Chapter 8

Regional and National Economic Impacts

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Regional and National Ecomomic Impacts

INTRODUCTION

This chapter examines the types, timing, and distribution of economic impacts associated with both development of a synthetic fuels industry using national coal and oil shale resources, and improved automobile fuel efficiency. identifying and assessing these impacts are difficult because: impacts are not distributed evenly in time or across regions, so that people may not receive benefits in proportion to the adverse consequences they experience; impacts are not translatable into directly comparable terms (e.g., dollars); the evaluation of impacts is subjective, based on perceptions of the uncertain benefits and costs of new technologies; and impacts are cumulative and may be difficult to monitor or attribute solely to a particular technology choice.

This chapter assesses the broad economic impacts of synfuels and changes in auto technology. Chapter 9 further analyzes employment effects and discusses other social impacts of these technological developments. Decisions about synfuels and making cars more efficient will require tradeoffs in terms of energy use, economic growth, and social welfare and equity. There will be both beneficial and adverse social consequences for the Nation as it moves towards energy independence.

ECONOMIC IMPACTS OF AUTOMOTIVE CHANGE

Overview

The economic impacts of improving automotive technology result primarily from two factors: the large investments that will be required for associated capacity, and changes in the goods and services purchased by the auto manufacturers. Large investments increase financial risk, exhaust profits, and influence the ability of firms to raise outside capital. Changes in goods and services used by manufacturers affect suppliers and, in turn, local economies. As automotive fuel economy increases, the structure and conduct of the auto industry and the relationship of the domestic auto industry to the general economy change. Radical increases in demand for fuel economy, induced either by changes in consumer preferences or by Government mandates, would lead to greater industry change, most likely in the form of acceleration or exacerbation of current trends.

Changes in the auto industry stem from both technological developments and new market trends, including strong competition from foreign manufacturers. Large increases in demand for fuel economy, and for small cars relative to large cars, encourage the industry to improve the fuel economy of all car classes and to invest in the production of small cars. These activities help domestic manufacturers to satisfy relatively new demands, but at the cost of diminished profits during at least the short term. Profits can fall when manufacturers prematurely write off large-car and other capacity investments and change their pricing strategies to replace large-car profits with small-car profits.

Meanwhile, manufacturers lose money when sales of their least efficient models decline. High fixed costs and scale economies make their profitability vulnerable to sales declines of even a few percent. Profits would therefore also fall if domestic manufacturers lost market share to foreign firms. Future opportunities to gain market share and profits will be limited by slowing market growth. *

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*The U.S. auto market is nearly saturated (there were 0.73 cars for every licensed driver in 1979, according to the Motor Vehicle Manufacturers Association) and the U.S. population is growing slowly. Therefore, auto sales will grow at lower rates than in past decades, probably averaging 1 to 1.5 percent per year.

Manufacturing Structure

The U.S. automotive industry includes three major manufacturers—General Motors (GM), Ford, and Chrysler-plus a smaller manufacturer, AMC (now almost half-owned by Renault, a French firm) and some very small specialty car manufacturers. The three major manufacturers have historically been characterized by moderate levels of vertical integration and broad product lines that include trucks and other vehicles as well as automobiles. During the past few decades, GM's operations have been the most extensive both vertically and horizontally; Chrysler's have been the least extensive.

Because of the high costs of production change, U.S. auto manufacturers are becoming less vertically integrated, relying increasingly on suppliers to. make components and other vehicle parts. For example, the Department of Transportation (DOT) reported that in late 1980 alone, domestic manufacturers announced purchasing agreements with foreign suppliers for over 4 million 4-cylinder gasoline engines plus several hundred thousand units of other engines and parts. Reliance on outside suppliers, referred to as "outsourcing," relieves short-term spending pressures on manufacturers. By spending less initially to buy parts rather than new plants and equipment (in which to make parts), manufacturers can afford to make more production changes while exposing less cash to the risk of financial loss due to limited or volatile consumer demands.

On the other hand, outsourcing may cause manufacturers to lose control over product quality. Also, manufacturers may incur higher vehicle manufacturing costs in the longer term because the price of purchased items includes supplier profits as well as production costs. Because of more severe financial constraints, Ford and Chrysler tend to rely on suppliers more than GM. In the future, all domestic manufacturers may outsource more from domestic suppliers, foreign firms, or foreign facilities owned by domestic manufacturers as a means of reducing capital investments and thus short-term costs.

Manufacturers are consolidating their operations across product lines and engaging in joint ventures, primarily with foreign manufacturers. While there appears to be no up-to-date source of data aggregating these changes, trade journals and the business press report that American firms are sharing production and research activities with foreign subsidiaries, with foreign firms in which they have equity (Ford with Toyo Kogyo, GM with Isuzu and Suzuki, Chrysler with Mitsubishi and Peugeot, AMC with Renault), and with other foreign firms. Joint ventures are also increasingly common between non-American firms, which have historically been highly interconnected.

Cooperative activity among auto firms worldwide is likely to grow. Many firms will be unable to remain competitive alone, because of the growing costs and risks of improving automotive technology and increasing competition in markets around the world. The quickest way for U.S. manufacturers to respond to a mandated or demand-induced fuel economy increase would be to use foreign automotive concepts directly, by licensing designs, assembling foreign-made automobile kits, or marketing imported cars under their own names. GM and Ford, for example, assemble Japanese-designed cars in Australia and AMC sells Renaults in the United States.

Domestic companies can make profits by merely selling foreign-designed cars. They can gain additional manufacturing profits without risking additional capital if they sell cars made by companies in which they have equity. Cooperative activity (and, in the extreme, mergers and acquisitions) allows firms to pool resources, afford large investments in research and development (R&D) or in plant and equipment, gain scale economies, and spread large financial risks. It is consistent with the reduction in the number of autonomous auto producers widely predicted by industry analysts.

Although the number of automotive manufacturing entities is declining worldwide, there may be continued growth in the number of firms producing and selling in the United States. Already, Volkswagen produces cars in Pennsylvania and is building a plant in Michigan; Honda is planning to build cars in Ohio; and Nissan is building a light truck plant in Tennessee. There are now about 23 different makes of foreign cars sold in the United States, excluding "captive imports" sold under domestic manufacturers' nameplates (e.g., the Plymouth Colt, which is made by Mitsubishi).[1] Manufacturers of captive imports, including Isuzu and Mitsubishi, are already preparing to enter the U.S. market directly.

Manufacturer Conduct

U.S. auto manufacturers are fundamentally altering their product, production, and sales strategies as automobile technology and consumer demand change. Several changes in product policy include the following.

First, the number and variety of models is falling. The highest number of models offered by domestic manufacturers was 375 in 1970; 255 were offered in 1980.[2] Manufacturers might sharply reduce the number of available models to increase fuel economy quickly, by producing relatively efficient models on overtime and ceasing production of relatively inefficient models.

Second, while cars of all size classes are shrinking in number, small cars are becoming more prominent in number, share of capacity, and contribution to revenues relative to large cars. Recent changes in price strategy have led to smaller profit differentials by vehicle size and higher absolute and relative small-car prices. As individual models become more alike in size, manufacturers will differentiate models by visible options and design.

Third, manufacturers may introduce new, oil-conserving products such as very small "mini" cars (e.g., GM's P-car and Ford's Optim projects) and vehicles powered by electricity as well as alternating fuels.

Cost-reducing alterations to the physical and financial characteristics of individual firms–widely reported in trade journals, the business press, and company publications—help manufacturers adjust to declines in sales and profits and growing investment requirements. Cost-cutting efforts include reductions in white-collar employment and elimination of relatively inefficient or unneeded capacity. During the last couple of years GM, Ford, and Chrysler have sold or announced plans to sell several manufacturing and office facilities. One investment analyst estimates that sales of assets may have provided over $600 million to GM and Ford during 1981.[3]

Efforts to reduce long-term costs focus on measures to improve productivity and reduce labor costs per unit. To improve productivity, manufacturers (and suppliers) are already investigating and beginning to use new types of equipment, plant designs, and systems for materials handling, quality control, and inventory management. Industry analysts and firms also expect that improved coordination between management and labor, vendors, and Government will be important means for improving productivity and competitiveness. Finally, manufacturers maintain that reductions in hourly labor costs (wages and/or benefits) are essential for making U.S. cars competitive with Japanese cars. Whether, when, and how much labor costs are lowered depends on negotiations between manufacturers and the United Auto Workers union.

Another cost-cutting measure is reduction in planned capital spending, Spending cutbacks affect firms differently, depending on their context. For example, Chrysler reduced 1980 planned capital spendings by $2 billion, halting a diesel engine project and others.[4] GM has announced cutbacks that take the form of spending deferrals and cancellations of planned projects (with little effect on immediate cash flow, however).

Another factor which complicates the evaluation of cutbacks is that U.S. projects abroad are, and could be, used to supply the U.S. market. Foreign projects are relatively cheap where foreign partners or foreign governments share in or subsidize investments. Cost-cutting efforts are consistent with growth in the share of U.S. auto investment and production abroad, because facilities in Central and South America, Asia, and in parts of Europe generally produce at lower costs

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[1] Automotive News, *1981* Market Data nook (Detroit, Crain Communications, Inc., Apr. 29, 1981).

[2] Maryann N. Keller, "Status Report: Automobile Monthly Vehicle Market Review" (New York: Paine, Webber, Mitchell, Hutchins, Inc., February 1981).

[3] Maryann N. Keller, personal communication, 1981.

[4] *Ward's* Automotive Reports, June 15, 1981.

and sell in home markets that are more profitable than the U.S. market.

Some analysts believe that if extreme pressures were placed on U.S. manufacturers to make sizable investment in brief periods of time, Ford and GM (at least) would reduce U.S. production in favor of foreign production (Chrysler has divested foreign facilities to obtain cash). U.S. manufacturers and suppliers are already operating with high fixed costs, large investment requirements, weak demand, and labor costs higher than foreign competitors. If there are sharp increases in fuel economy demand, or if there are other sources of growth in perceived investment requirements–without offsetting changes in manufacturing and demand/market share–these developments might give auto firms additional incentives to curb, if not abandon, auto production in the United States. If U.S. production were curtailed, it would affect production of new, very efficient small cars while U.S. production of larger and specialty cars would probably continue. Large and specialty cars are characterized by consumer demand that is relatively insensitive to price and in many cases limited to U.S. car buyers.

