulate removal systems; therefore, upsets from plugging, reactor malfunctioning, and other events can lead to major increases in emissions of some pollutants. These technical problems can also increase risks of leaks, explosions, and other plant accidents. Further, if units are improperly designed, risks in a complex plant are not simply additive. For example, a poorly designed section that plugs can result in other sections of a facility being shut down. These shut-downs result in temperature changes that can cause stress in valves and fittings, further contributing to leaks or other failures.

Water quality impacts are also of concern with accelerated development because wastewater treatment designs are just emerging. Materials balances and performance data based on preliminary designs are not available. The wastewater treatment systems have not been tested against actual plant conditions, since existing small pilot plants now send waste streams to adjacent refineries. Performance data from wastewater treatment systems being designed for pioneer plants need to be evaluated prior to full-scale commercialization. Because of this uncertainty and the Potential for failure in the wastewater treatment system, for example due to poisoning of biotreaters, the water quality risks would be increased under an accelerated schedule.

Generally, strong economic incentives exist for adequate design and testing in order to achieve a high level of plant operation capacity. Thus, developers are typically wary of a rapid development schedule for economic reasons. However, as discussed in Section 4.2, the environmental costs can sometimes be much larger than the economic costs if a plant does not perform properly. For example, fugitive emissions of toxic hydrocarbons may represent a substantial health risk, but they may only represent a small economic cost in terms of lost product. For this reason, accelerated development programs should include rigorous environmental monitoring programs.

5.2 DIFFICULTIES IN MONITORING

As discussed in Section 4.1, several of the potential environmental impacts associated with coal synfuels will be difficult to monitor and detect. This problem will exist even under a "normal" development pace (such as that illustrated in Figure 5-l), and it will be exacerbated by rapid commercialization programs. Rapid commercialization would limit data development and interpretation from monitoring programs. For example, the latency of skin cancer can be 5 to 10 or more years after exposure, with other cancers having an even longer latency. Rapid commercialization programs would increase the risks that environmental hazards would be overlooked during the first years of pilot or pioneer plant operation.

A "normal" development schedule, such as described in Section 5.0, can resolve a range of existing health uncertainties as summarized in Table 5-1. Pilot plant operation provides time for screening the range of products for bacterial mutagenicity, laboratory carcinogenicity tests, and toxicology studies. The

TABLE 5-1: HEALTH RISKS POTENTIALLY RESOLVED DURING A NORMAL DEVELOPMENT SCHEDULE

Plant Stage	Time Duration (years)	Uncertainties Potentially Resolved: Emissions/ Effluents/Products	Uncertainties Potentially Resolved: Health Risk
Pilot plant operation	1-4	Product composition	Bacterial mutagenicity Short-term laboratory carcinogenicity
Constructing pioneer plant	3-8	None	None
Demonstration of pioneer plant	8-14	Composition of discharge streams (preliminary)	Initial worker accident risk assessed potential public exposure determined
Construction of first commercial plant	12-15	None	None
Commercial plant operation	15-30	Composition of dis-charge streams	Levels of public ex-posure confirmed (commercial)
		Quantity of discharges	Longer term worker and and accident risks informed
Long term operation and retire-ment	30-55	Quantity of discharges; leaks; hazards assessment	Worker accident risk confirmed Actual public health risk informed
Decommissioning	55-	None	Public and occupational health risk more conclusively informed

demonstration (pioneer) plant phase provides for an evaluation of the composition of discharge streams, for determination of potential public exposure to chemicals, and an initial evaluation of occupational accident and exposure risks. A normal development sequence can provide for some determination of all but the long term risks, such as those due to cancer, prior to the operation of a commercial plant.

Although a range of short-term screening tests can be used to evaluate the hazards of intermediate process streams, discharges, and products, some hazard will remain that can only be evaluated with detailed occupational and public health studies. As indicated above, these studies are likely to identify risk (for some skin cancers) within as few as about 5 years. As indicated in the examples in Table 5-2 some cancers show up sooner than five years, such as those induced by chemical therapy or ionizing radiation. However, cancers initiated by occupational exposures to various chemicals, such as detection of elevated rates of lung and kidney cancer from exposure to chemicals in coal tar, typically require 10 to 20 or more years to be detected. Because the latency period of cancer is dependent on the organ, dose, and susceptibility of the population, no clear pattern emerges to dictate how effective a monitoring program can be over the short term. Apparently many of the risks can be determined within 5 to 10 years of the operation of a pioneer plant, but the degree of risk for many soft tissue cancers can only be determined after up to 30 or more years of commercial plant operation.