Other Firms

Suppliers

Automobile suppliers manufacture a wide variety of products, including textiles, paints, tires, glass, plastics, castings and other metal products, machinery, electrical/electronic items, and others. Changes in the volumes of different materials used to produce cars and the ways in which cars are produced are changing the demands on suppliers. In the near term, for example, GM predicts that the average curb weight of its cars will fall 21 percent, from 3,300 lb in 1980 to about 2,600 lb in 1985, with up to 67 percent more aluminum, 48 percent more plastics, and 30 percent less iron and steel, by weight. Rubber use will also fall. GM predicts that steel will comprise a relatively constant proportion of car weight, while the proportion of iron will fall and aluminum and plastics proportions may even double by 1985[5] (see table 58).

Changes in demands for materials and other supplies create pressures on traditional suppliers to close excess capacity and invest to develop or expand capacity for new or increasingly important products. They also create new business opportunities for firms whose products become newly important to auto manufacturers, such as semiconductor and silicone producers. The degree of hardship on individual traditional suppliers depends on how much of their business is automotive and on their resources for change. Like the auto manufacturers, suppliers operate in the context of a cyclical market which can cause their cash flow to be unstable. Table 59 indicates the dependence of different supplier groups on automotive business as of 1980.

The steel and rubber industries have already been adversely affected by changing auto demands together with stronger import competition. Tire manufacturers have suffered with the rise in popularity of radial tires (which are replaced less frequently than bias ply tires and require different production techniques) and the fall in rubber use per vehicle. Between 1975 and 1980, over 20 tire plants (about one-third of the domestic total) were closed, one major tire manu-

Table 58.—GM's Major Materials Usage
(per typical car, 1980 v. 1985)

	1980		1965	
Materials	Pounds	Percent total	Pounds	Percent total
Iron.	500	15%0	250-300	10-12%
Steel.	1,900	58	1,450	58
Aluminum	120	4	145-200	6-8
Glass	92	3	60	
Plastics	203	6	220-300	8-12
Rubber.	86	3	88[a]	3[a]
Other	377	11	277	11
Total	3,300	100%	2,600	100%

[a] GM projects actual rubber use to be less than SS lb in 19S5.

SOURCE: General Motors Corp., reported in *Wards Automotive* Reports, Apr. 27, 1981.

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[5] "GM Sees Big Gain for Aluminum, Plastics in 'Typical' 1985," Ward's Automotive Reports, Apr. 27, 1981.

Table 59.—1980 Motor Vehicles (MVs) and Parts Supplier Trade

Industry	Percent of industry output for MVs and parts	Value of output for MVs and parts
Textiles	7 +	$4 billion+
Wood products	2 +	618 million +
Nonhousehold furniture	2.4	260 million
Paper and allied products.	3	2.5 billion +
Chemical	4 –	15 billion+
Plastics, synthetic rubber, and synthetics. .	6 –	4 billion+
Paints and allied products	8 +	900 million +
Tire and rubber products (OEM)	13	4 billion+
Glass	11–	1.3 billion
Steel furnaces, foundries, and forgings	21–	24.6 billion
Aluminum and aluminum products	14.6	4 billion+
Copper and other nonferrous metal products	11–	6 billion+
Metal products and machine shop products	13–	22 billion
Metalworkings and industrial machinery . . .	5.6	8 billion+
Service industry machinery	12	3 billion
Electrical and electronic equipment	5.2	8 billion
Scientific and controlling instrument	7.5	900 million

NOTES: "+" means "greater than" and "–" means "less than." "OEM" stands for "original equipment manufacturer. "

SOURCE: The Automotive Materials Industry Council of the United States.

facturer (Mansfield) declared bankruptcy, and another (Uniroyal) suffered severe financial problems (see fig. 18). Several steel plants were closed during the same period. In both industries, additional plant closings and continued import competition are likely in the 1980's, although the elimination of excess and inefficient capacity is expected by Government and private analysts to leave these industries financially healthier.[6]

Machinery and parts suppliers also face import competition and product demand changes. A recent Delphi survey of auto suppliers conducted by Arthur Andersen & Co. and the Michigan Manufacturers Association (hereafter referred to as A&M) predicted that these suppliers will be investing together at least $2 billion per year in the 1980's, especially for new equipment (about 60 percent of total investment). z Machinery investments are needed both to make new types of supplied products and to help suppliers adapt to a shortage of skilled machinists. A recent study prepared for DOT by Booz-Allen & Hamilton describes the types and levels of investments associated with different types of auto activities on a new-plant basis (see table 60).[8]

Analyses by A&M, Government agencies, and industry analysts suggest that both appreciation of the types of supplier changes needed and ability to make those changes are greater among larger supplier firms than among smaller ones. Most supplier firms are small- and medium-sized, although a few large firms have large shares of the auto supply business. Among GM's total 32,000 suppliers in the United States, for example, only 4 percent have at least 500 employees while 52 percent have at most 25.[9]

Auto product change and market volatility are leading large suppliers, in particular, to diversify into nonautomotive products. For example, between 1978 and mid-1981 Eaton Corp., a major supplier, spent about $470 million to buy companies producing electronics, machinery, electrical parts, hydraulic systems, and other high-technology goods.[10] Large suppliers are also

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W .S. Department of Commerce, *1981* U.S. *Industrial Outlook* (Washington, D.C: U.S. Government Printing Office, 1981).

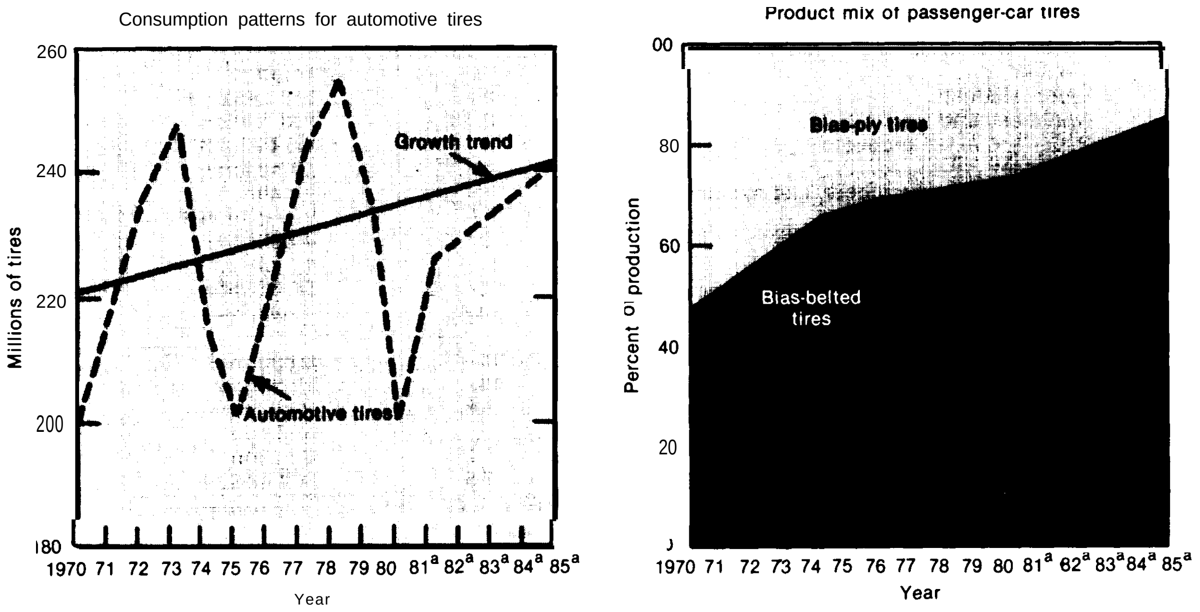
[7] Arthur Andersen & Co. and the Michigan Manufacturers' Association, "Worldwide Competitiveness of the U.S. Automotive Industry and Its Parts Suppliers During the 1980s" (Detroit: February 1981).

[8] Booz-Allen & Hamilton, Inc., Automotive Manufacturing *Processes* (Washington, D.C: U.S. Department of Transportation, National Highway Traffic Safety Administration, February 1981).

[9] "Supplier Conference, Ford/Europe Interview Underscore Threat, " Ward's Automotive *Reports, June* 15, 1981.

[10] "Eaton: Poised for Profits From Its Shift to High Technology," Business Week, June 8, 1981.

Figure 18.—Tire Industry Trends



[a]Estimated by Bureau of Industrial Economics.

SOURCE: Trade Association data.

[a]Estimated by Bureau of Industrial Economics.

SOURCE: Trade Association data.

Major tire manufacturer earnings fall,
July 1979 to June 1980, as the table below shows:

Company	Change in earnings
Armstrong. . . .	+ 12.1%
Cooper	negative (loss)
Dunlop	negative (loss)
Firestone	negative (loss)
General	negative (loss)
Goodrich	+ 11.2%
Goodyear	– 40.8%
Mohawk	negative (loss)
Uniroyal	negative (loss)

SOURCE: U.S. Department of Commerce, Bureau of Industrial Economics *1981 U.S* Industrial Outlook January 1981.

strengthening their international operations, diversifying away from the U.S. market. Small- and medium-size firms are likely to follow auto manufacturers in undertaking joint R&D and production ventures, while mergers and acquisitions and even closings or bankruptcies are likely. * The A&M survey predicted that decline in the numbers of suppliers will lead to increased vertical integration among suppliers, while strong import competition and other market changes will motivate increases in supplier productivity.

Sales and Service

Other segments of the auto industry include dealers and replacement part and service firms. The latter group, which serves consumers after they buy their cars, is called the automotive aftermarket.

Dealer sales activities are not necessarily affected by changing auto technology per se. Sales depend on consumer income and general eco-

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*According to Dun & Bradstreet, transportation equipment firms, primarily including auto suppliers, suffered financial failure at a rate of 101 per 10,000 in 1980, as compared with a rate of 42 per 10,000 for all manufacturers.

Table 60.—Examples of Supplier Changes and Associated New Capacity Investment[a]

Characteristics	Approximate capital requirements for property, plant, and equipment
Foundries	
90 percent of auto castings use iron, 92 percent of which are sand cast, and auto manufacturers operate about 20 percent of U.S. sand casting capacity	$21 million (typical independent die cast foundry producing 15,000 tons/year)
Downsizing and production of smaller parts generates excess capacity	
Materials substitution reduces sand casting with iron and increases die casting with aluminum	
Metal stamping	
Autos have had up to 3,000 stampings and auto manufacturers produce about 60 percent of all stampings by weight	$67 million (typical captive plant producing stampings for 175,000 cars/year; independent plants are smaller and cheaper)
Materials substitution decreases carbon steel, increases high-strength steel and aluminum for stampings	
Plastics processing	
Injection molding	$31 million (typical plant producing 65 million lb parts/year)
Compression molding	$43 million (typical plant producing 60 million lb compound/year
Reaction injection molding	$19 million (typical plant producing 30 million lb parts/year)

[a] Figures for completely new facilities.