TABLE 5-2: TYPICAL LATENCY PERIODS IN CANCER DETECTION

Latency Period (years)	Cause	Cancer (site)
(o. 2 to 0.3)	Chemical therapy	Lymphoma (lymph glands)
2 to 15	Ionizing radiation	Leukemia (blood)
5 to 10	PNAS	Skin cancer
lo-	Mustard gas	Lung cancer
10 to 15	Vinyl chloride	Liver cancer
10 to 30	Smoking	Lung cancer
10 to 30	Ionizing radiation	Breast cancer
20 to 40	Coal tar	Lung and kidney cancer
35 to 50	Asbestos	Mesothelioma (chest or stomach lining)
up to 60	Burns	Skin cancer

Source: Compiled from National Cancer Institute 1981; Braunstein, Copenhaver and Pfuderer 1978; NIOSH 1977.

5.3 REGULATORY LAG

A closely related problem is regulatory lags that would occur during an accelerated development schedule. As indicated in Section 2.0, emission and discharge standards do not exist for coal liquefaction plants. EPA and DOE are developing "Pollution Control Guidance Documents" (PCGD's) which will serve as guidelines for evaluating plant designs in the near future. Final standards will be an on-going process as more is learned from each new pilot or pioneer commercial plant. If a synfuels commercialization program is accelerated by building the next generation of plants before fully evaluating the previous one, or by simply by-passing steps in the normal scale of sequence, then some types of environmental regulations (such as emission standards) would always lag behind ongoing design and construction. Experience with the nuclear power industry has shown the problems of attempting to redesign components of a very complex system in response to environmental/safety concerns while the project is under construction. Accelerated development increases environmental risks because each generation of plants would not be guided by environmental regulations informed by the prior generation, and any modifications or retrofits needed to correct past deficiencies would often be very expensive.

5.4 IMPACTS FROM RAPID CONSTRUCTION

Accelerated development of synfuels could also aggravate the socioeconomic and environmental problems associated with "boom and bust" population cycles in small communities. These problems include:

- Inadequate municipal services (water supply, police and fire protection, etc.);
- Insufficient housing;
- Water quality and ecological effects (e.g., inadequate sewage treatment capacity); and
- Inadequate streets, roads, and highways.

Although these growth management problems will exist for any large construction project in rural areas, they will be increased by an accelerated synfuels program because of the number of plants required, the lack of means to coordinate plant schedules, and the probability that many facilities will be located in clusters in single or multicounty regions in the eastern U.S. (for example, see Enoch 1980). As an example, Figure 5-2 shows the number of workers included in synfuel plant construction in a 30-mile radius of Owensboro, Kentucky, if plans developed in 1980 should be implemented.