SOURCE: Booz-Allen & Hamilton, Inc.. Automotive *Manufacturing* Processes, prepared for the Department of Transportation, National Highway Traffic Safety Administration, February 1961.

Table 61 .—1980 Auto Repair Facilities

Type of facility	Quantity
Dealers	26,000
Auto repair shops (independent and franchised)	170,000
Tire—battery-accessory outlets	18,850
Other auto and home supply stores	1,860
Gasoline stations	70,000
General merchandise stores	3,500
All others	1,430
Total	292,240
Total including facilities selling only parts, accessories	331,090

SOURCE: *Wards Automotive* Reports, Apr. 6, 1981.

nomic conditions (including the availability of credit), demographic conditions (including household size), the price of fuel, and vehicle price and quality attributes. Although consumers have responded to recent gasoline price increases by demanding relatively fuel-efficient cars, the experience of the recent recession illustrates that overall sales levels in a given year are primarily determined by consumer finances and not by vehicular technology.

There are about 300,000 automobile repair facilities in the United States[11] (see table 61). New automobile technology affects them because automobile design and content are changing. For example, problems in new, computer-controlled components will be diagnosed with computerized equipment, and plastic parts will be repaired with adhesives rather than welding. Components are more likely to be replaced than repaired on the vehicle or even at the repair shop. While automobile service firms will have to invest in new equipment and skills to service new cars, continued service needs of older cars may ease the transition,

However, the concurrent operation of very different types of cars requires firms to double their parts inventories to service both types. The dollar value of parts and the frequency of repairs are also likely to differ between new and old car types. Manufacturers are attempting to curb service cost growth by designing cars for easy servicing. For example, the Ford Escort and Lynx and the Chrysler K and Omni/Horizon cars were designed so that servicing during the first 50,000 miles would cost less than $150.[12]

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[11] "Auto Repair Facilities Total 300,000, " *Ward's* Automotive Reports, Apr. 6, 1981.

[12] Francis J. Gaveronski, "Ford's New Escort, Lynx Designed for Easy Service," Automotive News, May 19, 1980, and "Chrysler K-car to Stress Ease of Diagnosis, Repair, " Automotive News, June 16, 1980.

The effects of new repair and service practices on the structure of the aftermarket are uncertain. During the past decade, repair and service activity shifted from dealers to service centers run by general retailers (e.g., Sears) and tire retailers (e.g., Firestone) and to specialized franchised centers for tune-ups, body work, or component service (e.g., AAMCO Transmissions and Midas Muffler). Both of these trends help to moderate service cost increases because of scale economies in planning and management. However, the intimate and advance knowledge of new technologies held by manufacturers is likely to help dealers regain repair and service business. While dealers now perform about 20 percent of auto repairs, they are expected to gain a greater share by the mid-1980's. Meanwhile, scale economies in advertising and inventory management may promote consolidation among parts firms.[13]

Prospects

Further financial strain on the domestic auto industry is not likely to lead to financial failure of major manufacturer and supplier firms (except perhaps Chrysler, but Government intervention makes its future hard to predict). However, the continued viability of many smaller auto suppliers is becoming especially uncertain because automotive technology changes make products and capacity obsolete. While the industry may continue to contract, "collapse" of its leading firms is not likely because major and even intermediate-sized firms can make at least partial adjustments to automotive market changes; adjustments are already under way. Reduction in the U.S. activities of domestic firms and failure or contraction of smaller firms would, nevertheless, severely affect employment and local economies.

In contemplating the future of the industry it is important to appreciate what financial failure means. In a technical sense, businesses fail when they are unable to make scheduled payments. If this inability is temporary, firms can usually negotiate with creditors or seek protection from bankruptcy courts to relieve immediate creditor demands. In many cases, bankrupt firms are successfully reorganized, structurally as well as financially. However, some firms find that the stigma of bankruptcy makes producing and selling especially difficult. * If selling a firm's assets generates more value than using them for production by the firm, the firm is fundamentally unviable, and there are financial and economic grounds for liquidating it.

Barring Government support or merger, Chrysler is the large automotive firm most likely to fail if viability in the U.S. market entails large investments that it cannot afford. AMC has been at least temporarily rescued by the French Government-backed Renault. Because Chrysler's financial weakness has been known for years, the magnitude of the potential social and economic effects of its failure has been diminishing as Chrysler has cut back its operations and suppliers have reduced their dependence on Chrysler as a customer.

In mid-1979, when Data Resources, Inc., prepared for the U.S. Department of the Treasury a simulation of the macroeconomic effects of a Chrysler bankruptcy and liquidation, it found that only temporary macroeconomic instability was likely to result, although 200,000 people might be permanently unemployed. Dependence of workers and businesses on Chrysler has diminished since that simulation was done, although small firms for which Chrysler is a primary customer remain vulnerable. If Chrysler were to liquidate, its exit from the U.S. market would provide opportunities to domestic and foreign manufacturers to expand market share and purchase plant and equipment at relatively low cost. This could relieve financial pressures on Ford and GM.

While contraction of the U.S. auto industry may result in fewer, healthier firms, employment and local economies will suffer.** Loss of jobs will re-

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[13] Maryann N. Keller, "Status Report: Auto Parts Industry Automotive Aftermarket Quarterly Review" (New York: Paine, Webber, Mitchell, Hutchins, Inc., July 29, 1980).

*When Lockheed and Chrysler appealed for Government aid, they both argued that their customers would not buy from firms in bankruptcy. This is more likely to be a problem for automobile (or aircraft) manufacturers than for their suppliers, given the difference in size of customer purchase and producer liability.

**Also, change in the amount of U.S manufacturer operations in Canada (not considered "foreign") could imply violation of our obligations under the Automotive Products Trade Act agreements with Canada.

suit predominantly from supplier-firm difficulties. Unemployment of auto industry workers may also affect the performance of the national economy. Unemployment causes a more than proportionate decline in aggregate production, because slack demand reduces average hours per worker, output per worker, and entry into the labor force, The reduction in disposable personal income (DPI) because of unemployment reduces personal consumption spending. Reduced personal consumption (and business fixed investment) spending reduces gross national product (GNP), causing DPI to fall, and so forth. Both personal and corporate tax revenues decline, while transfer payments to unemployed workers and economically depressed communities rise.

The national economy can better adjust to auto industry trauma than local and regional economies because the national economy is more diversified, and because, over time, national economic sensitivity to auto industry problems has been diminishing. Since World War II, manufacturing employment in the Midwest (and Northeast) has been declining as a percent of national manufacturing employment; it has declined in absolute volume since 1970 because job opportunities have not been growing, foreign and domestic firms have located facilities in other regions, and other industries primarily located elsewhere have been growing in their importance to the economy. * In this context of structural change, the 1975 recession seems to have been a turning point for traditional Midwest manufacturing, accelerating a trend of decline that was further aggravated by the 1979-80 oil crisis and recession.

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*Electronics, computing equipment, chemicals and plastics, aerospace equipment, and scientific instruments have been the leading growth industries in the postwar period. These industries are both outlets for diversification by auto-related firms and competitors to traditional auto-related firms in automotive supply.

ECONOMIC IMPACTS OF SYNFUELS

Because large blocks of capital are required for synfuels projects, they will be visible centers of economic activity even from a national viewpoint and, in fact, for' people outside of the synfuels industry, the economic costs and benefits of synfuels may be more easily understood in terms of regional and national impacts.

Despite the absence of commercial experience, an outline of the synfuels industry emerges with comparisons to coal mining, conventional oil and gas production, chemicals processing, and electric power generation. By itself, this new industrial organization is an important economic impact, as it changes the way economic decisions are made regarding the supply of premium fuels. Furthermore, along with the technologically determined menu of resource requirements, industrial organization determines the major regional and national economic impacts of synfuels deployment.

potential regional and national economic impacts are then explored through comparisons of aggregate resource demands and supplies. Since plans call for very large mines and processing plants, and perhaps many construction projects in progress at once, the emphasis is on potential bottlenecks which could delay deployment schedules and drive up project costs. If severe resource bottlenecks do occur, the resulting inflation in the prices of these resources will spread through the economy, driving up prices and costs for a broad range of goods and services.

These resource costs add up in the next section of this chapter to financial requirements for projects and for the industry as a whole. To the extent that the Federal Government does not intervene, individual firms must compete in financial markets with all other products and all other firms for limited supplies of debt and equity capital. With the important exception of methanol and ethanol from biomass, * the large scale and long leadtimes of synfuels projects may make it difficult to raise capital, especially during the next

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*Ethanol from biomass is not included in this discussion because with current technology its potential production is limited by the availability and price of feed-grain feedstocks. However, if economic processes for converting ligno-cellulose into ethanol are developed, ethanol could compete with methanol as a premium fuel from biomass.

decade, when important technological uncertainties are likely to remain. Federal subsidies or loan guarantees will speed synfuels deployment–but only by reducing capital available to other types of investments, by reducing other Federal programs, by increasing taxes, or by increasing the Federal deficit. Depending on general economic conditions, each of these different market interventions may be inflationary.

Each of these areas of regional and national economic impacts—industrial structure, potential resource bottlenecks, finance capital, and inflation as related to synfuels development–is discussed below.

The Emerging Industrial Structure of Synfuels

Synfuels are fundamentally different from conventional oil and gas because they are manufactured from solid feedstocks and because synfuels economics may lead to the replacement of conventional fuels by methanol and low- or medium-Btu gas in the future. Liquids from coal and oil shale, the feedstocks with a natural resource base sufficient to fully displace petroleum in the long run, involve economies of scale which encourage ownership concentration. The methanol option, however, provides offsetting opportunities for large chemical firms to enter the liquid fuel business and, based on biomass feedstocks, it may also allow many small producers to supply local markets throughout the Nation.

The following discussion is broken down into the four stages of synfuels production. While this breakdown is convenient, it should be understood that several stages of production may be performed on the same site in order to minimize handling, transportation, and management costs.

Mining Coal and Shale

Mining for synfuels will closely resemble mining for any other purpose except that the mines dedicated to synfuels production will be relatively large .[14] It takes approximately 2.4 million tons of coal per year to fire an 800 MWe generator and about three times that much to feed a 50,000 barrels of oil equivalent per day (BOE/D) coal synfuels plant, and about four to eight times as much oil shale (by weight) for the same output of liquid fuel produced by surface retorting. *

Capital costs for development of a coal mine depend primarily on the depth and thickness of the coal seam. Average investment cost data can be misleading, since each mine is unique, but it takes about $60 of investment per annual ton of coal mined underground (1981 dollars). With coal preparation and loading facilities, investments at the mine site may approach $100 per annual ton, or about $750 million for capacity sufficient to supply a 50,000 bbl/d synfuels plant. Western surface mining may in certain cases be substantially less expensive. * * Furthermore, substantial synfuels production may be achieved on the basis of existing excess mining capacity.***

In the absence of commercial experience, investment cost estimates are unavailable for shale mining. It is clear, however, that they can be either larger or smaller than for coal, depending on two opposing factors. First, investments costs could be much higher because of the low energy density of shale. Hence, much more material must be mined per barrel of oil equivalent. Second, shale investment costs could be lower because major shale resources lie in very thick

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[14] For an extensive discussion of mining techniques and costs, see The Direct Use of Coal: Prospects and Problems of Production and Combustion, OTA-E-86, (Washington, D. C.: U.S. Congress, Office of Technology Assessment, June 1979), chs. Ill and IV.

*This range is determined by the Btu content of coal and shale and by the efficiencies of converting a Btu of solids into a Btu of finished liquid fuels. If we just compare shale oil and methanol (the two liquid synfuel options which are best understood and probably of least cost), conversion efficiencies are comparable, so the difference in feedstock rates is entirely a matter of the energy density of the feedstock. Coal has 16 to 30 MMBtu/T with Western coal typically on the lower end of the range. Shale, which is presently considered suitable for retorting, has 3.6 to 5.2 MM Btu/T. Hence, the ratio of shale to coal inputs can be as low as 4.2 and as high as 8.3.

**Investment cost data were obtained from National Coal Association. Federal surface mine regulations have increased investment requirements in increasing the equipment required to operate a mine and to reclaim land after coal has been removed, by increasing the amount of premining construction and equipment required to establish baseline data, and by extending the required development period.

* * *The National Coal Association estimates excess capacity at 100 million to 150 million tons per year. The low end of the range is calculated on the basis of the number of mines closed and the number of workers working short weeks. The high end of the range is calculated by comparing peak weekly production to average annual output per week.

seams (in some areas over 1,000 ft thick) and often relatively near the surface. Estimates for the first commercial shale project indicate that mining investments for a 50,000 bbl/d project may be substantially below $750 million.* Furthermore, if in situ retorting techniques fulfill optimistic expectations, shale mining could become relatively inexpensive as mining and retorting operations are accomplished together underground.

Mine investment is important in project planning, but its share in total investment is still usually less than a third. (Notice that in the estimated investment costs for coal-based synthetics in ch. 8, the cost of the mine was not included. It is included in ch. 4 in the discussion of total investment costs.) Beyond actual costs, the activity of mining itself is important in the synthetic fuel cycle because of its previous absence in the U.S. oil and gas industry. In fact, the entire sequence of economic events associated with extraction of coal and shale contrasts sharply with the extraction of conventional petroleum and natural gas. The key difference is that oil and gas reserves must be discovered, with potentially large rewards for the discoverer, while the location and morphology of coal and shale resources have been known for a long time.

A wildcat driller, looking for an oil or gas deposit, can rent and operate a drilling rig with a relatively small initial investment. Since the most promising prospects have already been drilled in this country, exploration typically is a high-risk gamble and, although investment is small compared with development of resources, it can still require large sums of money in frontier areas such as deep water or the Arctic. The uncertainty is a deterrent to investment, but potentially large payoffs and special Federal tax incentives continue to attract large numbers of investors and large sums of capital.[15] Furthermore, the wildcatted can induce cooperation from landowners, local government officials, and any other powerful local interests by promising royalty payments, or at least a rapid expansion of local business activity, without serious environmental impacts. Only after a substantial reservoir has been discovered is it necessary to make relatively large investments in development wells, processing equipment, and pipelines.

In mining, there is nothing comparable to the opportunity and uncertainty of discovery wells. Most of the business parameters of a potential mine site are evident to the landowner and to all potential mining companies, which means that profit margins are generally limited by competitive bidding.

As discussed below, mines also typically employ more labor per million Btu of premium fuel produced than oil and gasfields[16] and they have many more adverse environmental impacts (e.g., acid drainage, subsidence, etc). For both reasons, interests external to the firm are more likely to oppose and perhaps interrupt mining operations. Investors realize such contingencies and see them as risks for which they expect compensation.

This discussion of relative payoffs and risks is by no means complete or conclusive, but it does suggest that private investors may exploit min-

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*The Denver office of Tosco Corp. estimates that mine costs for the Colony project, which is the first shale project to proceed with commercial development, could be as low as $250 million. That particular site has the advantage that large-scale open pit mining equipment can be used in an underground mine, since the seam is horizontal and the mine can be entered via portals opened in a canyon wall. This means that the reclamation costs of a surface mine can be avoided as well as the costly mine shaft of a conventional underground mine. Furthermore, the site is propitious because there is virtually no methane trapped in the shale, so safety measures are minimal. In the future, mine costs as well as conversion costs may be held down by in situ liquefaction, but this technology remains unproven.

[15] In 1979, approximately $12.5 billion was invested in exploration for oil and gas in the United States. That includes (in billions), $5.4 for lease acquisition, $4.5 for drilling, $2.3 for geological and geophysical activity, and $0.3 for lease rentals. (See Capital *Investments* of the World *Petroleum Industry,* 1979, Chase Manhatten Bank, p. 20, and Basic *Petroleum* Data Book, American Petroleum Institute, vol. 1, No. 2, sec. III, table 8a). $12.5 billion is about 3 percent of total gross domestic investment ($387 billion). (See 1980 Statistical Abstract, p. 449.)

The oil and gas industry receives special tax treatment mainly in terms of expensing intangible expenditures of exploration, even though they are surely treated as capital expenses in corporate accounts.

[16] Although oil and gas has been closing steadily, in 1979 it took approximately 14,500 workers (miners and associated workers) to produce a Quad of coal and about 11,500 workers to produce a Quad of oil and gas. However, the labor intensity of mining for synfuels is actually 160 to 200 percent greater than for coal alone, since only about 50 to 60 percent of the energy in coal feedstock remains in the finished synfuel product. See 1980 Statistical Abstract, p. 415, for employment data and 1980 Annual Report to Congress, Energy Information Administration, p. 5, for production data. See note 2, ch. 9 for further discussion of labor productivity.

ing prospects for synfuels much more slowly than prospects for conventional oil and gas, or that investors will accept much greater risks with conventional oil and gas prospects because of the offsetting chances of striking it rich. Synfuels capacity could still expand rapidly, but probably not without very high profit incentives to reorient investors who have traditionally been in oil and gas exploration.

Conversion Into Liquids and Gases

During the second stage of production, solid feedstocks are converted into various liquids and gases. Current synfuels project plans indicate that coal or shale conversion plants will resemble coal-fired electric power stations in the sense that both convert a large volume of solid feedstock into a premium form of energy. They will resemble chemical processing (in products such as ammonia, ethylene, and methanol from residual oil or natural gas) and petroleum refining facilities in their use of equipment for chemical conversions at high temperatures and pressures. *

Of the $2 billion to $3 billion (1981 dollars) required overall for a 50,000 BOE/D shale project, between one-third and one-half goes into surface retorts which decompose and boil liquid kerogen out of the shale rock. A larger fraction of total project costs is required to obtain methanol from coal, but with subsequent avoidance of the upgrading and refining costs.** In general (but with the exception of in situ mining shale), the conversion step alone requires investments comparable to a nuclear or coal power station of 1 GWe capacity or to outlays for a 200 to 400,000 bbl/d petroleum refinery.[17]

Factors other than economy of scale dominate the economics of syngas production, as demonstrated by the existence of many small gasification plants across the country.[18] Two factors account for this. First, gasification is only the first stage in the production of either methane or methanol, so costs of the second stage can be avoided and system engineering problems are less complex and more within the technical capabilities of smaller users. Airblown gasifiers involve the least engineering, since they do not require the production of oxygen, but only certain onsite end users such as brick kilns can use the low-Btu gas. The second reason involves transportation and end-use economics.

In many industrial applications, natural gas (methane) has been the preferred fuel or feedstock, but medium-Btu gas is an effective substitute in existing installations because it requires relatively minor equipment changes. Either low- or medium-Btu gas may be used in new installations, depending on the industrial process and site-specific variables. However, since these methane substitutes cannot be transported over long distances economically, conversion facilities must be located near the end users.

The size of the conversion facility is therefore determined by the number and size of gas consumers within a given area, and this often dictates conversion plants that are small in comparison with a 50,000 bbl/d liquid synfuels plant. Consequently, industrial gas users may choose to locate near coalfields in order to produce and transport their own gas or to contract from dedicated sources. Either approach assures security of supply and availability over many years.

Upgrading and Refining of Liquids

As discussed in chapter 6, raw syncrudes from oil shale and direct liquefaction must be upgraded and refined to produce useful products. Technically, these activities are quite similar to petroleum refining, and this affords a competitive advantage to large firms already operating major, integrated refineries. This bias toward large, established firms is reinforced in the case of direct

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*Refineries typically use lower pressures than chemical plants and lower than what is expected for synfuels conversion.

* * For a breakdown of methanol costs, see ch. 8.

[17] As discussed in ch. 8, all synfuels capital cost estimates are very uncertain because none of these technologies has been used commercially. Furthermore, engineering cost estimates available to OTA typically do not clearly differentiate costs by stages of production. Nevertheless, the conversion step, going from a solid feedstock to a gas or a liquid product, is undoubtedly the most expensive single step in synfuels production. For presentation of costs for electric power stations see *Technical Assessment Guide,* Electric Power Research Institute, July 1979.

[18] See National Coal Association, "Coal Synfuel Facility Survey," August 1980, for a listing and discussion of between 15 to 20 low-Btu gas facilities coupled with kilns, small boilers, and chemical furnaces.

coal liquids by the apparent cost reduction if upgrading and refining are fully integrated with conversion, thus making it difficult for smaller firms to specialize in refining as some do today. Upgraded shale oil, on the other hand, is a high-grade refinery feedstock that can be used by most refineries.

Downstream Activities: Transportation, Wholesaling, and Retailing

As long as synthetic products closely resemble conventional fuels, downstream activities will be relatively unaffected. However, medium- or low-Btu gas and methanol are sufficiently different to require equipment modifications, and they may be sufficiently attractive as alternative fuels to induce changes in location of business and structure of competition.

Depending.on the market penetration strategy, methanol may be mixed with gasoline or handled and used as a stand-alone motor fuel. As a mixture, equipment modifications will involve installation of corrosion-resistant materials in the fuel storage and delivery system. As a stand-alone fuel, methanol may have its own dedicated pipeline and trucking capacity and its own pump at retail outlets, and auto engines may eventually be redesigned to obtain as much as 20 percent added fuel economy, primarily by increasing compression ratios and by using leaner air-fuel mixtures when less power is required. *

If firms currently producing methanol for chemical feedstocks should enter fuel markets,[19] drivers stand to gain from the increased competition among the resulting larger number of major fuel-producing companies and by competition between methanol and conventional fuel. Furthermore, with coal-based methanol providing a critical mass of potential supply, drivers across the Nation may be able to purchase fuel from small local producers (using biomass feedstocks), a situation which has not obtained since the demise of the steam engine.