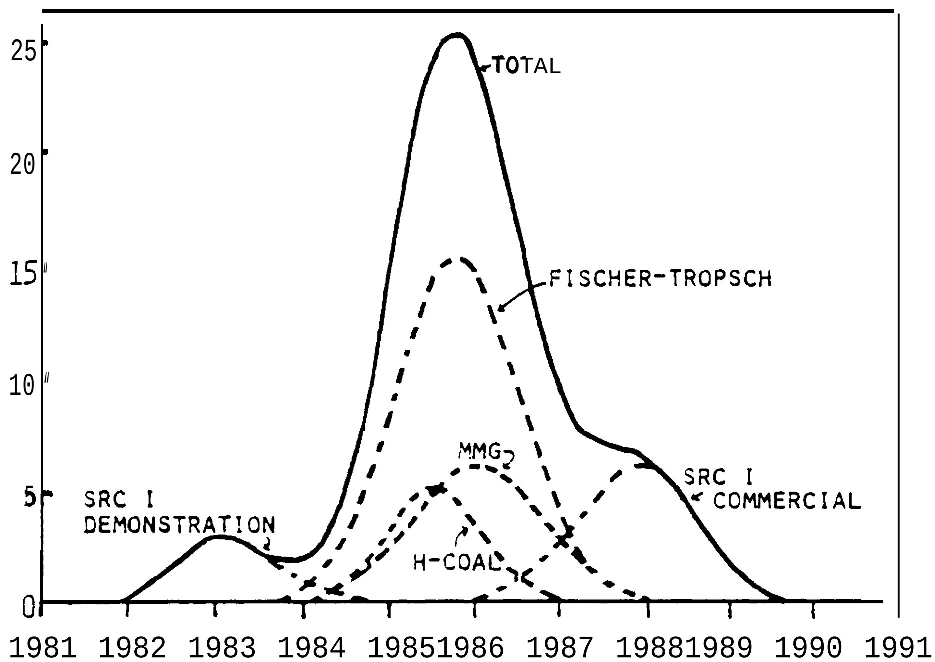
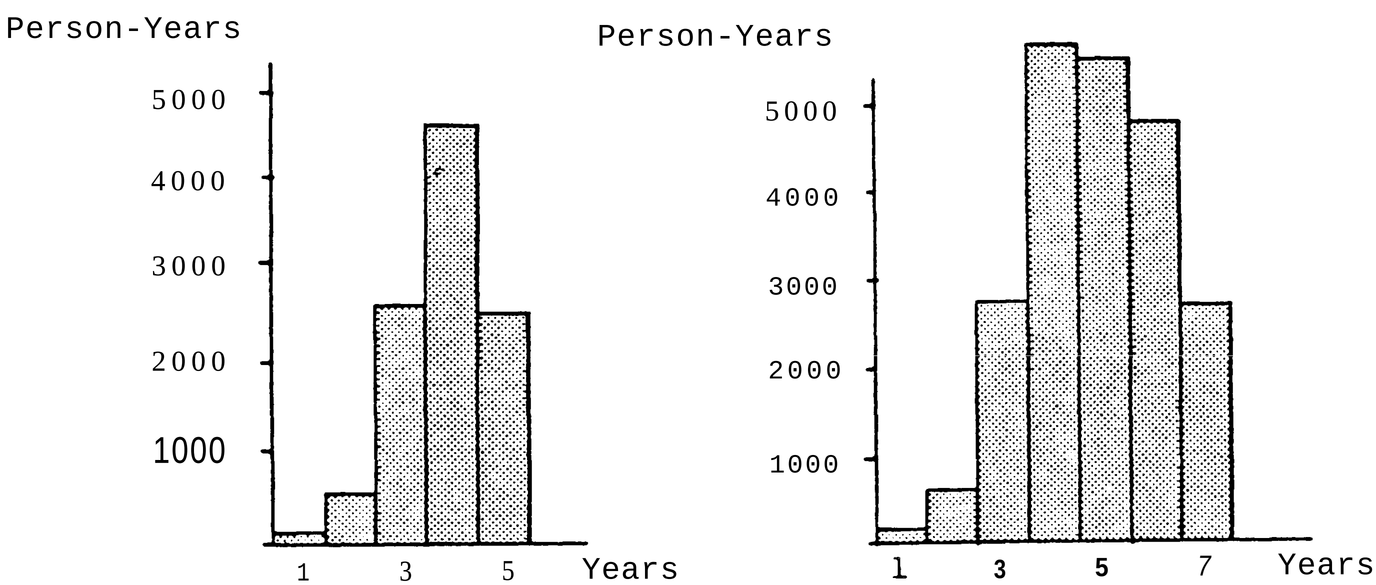


Figure 5-2: Synfuel plant construction labor requirement near Owensboro, Kentucky.

Source: Enoch 1980.

Scheduling can **play** a major role in determining the magnitude of population impacts experienced by a community. Construction of a coal synfuel plant can require a peak workforce of approximately 5,000; this can result in population increases of 15,000, including family members and secondary population growth. Figure 5-3(A) illustrates a typical workforce schedule for a coal gasification plant. <u>Simultaneous construction of two or more plants in an area under an accelerated synfuels commercialization program will proportionately increase population and probably exponentially increase impacts</u>. On the other hand, construction of multiple plants can be phased so that population impacts are lessened, as illustrated in Figure 5-3(B).



(A) Single Plant

(B) Two plants started 2 years apart

Figure 5-3: Workforce schedules for coal gasification projects. Source: White <u>et al</u>. 1979.

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