Medium- or low-Btu gases are effective substitutes for high-Btu gas (methane) but, as discussed above, their relatively low energy density prohibits mixing in existing pipelines and generally restricts the economical distance between producer and consumer (the lower the Btu content the shorter the distance). Hence, deployment of these unconventional gases will require dedicated pipelines, relocation of industrial users closer to coalfields, or coal transport to industrial gas-users.

Conclusion and Final Comment

Massive financial and technical requirements for synthetic liquids from oil shale and coal encourage ownership that is more concentrated than has been typical in conventional oil and gas production. Large firms, already established in petroleum or chemicals, have three major advantages.

First, they can support a large in-house technical staff capable of developing superior technology and capable of planning and managing very large projects. Second, they can generate large amounts of investment capital internally, which is especially important during the current period of high inflation (inflation drives up interest on borrowed capital, making it much more expensive for smaller firms who must supplement their more limited internal funds).

Third, such firms already have powerful product-market positions where synthetic liquids must compete, so entry by new firms involves a greater risk that synthetic products cannot be sold at a profit. * The second and third advantages may be

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*See ch. 9 for further information about methanol vehicles.

[19] At the present time, approximately 1.2 x 109 gal barrels of methanol (11 x 10^6 BOE) are produced domestically, primarily from natural gas, and used almost exclusively as a chemical feedstock. See Chemical and Engineering News, Jan. 26, 1981.

*Predicting investment behavior is always difficult, but barring Federal policy to the contrary, the most likely group of potential investors are the 26 petroleum and chemical firms, each with 1981 assets of $5 billion or more (see list below). Seven chemical firms were included in this list primarily because they may be in a strong position to produce and market fuel methanol, based on their experience with methanol as a chemical feedstock.

Fortune, May 4, 1981, presents a listing of the 26 largest (in terms of total assets) petroleum and chemical firms: Exxon, Mobil, Texaco, Standard Oil of California, Gulf Oil, Standard Oil of Indiana, Atlantic Richfield, Shell Oil, Conoco, E. 1. du Pent de Nemours, * Phillips Petroleum, Tenneco, * Sun, Occidental Petroleum, Standard Oil of Ohio, Dow Chemical, * Getty Oil, Union Carbide, * Union Oil of California, Marathon Oil, Ashland Oil, Amerado Hess, Cities Service, Monsanto, * W. R. Grace, * and Allied Chemical. * Asterisk indicates firm primarily in the chemicals industry.

This conclusion about the dominance of larger companies holds despite the fact that current synfuels projects planned or under study

(continued on next page)

nullified if several smaller firms can effectively band together into consortia, but it maybe much more difficult for a consortium to build a technical staff which can develop superior technology and manage large projects during the next decade, when there will be many technical risks.

Ownership concentration is an important aspect of industrial organization in an economy organized on classical economic principles of anonymous competition, market discipline, and consumer sovereignty. Very large synfuels projects owned by very large energy corporations and consortia of smaller firms would not be anonymous, even from the viewpoint of the national economy, and they would have leverage to dictate terms in their input and output markets.

Conversely, once companies have made very large investments in new synfuels projects, they become visible targets for political action which might significantly raise costs or reduce output. Visible producers may not in fact allocate resources much differently than if there were only anonymous competitors, but at least the opportunity to manipulate markets exists where it would not otherwise—and just the appearance of doubt about the existence of consumer sovereignty can raise serious political questions.

The capital intensity of synfuels will also change the financial structure of the domestic liquid and gaseous fuel industry. Compared with investments in conventional oil and gas during the last 20 years, investment in synfuels per barrel of oil equivalent of productive capacity (barrels of oil per day) will increase by a factor of 3 to 5.[20] While all such calculations are of necessity very imprecise, the order of magnitude is confirmed by data contained in the 1980 Annual Report of Exxon Corp. As of 1980, Exxon's capitalized assets in U.S. production of oil and gas totaled $11.5 billion, and its average daily production rate (of crude oil and natural gas) was about 1.4 million BOE; so its ratio of capital investment to daily output was $8,200.[21] A 50,000 BOE/D synfuels plant at $2.2 billion implies a ratio more than five times larger ($44,000/BOE/D).

In other words, switching from conventional to synthetic liquids and gases amounts to a substitution of financial capital (and the labor and durable goods it buys) for a depleting stock of superior natural resources. A parallel substitution of investment capital for natural resources is occurring as conventional resources are increasingly hard or expensive to find and develop because of the depletion of the finite stockpile of natural resources.

As long as the United States could keep discovering and producing new oil and gas at relatively low cost, energy supplies did not impose serious inflexibilities on our economy. When we needed more we could get it without making much of a sacrifice. With synfuels, it is necessary to plan ahead, making sure that capital resources are indeed available to supply synfuels projects, and that product demand is also going to be available at least a decade into the future so that large synfuels investments can be amortized.

The current financial situation of many electric utilities in the United States illustrates the risks entailed when plans depend on long-term price and quantity predictions which may prove to be wrong. It was not long ago that utility investments were considered almost risk-free, and the industry had for decades raised all the debt it wished at low rates. Needless to say, the utility situation has now dramatically reversed as the result of sharply rising costs embodied in new, long-lived gener-

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involve many relatively small firms. For example, three of the four major parties in the Great Plains Gasification Project are primarily involved with either gas-distribution or transmission: American Natural Resources Co., Peoples Energy Corp., and Transco Cos. Inc. American Natural Resources is associated with gas-distribution firms operating in Michigan and Wisconsin; Peoples Energy Corp. is associated with Northern Natural Gas, a major distributor in the Midwest; and Transco is the parent company of Transcontinental Gas Pipeline Co., a major operator of transmission lines. The fourth partner, Tenneco, is also a major transmission company, but it was included in the group of top 26 firms listed above because of its chemical processing business. Undoubtedly, all four firms' participation is predicated upon the existence of Government subsidies and loan guarantees, but that is especially true for the three smaller firms.

[20] Comparison based on data for total costs of oil and gas wells, plus estimated costs for predrilling activities over the period from 1959-80. Capital outlays per barrel oil equivalent of reserves over the past 20 years averaged about $1.60. Depending on the synfuels option, a synfuels plant would have a comparable ratio of $5.40 to $7.00/BOE of "reserves." Well-drilling and other exploration costs were obtained from Society of Exploration Geophysicists, Annual Reports and from Joint Association Survey of the U.S. Oil and Gas Producing Industry.

[21] See 1980 *Annual* Report of Exxon *Corporation,* pp. 34, 44, 51.

ating capacity. while it may be premature to draw an analogy with synfuels, it is clear that synfuels will tie up capital in considerably larger blocks and for considerably longer periods than was true for conventional oil and gas reserves over the last 30 years.

Compared with synthetic petroleum, methanol presents two opportunities to partially offset the tendency toward industrial concentration. First, as indicated above, its present use as a major chemical feedstock provides an opportunity for large chemical firms to enter the liquid fuel business. Second, since methanol can be produced from wood and other solid biomass, small-scale conversion plants (approximately $1 O-million investments) operated by relatively small entrepreneurs may be able to take advantage of local conditions across the country. * Assuming cost competitiveness, having a mixture of small- and large-scale methanol producers may reinforce the attractiveness of downstream equipment investments (e. g., retail pumps and engine improvements), thus making it more likely that drivers will indeed have an attractive methanol opt ion.

Besides methanol, synthetic gases may attract additional large and small firms from outside the petroleum and chemical industries. Depending on the deregulated "well head" price of natural gas (relative to fuel liquids) and depending on regulatory policy regarding utility pricing, synthetic natural gas and synthetic medium-Btu gas may become profitable investments for gas utilities. Indeed, the first synthetic gas project to reach the final planning stage has substantial gas utility ownership, * * Syngas may become attractive as a methanol coproduct or as a primary product, in either case taking advantage of capital savings and higher conversion efficiencies than if methanol or gasoline is the sole product of indirect liquefaction.

A final comment can be made about the location of the synfuels industry. Shale oil production will be concentrated in Colorado and Utah, since that is where superior shale resources exist and since unprocessed shale cannot be shipped as a crushed rock without driving up costs prohibitively, Coal-based synfuels offer the possibility of spreading liquid fuel production over a wider cross section of the Nation. This is especially important for the Northeast and North Central section of the United States, where there remain substantial coal deposits in Pennsylvania, Ohio, and Illinois, States which have by this time depleted most of their original petroleum reserves.

Unlike their shale counterparts, coal-conversion facilities and subsequent upgrading and refining plants need not be immediately adjacent to the mine mouth, since coal's shipping costs per Btu are less than for shale. Location of facilities and, hence, their regional impacts will depend on site-specific factors and the available modes of transportation. Location of facilities to convert biomass into methanol will be determined primarily by local availability and cost of biomass feedstocks. This restriction is imposed by the dispersed location of plant material, rather than by differences in energy density (biomass feedstocks such as wood have an energy density only marginally lower than some Western coals).

Potential Resource Bottlenecks and Inflation

Technology, ownership concentration, and (in certain important cases) regional concentration, all combine to impose heavy demands on labor, material, and financial resources relative to current and potential new supplies of the same resources. If deployment plans fail to account for supply limitations, long project delays and large cost overruns can occur.

Anytime a capital-intensive industry attempts to start up quickly, temporary factor input shortages can be expected—if not more extreme "bottlenecks" or chronic shortages which generally disrupt construction schedules. Ideally, shortages and, certainly, bottlenecks can be avoided by ad-

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*One domestic company, International Harvester, is presently developing technology to mass-produce this equipment and transport it to the purchaser's location in easily assembled modules.

* *This compares with total private domestic investment in 1980 of about $395 billion, and out of that total about $294 billion went for nonfarm investments in new plant and equipment. Also in 1980, two large blocs of energy investments were $34 billion for oil and gas exploration and production and $35 billion for gas and electric utilities.

vanced planning and giving suppliers purchase contracts years in advance if necessary to ensure availability. However, while such planning and long-term commitments minimize shortage risks, they also increase risks of loss should plans be technically ill-conceived and commitments are made to projects with actual costs much larger than planned. These two sets of risks must be weighed against each other, but at the present time technical risks clearly are more significant.

In order to predict resource bottlenecks and their impacts, the full array of supplier market dynamics must be understood. In this limited discussion, one can only begin to compare potential demands and supplies for key synfuels resources.

As a final introductory remark, it should be clear that factor price inflation drives up costs in many industries, not just for builders of synfuels plants. Industries that appear most vulnerable to inflation resulting from synfuels deployment will be identified. However, in general, a much larger study would be necessary to trace inflationary pressures through complex interindustry transactions.

Experienced Project Planners, Engineers, and Managers

As planned, the construction of oil shale and coal liquids projects requires the mobilization of thousands of skilled workers and massive quantities of equipment and materials. Of all these synfuels investment resources, the supplies of skilled engineers and project managers are the most difficult to measure, and in the final analysis, it is left up to the large investing firms to decide for each project when a critical mass of talent has been assembled. While individual firms may have excellent engineering departments, the possibility of supply bottlenecks for chemical engineering services, across the full spectrum of chemical processing industries, must be of concern because of the potential financial risks due to design errors and because of the length of time required to educate and train new people. *

t the present time, only one of the country's 10 major architectural and engineering (A&E) firms[22] has actually built a synfuels plant. * No commercial-scale plant has been built. Given this general inexperience, and making the reasonable assumption that A&E firms will not be short of work worldwide, it seems highly unlikely that synfuels construction contracts for the first round of a rapid deployment scheme will be able to hold builders to binding cost targets and completion dates. Consequently, those who would actually take investment risks may be extremely skeptical of builders' qualifications and judgment, and this may severely limit the apparent supply of qualified engineers and engineering firms.

Furthermore, if synfuels projects proceed ahead at a rapid pace despite the technical uncertainties and commercial inexperience, it could drive up the A&E costs for other large, new processing facilities which rely on the same limited group of A&E firms and the same pool of skilled workers. Of all synfuels resource markets, the possibilities

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● Well-trained engineers and project planners can still make major mistakes, but risks due to miscalculations and design errors are controlled by careful training and building up experience incrementally. Commonly accepted periods for obtaining a bachelor's degree and subsequent on-the-job training range from 6 to 10 years.

Several recent examples illustrate that errors in the design of large mining and chemical processing plants do occur and can cause severe cost overruns and project delays. Perhaps the most extreme case was the Midwest (nuclear) Fuel Reprocessing Plant built for General Electric. Construction started in 1968, with completion planned for 1970 at an estimated cost of $36 million. Unfortunately, expected time for major technical component failure in the new plant was less than the time required to achieve stable operating conditions. The project was abandoned and the company estimated that an additional expenditure of between $9o million and $130 million would have been required to redesign and rebuild.

Additional examples include a municipal solid waste gasifier in Baltimore begun in 1973 which never achieved its major goal of commercial steam production, an oil sands project in Canada which underwent extensive retrofit when the teeth of its large mining shovels were worn away in a matter of weeks by frozen oil sands, and so on. Clearly, major design errors have happened in the past and are likely in the future, with the number and severity of such errors increasing if a shortage of experienced design engineers develops,

For further information about these and other examples of design errors, see Edward Merrow, Stephen Chapel, and Christopher Worthing, A Review of Cost Estimation in New Technologies: *Implication for Energy Process Plants and Corporations,* July 1979.

[22] According to Business *Week,* Sept. 29, 1980, p. 84, the 10 major A&E firms, in order of their largest projects to date, are: Fluor, Parsons, Bechtel, Foster Wheeler, C-E Lummus, Brown and Root, Pullman Kellog, Stone and Webster, CF Braun, and Badger.

*The Fluor Corp. built Sasol I and II in South Africa and will undoubtedly sell this technology and its unique experience in the United States. However, different resource endowments can cause very different engineering economics in different countries, and thus this existing technical base may have to be adapted to the United States by investing in significant additional engineering.

for propagation of inflation from synfuels into the rest of the economy is greatest here. Petrochemicals, oil refining, and electric power generation are all industries which depend on the same engineering resources in order to build new facilities. in 1979, these three industries accounted for more than 25 percent of the total investment in new plant and equipment.[23]

Mining and Processing Equipment, Including Critical Metals for Steel Alloys

The construction of massive and complex synfuels plants will require equally massive and diverse supplies of processing equipment and construction materials. Some of this equipment must meet high performance standards for engineering, metals fabrication, component casting, and final product assembly because it must withstand corrosive and abrasive materials under high pressure and temperature.

Potential supply problems can be identified first by comparing projected peak annual equipment demand (for each deployment scenario) to current annual domestic production. While projections were not done specifically for OTA's low and high scenarios, useful information can be extrapolated from an earlier projection for the deployment of coal liquids.[24] In that analysis, which postulated 3 million barrels per day (MMB/D) of synfuels by 2000, 7 of 18 input categories were identified as questionable because projected synfuels demands account for a significant fraction of domestic production. * Supply problems for chromium, the one item in this group of seven which is not a manufactured piece of equipment, would not be caused by synfuels deployment, since synfuels requirements would amount to less than 3 percent of domestic consumption, but supplies may nevertheless be difficult to obtain because U.S. supply is imported, much of it from politically unstable southern Africa.[25]

For the six types of equipment identified, the actual occurrence of bottlenecks will depend on the ability of domestic industry to expand with synfuels demand. In all cases, including draglines and heat exchangers—where coal synfuels requirements exceed 75 percent of current domestic production even in the low scenario—there appear to be no technical or institutional reasons why, if given notice during the required project planning period, supplies should not expand to meet demand with relatively small price incentives.

In general, this optimistic conclusion is based on the fact that leadtimes for expanding capacity to produce synfuels equipment are shorter than the leadtimes required to definitely plan and then build a synfuels plant.[26] The fact that many plants would be built at the same time does not nullify this basic comparison as long as all synfuels construction projects are visible to supplier industries, as they should be. Furthermore, foreign equipment suppliers can be expected to make up for deficiencies in domestic supply if not actually displace domestic competitors.

For example, consider the case of heat exchangers. As indicated in table 62, coal synfuels

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[23] For data see Statistical Abstract, 1980, p. 652.

[24] Data obtained from "A Preliminary Study of Potential Impediments," by Bechtel National, Inc., which is one part of a three-part compendium, Achieving a Production Goal of 1 Million B/D of Coal Liquids by 1990, TRW, March 1980. We can extrapolate from coal liquids to all other synfuels because subsequent research (by E. J. Bentz & Associates, OTA contractor) indicates that shale oil, coal liquids, and coal gases are all quite similar in their total use of processing equipment per unit output (measured in dollars) and in their mix of processing equipment. Furthermore, the Bechtel study remains useful, despite its age, since subsequent increments in synfuels plant costs do not add items to this list or significantly increase demand requirements for the group of seven critical items. In other words, recent escalations in plant costs are primarily related to increases in the expected prices of components and to increasing demands for certain components which are insignificant when compared with productive capacity nationwide.

*Significance in this case means that projected synfuels demand exceeds 1 to 2 percent of domestic production. Since this is a relatively low threshold, this list should stay about the same for both scenarios.

[25] The chief use of chromium is to form alloys with iron, nickel or cobalt. In the United States, deposits of chromite ore are found on the west coast and in Montana. However, domestic production costs are much higher than in certain key foreign countries. In 1977, South Africa produced about 34 percent of total world production, with the U.S.S.R. and Albania producing another 34 percent. Other major producers are Turkey, the Phillipines, and Zimbabwe. See Minerals in the U.S. Economy: Ten-Year Supply-Demand Profiles for Nonfuel Mineral Commodities (1968-77), Bureau of Mines, U.S. Department of Interior, 1979.

[26] One can never be certain about how well industrial systems will adapt to rapidly expanding demand for a limited number of highly engineered types of equipment which must be produced with stringent quality control, However, informal surveys of equipment manufacturers have not revealed substantial reasons why equipment supplies should not be responsive to moderate price incentives. See Frost and Sullivan, Coal Liquefaction and Gasification: Plant and Equipment Markets 1980 2000, August 1979.

Table 62.—Potentially Critical Materials and Equipment for Coal Liquids Development

Category	Units	(A) Peak annual requirements	(B) U.S. production capacity	(A)/(B) (percent)
1. Chromium	tons	10,400	0	—
2. Valves, alloys, and stainless	tons	5,900	70,000	8
3. Draglines.	yd	2,200	2,500	88
4. Pumps and drivers (less than 1,000 hp). . .	hp	830,000	20,000,000	4
5. Centrifugal compressors (less than 10,000 hp.	hp	1,990,000	11,000,000	18
6. Heat exchangers	ft^2	36,800,000	50,000,000	74
7. Pressure vessels (1.5 to 4 inch walls)	tons	82,500	671,000	12
8. Pressure vessels (greater than 4 inch walls)	tons	30,800	240,000	13

SOURCE: Achieving a Production Goal of *1* Million *B/D* of Coal Liquids by *1990,* draft prepared for the Department of Energy by TRW, Inc. and Bechtel National, Inc., March 1980, pp. 4-28. Although these projections apply to the achievement of 3 MM B/D of coal liquids, and not specifically to the low and high production scenarios Postulated in this report, they nevertheless Indicate rough orders of magnitude for equipment demand. See footnote 16 of this chapter for further discussion of alternative synfuels projections.

requirements for the low scenario could account for about 75 percent of current domestic U.S. production. Extrapolation from table 62 indicates that requirements for the high scenario could amount to 150 percent of current production and, as data in table 63 indicate, even in the low scenario, synfuels demand could exceed current U.S. production for “fin type” heat exchangers. However, productive capacity can expand as rapidly as machine operators and welders can be trained, which for an individual worker is measured in terms of weeks and months. Additional heat-treated steel and aluminum inputs will also be required, as well as manufacturing equipment, but in all cases supplies of these inputs should expand with demand .27

This generally optimistic assessment does not mean that temporary shortages could not occur and temporarily drive up equipment prices if prospects for synfuels deployment should improve dramatically.[28] However, as orders for new equipment skyrocket, new capacity should become available in time so that extremely high equipment prices can be avoided if project managers are willing to accept relatively brief (measured in months) delays in delivery.

Skilled Mining and Construction Labor

Construction workers and their families can move with employment opportunities, but moving is costly and especially burdensome if jobs in an area last for only a period of months. In order to induce essential migration, synfuels projects must incur high labor costs in the form of travel and subsistence payments as well as

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[27] Compared with the full range of heat exchangers used in industrial and utility applications, those likely to be used in synfuels plants will operate at relatively low temperatures. Low-temperature units are made primarily out of carbon steel, low-alloy steel, and enamel steel, all of which are readily available in commodity markets where demand for heat exchangers is a small fraction of the total. Hence, material inputs are unlikely to restrain expansion of heat exchanger supplies.

It is also unlikely that skilled labor or manufacturing plant and equipment will limit supplies, because the required welding and machine operator skills can be learned in a period of weeks if necessary, and manufacturing facilities are not highly specialized. Background information about the heat exchanger industry, and synfuels technology in particular, was obtained by private communication with James Cronin, Manager of Projects, Air Preheater Division, Combustion Engineering, Wellsville, N.Y.

[28] A commonly cited example of a temporary inflationary spurt, caused by a construction boom, occurred in the U.S. petrochemicals industry in 1973-75. Over the period from the mid-1 960’s to mid-1 970’s, the following three price indices show a distinctive pattern for chemical process equipment:

Year	Chemical process equipment[a]	Producer goods[b]	All machinery and Equipment
1967 . . .	100	100	100
1970	81	110	111
1971 .	86	119	118
1972	74	135	122
1973	91	160	139
1974	139	175	161
1975	167	183	171
1976	188	194	182
1977 ., . . .	154	209	206

[a] Data obtained from Annual Survey of Manufacturers, Bureau of Census, U S. Department of Commerce, SIC No. 35591 005, as reported in ASM-2.

[b] Data obtained from U.S. Statistical Abstract, 1979, PP 477-79.

In words, chemical process equipment prices reversed a decline in 1973, increased by more than 150 percent through 1976, and then tapered off again in 1977. This compares with a steady upward trend from both producer goods and all machinery and equipment.

Table 63.—Peak Requirements and Present Manufacturing Capacity for Heat Exchangers (Million Square Feet)

	Peak requirements for 3 MMB/D of coal liquids (1985)"	U.S. manufacturing capacity
1. Process shells and tubes.	22.0	27
2. Fin type	9.2	8
3. Condensers	4.4	15
	36.8	50

apeak requirements indicate maximum **capacity** requirements **if synfuels** Projects are to maintain production schedules.

SOURCE: Achieving a Production Goal of 1 Million B/Do *f Coal* Liquids by *1990,* draft prepared for the Department of Energy by TRW, Inc. and **Bechtel** National, Inc., March 1980, pp. 4-28.

"scheduled overtime. " * However, while the influx of people and the relatively high payments to workers may cause severe local inflation, regional and national impacts should not be significant. Confidence in this conclusion is based primarily on the fact that training in construction skills can be obtained in the period of weeks and months and that, if anything, there is an oversupply of people willing to enter these trades.[29]

Miners will be expected to move into a new area and stay permanently. Although it would seem reasonable to suppose that workers would be reluctant to mine underground, where working conditions can be unpleasant and hazardous, historical experience suggests otherwise. In the Eastern mines, with present wages about 140 percent of the national average in manufacturing, labor shortages have not been a serious problem.[30]

Basic Construction Materials

Among all synfuels resources, basic construction materials (primarily steel and concrete) are least likely to cause serious bottlenecks. The more rapid the pace of deployment, the more likely a premium price must be paid for steel and cement, but supplies of both should be highly responsive to price incentives.

Mineral resources for the manufacture of Portland cement (the class of hydrolic cement used for construction) are widely distributed across all regions of the Nation. The same is true for the sand and gravel that are mixed with cement and water to make concrete. The only constraint on supplies of cement or concrete is the time required to construct new capacity, which takes at most 3 years for a new cement plant and much less than that for a concrete mixing facility.[31] Since these times are short relative to the construction period for a synfuels project, cement shortages should not be a serious problem.

Steel supplies, on the other hand, may be insufficient in certain regions because required resources such as iron ore, scrap, and coking coal are not widely distributed. However, steel can be shipped long distances without dramatically raising costs. For example, unfabricated structural shapes and plates (e.g., 1 beams) are valued today at approximately $25 per hundred pounds FOB

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*Apparently, it is important for major employers to emphasize that they do not pay premium wages and salaries for large construction projects, but instead there are various special considerations. Whatever it is called, total worker remuneration appears to provide an abnormally large incentive.

[29] Bechtel's experience at nuclear powerplant sites in Michigan, Pennsylvania, and Arizona has demonstrated that a person with limited welding experience can be upgraded to "nuclear quality" in 6 to 12 weeks of intensive training. See Bechtel, "Production of Synthetic Liquids, " pp. 4-23. Actual training periods are influenced by various institutional factors. For further discussion of labor productivity see K. C. Kusterer, Labor Productivity in Heavy Construction: Impact on *Synfuels* Program Employment, Argonne National Laboratory, ANL/AA-24, U.S. Department of Energy.

The supply of people willing to work on large construction projects seems to be very price-elastic. In other words, large numbers of skilled or "able-and-willing-to-learn" workers will migrate to even remote construction sites if wage incentives exceed going rates elsewhere in the Nation by 20-30 percent. Although it is difficult to confirm this conclusion in published literature, it appears to be commonly held among university-based experts as well as in the construction industry, Information was obtained from private communications with J. D. Borcherding, Department of Civil Engineering, University of Texas in Austin; Richard Larew, Department of Civil Engineering, Ohio State University; John Racz, Synfuels Project Manager, Exxon USA in Houston; and Dan Mundy, Building Construction Trades Department, AFL-CIO, in Washington, D.C.

[30] As prescribed in the new United Mine Workers/Bituminous Operators Association contract, dated June 6, 1981, underground miners presently earn $10 to $11.76 per hour and surface miners $11.15 to $12.53. This compares with the national average wage in manufacturing of $7.80 and the average wage in construction of $9.90, both calculated for March 1981. See Monthly Labor Review, May 1981, p. 84, for additional wage data. The generalization, that labor supply has not been a serious problem, is a conclusion reached but stated only implicitly in an OTA report, *The* Direct Use of *Coal,* op. cit.

[31] Information about the resource base and construction leadtimes obtained by private communication with Richard Whitaker, Director of Marketing and Economic Research, Portland Cement Association, Skokie, III,

(freight on board at the factory) and they are commonly shipped from Bethlehem, Pa., to Salt Lake City, Utah, for another $4 per hundred pounds. In other words, even if local production is insufficient to meet the needs of synfuels deployment, vast additional supplies from a national network of suppliers can be shipped into the area without driving up costs excessively .[32]

Final Comments

Despite OTA's conclusions that resource shortages other than engineering skills need not obstruct synfuels deployment, it does not follow that rapid synfuels deployment would not be inflationary for a broad range of resource inputs. Disregarding the prospect of Federal intervention to speed up deployment or to alleviate impacts, rapid deployment could cause bursts of inflation in an economy where certain suppliers have dominant market positions at least within regions, where skilled workers are reasonably well organized, and where people have grown accustomed to inflation. In such circumstances, it would be surprising if those with power to negotiate their revenues and incomes did not exercise it to their advantage when demand for their product and services is rapidly expanding.

Another caveat should also be made concerning the importation of processing equipment. If foreign suppliers compete successfully and become major suppliers of synfuels equipment, as they have already demonstrated in the Great Plains Gasification Project, rapid deployment could result in substantial foreign payments.[33] Depending on the general balance of payments picture, this could devalue the dollar in foreign exchange markets and thus increase the price of all imports into the United States. Perhaps offsetting this concern about balance of payments, the success of equipment imports may have a salutary effect on domestic producers by inducing them to improve their products and lower their costs.

Finance Capital and Inflation

In addition to potential shortages among resource inputs, the deployment of synfuels capacity may be restrained by the limited availability of financial capital. Such a limit has already been mentioned for small companies which cannot raise $2 billion to $3 billion and for any company trying to borrow at presently inflated interest rates.

Limits may also be imposed by financial markets that compare synfuels against all other types of investments. If synfuels projects are indeed unprofitable, the number of projects funded may be small or, if they are profitable, the number may be large. In this sense, a market-based synfuels deployment scenario should be self-correcting, with the lure of profits attracting new investment when expansion is warranted and the pain of losses driving investors away and thus curtailing deployment. Any of the previously discussed shortage possibilities, should they arise, will be perceived sooner or later by investors and the number of projects reduced as a result.

Whether or not deployment is by market incentives or Government policy, the adjustment and possible disruption of financial markets required by synfuels deployment can be discussed in terms of gross investment data. Assume that on the average, during its 5-year construction period, a $2.5-billion synfuels project requires $500 million in outlays annually. This compares with total private domestic investment in 1980 of about $395 billion, of which total about $294 billion went for nonfarm investments in new plant and equipment. Also in 1980, two large blocs of energy investments were $34 bilion for oil and gas exploration and production and $35 billion for gas and electric utilities.[34]

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[32] Data obtained from American *Metal Market,* June 16, 1981, and from Bethlehem Steel, Washington Office. It should be noted that fabricated steel or steel which has been tailored to specific applications can cost as much as $75 per hundred pounds and hence shipping costs may add much less to delivered costs (on a percentage basis).

[33] In this first major synfuels project, the Japanese low bid was substantially below apparent costs. Among other things, this indicates the competitive determination of at least one foreign supplier to capitalize on synfuels deployment. For related comments by U.S. Steel firms, see *Metals Daily,* Sept. 4, 1980; and the Chicago Tribune, Aug. 30, 1980. For a general analysis of the U.S. steel industry and its competition from abroad, see Technology *and Steel Industry* Competitiveness, OTA-M-122 (Washington, D. C.: U.S. Congress, Office of Technology Assessment, June 1980).

[34] All investment data except for oil and gas were obtained from the Survey of Current Business, Bureau of Economic Analysis, U.S. Department of Commerce, September 1981, pp. 9, S1. Oil and gas

In other words, 12 fossil synfuels plants under construction at the same time would account for about 18 percent of the 1980 investments for the production of petroleum and natural gas, about 17 percent of 1980 investments by electric utilities, or about 5 percent of the total investment in manufacturing. At this pace, assuming 5-year construction periods, approximately 2 MMB/D capacity could be installed over the next 20 years (the low scenario). Almost three times this many plants on the average must be under construction at one time, and about three times as much capital must be committed to achieve the goal of just under 6 MM B/D by 2000 (high scenario). In either case, this average would be achieved by means of a relatively gradual startup, as technologies are proven and experience is gained in construction, followed by a rapid buildup as all systems become routine.

The question remains: Can funding be reasonably expected for scenarios presented in this report? The answer depends on the future growth of GN P and the future value of liquid fuels relative to other fuels and to all other commodities. Without trying to predict the future, the question may be partially answered by showing that such a diversion of funds to energy applications has precedents in recent history.

From 1970 to 1978, investments in oil and gas grew at a rate of about 7.5 percent per year and investments in electric utilities grew at about 5 percent per year, both in constant dollars.[35] A glance back at synfuels requirements as fractions of existing energy investments shows that it would take only about 2.5 years of 7.5 percent growth in oil and gas investments or about 3.5 years of 5 percent growth in electric utility investments to provide sufficient incremental funds to support the low scenario, and about three times as many years of growth in each case to fund the high scenario.

In other words, another 5-year period of expansion in energy investments, similar to their growth in 1970-78 with oil and gas and electricity added together, could provide more than enough funds annually to reach the goal of about 6 MMB/D of synfuels by 2000 (high scenario), assuming that this higher level of investment were sustained for the next 20 years. Furthermore, if such rapid deployment were economically justified (i.e., other costs were rising sufficiently to make synfuels relatively low-cost options) there would be an economic incentive to divert funds to synfuels which had been devoted to conventional fuels.

Final Comments About Inflation and Synfuels

In an inflating economy, all price increments tend to be viewed as inflationary. However, this appearance obscures the fact that some price increases are necessary adjustments in relative prices in order to reduce consumption and to increase production. The latter will be true if synfuels place large, long-term, new demands on scarce human and material resources.

On the other hand, construction costs have grown faster than the general rate of inflation since the mid-1960's.[36] (See fig. 19.) Recently, the reverse has been true but there is reason to be concerned that rapid synfuels deployment could exacerbate what has been a serious inflationary problem. In any case, rising real costs of construction has been one of the major reasons why "current" estimates of synfuels costs have more or less kept pace with rising oil prices. (See ch. 6 for more detailed discussion.)

Finally, although most of this discussion has explored how synfuels deployment may aggravate inflation, the cause and effect could be reversed if deployment of first generation plants is too slow. That is, if the promise of synfuels remains

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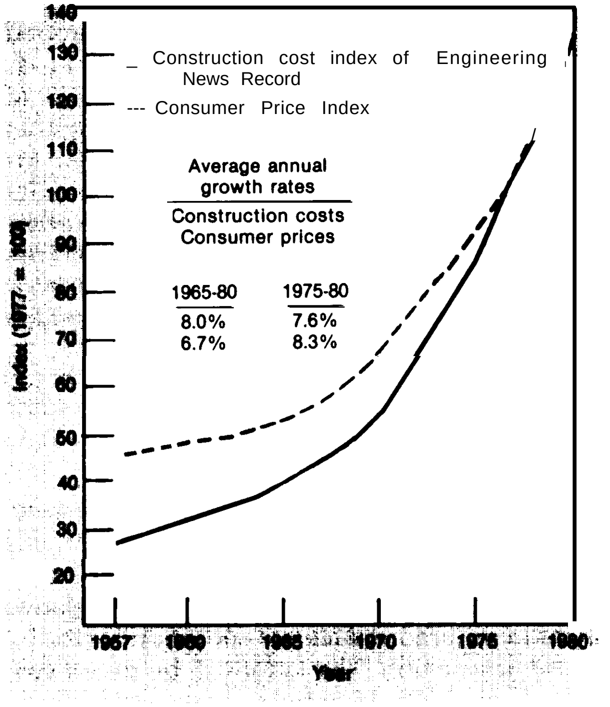
investment data were obtained from *Petroleum Industry Investments in* the 80's, Chase Manhatten Bank, October 1981. The total of $34 billion is broken down into $22 billion for service equipment, $6.3 billion for lease bonuses, and $3.1 billion for geological and geophysical data gathering.

[35] Energy investment growth data obtained from *1978 Annual Report to Congress*, Energy Information Administration, p. 128.

[36] Consumer Price index obtained from 1980 U.S. Statistic/ Abstract, p. 476. Construction Cost Index obtained from Engineering News Record, McGraw Hill, Dec. 4, 1981, Market Trends Section. The actual data series published in this journal has been converted from a base year of 1916 to a base year of 1977. There are several construction cost indices published by reputable sources, but only the ENR was reproduced here because the data available to OTA suggest that all such series reflect more or less the same trends.

Figure 19.—Time Series Comparison: Construction Costs and Consumer Prices



SOURCE: U.S. Bureau of Labor Statistics, “Monthly Labor Review and Handbook of Labor Statistics,” annual, and **“BM** and ID Investment Manual,” ***Investment Engineering,*** sec. 1, part 6, item 614, pg. 1, Apr. 16, 1961.

in the distant future and conservation attempts are clearly insufficient to balance oil supply and demand worldwide, there will be no market-imposed lid on the price of oil and no reason to expect that sharp oil import price increases will not continue to destabilize domestic prices. In that case, the inflationary impacts of rapid deployment may appear to be much more acceptable.

Chapter 9

Social Effects and Impacts

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Social Effects and Impacts

INTRODUCTION

Increased automotive fuel efficiency and production of synthetic fuels will both give rise to a variety of social impacts. The impacts of increasing fuel efficiency will occur primarily as changes in employment conditions, while the impacts of producing synthetic fuels will be felt primarily in communities which experience rapid surges and declines in population as plants are built and begin to operate.

SOCIAL IMPACTS OF CHANGING AUTOMOTIVE TECHNOLOGY

Overview

The characteristics and uses of automobiles sold in the United States indicate that historically Americans have valued automobiles not only for personal transportation but also as objects of style, comfort, convenience, and power. Substantial increases in the costs of owning and operating automobiles that occurred during the 1970's, and that are expected in the future, are motivating consumers to change their attitudes and behavior in order to reduce spending on personal transportation. Some have purchased smaller, more fuel-efficient vehicles. Others have chosen to keep their present vehicles longer. Large numbers are simply driving less. Since January 1979, the combined subcompact and compact share of total sales has climbed from 44 to 61 percent, and gasoline consumption has declined 12 percent. About one-half to three-quarters of these fuel savings can be attributed to increased fuel efficiency of the automobile fleet.

Although about 12 percent of personal consumption expenditures has historically gone to automobile ownership and operation, rising costs may ultimately induce consumers to spend a smaller share of their budgets on automobiles or —at least—not to let that share increase. Recent increases in the small-car proportion of new-car sales suggest that consumers are prepared to trade cargo space and towing capability for high fuel economy and the prospect of relatively low operating costs. in the future, instead of buying vehicles designed for their most demanding transportation needs, people may buy small vehicles for daily use and rent larger vehicles for infrequent trips with several passengers, bulky or heavy cargo, or towing. The movement toward small cars is slowed by the tendency for people to retain cars longer than before. * Purchases of fuel-efficient vehicles and ownership of several vehicles, each suited for different transportation needs, would be facilitated by improved economic conditions.

Ridesharing and mass transit use have become more common and could increase further. Since the 1973-74 oil embargo public transit ridership has increased 25 percent.[1] Ridesharing and transit use are limited by the dispersion of residences and jobs, and, for transit, by the adequacy and availability of facilities. Mass transit capacity is limited during peak commuting periods and often is unavailable or scheduled infrequently in areas outside of central cities.

It should be noted that low-income people are likely to have the fewest options for adjusting to rising automobile costs. People with low incomes already tend to own fewer vehicles, have relatively old vehicles (which were typically bought used), travel less, and share rides or use public transit more than the affluent.

Consumers are likely to respond differently to electric vehicles (EVs) and small conventionally

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*Thirty-five percent of private vehicles were over 5 years old in 1969, 51 percent were over 5 years old in 1978.

[1] American Public Transit Association.

powered cars (using internal combustion engines) because of different cost, range, and refueling attributes (see table 64). The conventionally powered car would have two significant advantages over an EV: unlimited range (with refueling) and substantially lower first cost. The EV, on the other hand, would offer the advantage of being powered by a secure source of energy (electricity) and therefore assure mobility in the event of disruption of gasoline supplies. It is not clear how the consumer would weigh these two options, although the degree to which EV manufacturers can reduce the cost differential is certain to be very important.

Employment

In 1980, the Bureau of Labor Statistics estimated that there were fewer than 800,000 people employed in primary automobile manufacturing and automotive parts and accessories manufacturing. This compares with employment levels over 900,000 during the peak automobile production period, 1978-79.[2] These figures, however, present an incomplete picture of employment. Although the Bureau of the Census counts employees in industries producing various primary products, it does not identify how many workers contribute to intermediate products used in automobiles or other finished goods. Thousands of automotive people perform work in support of automobile manufacturing within industries otherwise classified—producing, for example, glass vehicular lighting, ignition systems, storage batteries, and valves. Thus, the Department of Transportation estimated that during 1978 to 1979 about 1.4 million people were employed by auto suppliers overall.[3]

Historically, the growing but cyclical nature of the auto market resulted in a pattern of periodic growth and decline in auto-related employment (see table 65). Current and projected trends for strong import sales, decline in the growth rate of the U.S. auto market, increased use of foreign suppliers and production facilities, and adoption of more capital-intensive production processes and more efficient management by auto manufacturers and suppliers will contribute to a general decline in auto industry employment.

Specific changes in employment will depend on the number of plants closed or operating un-

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[2] Bureau of Labor Statistics, Current Employment Statistics Program data.

[3] U. S. Department of Transportation, *The* U.S. *Automobile Industry,* 1980: *Report* to the President from the Secretary of Transportation (Washington, D.C: Department of Transportation, January 1981).

Table 64.—initial and Lifecycle Costs of Representative Four-Passenger Electric Cars

	Near term					Advanced		
	Pb-Acid	Ni-Fe	Ni-Zn	Zn-CL$_2$	(ICE)	Zn-CL$_2$	Li-MS	(ICE)
Initial cost, dollars	8,520	8,400	8,130	8,120	4,740	7,050	6,810	5,140
Vehicle	6,660	5,950	5,720	5,540	4,740	5,410	5,180	5,140
Battery	1,860	2,450	2,410	2,580	—	1,640	1,630	—
Lifecycle cost, cents per mile	23.9	24.9	26.6	22.0	21.4	19.4	20.1	21.8
Vehicle	5.0	4.5	4.3	4.2	4.3	4.1	3.9	4.7
Battery	3.0	4.8	7.0	2.3	—	1.4	2.6	—
Repairs and maintenance	1.5	1.5	1.5	1.5	3.9	1.5	1.5	3.9
Replacement tires	0.6	0.5	0.5	0.5	0.4	0.4	0.4	0.4
Insurance	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
Garaging, parking, tolls, etc.	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1
Title, license, registration, etc.	0.7	0.6	0.6	0.6	0.6	0.5	0.5	0.5
Electricity	2.3	2.2	2.0	2.2	—	1.7	1.5	—
Fuel and oil	—	—	—	—	4.0	—	—	3.7
Cost of capital	5.5	5.5	5.4	5.4	3.0	4.5	4.4	3.3

NOTE: All costs are In mid-1980 dollars.

Assumptions:

Electricity price	S0.03 per kilowatt-hour
Gasoline price	$1.25 per gallon
Electric vehicle life	12 years
Internal combustion engines vehicle life	10 years
Annual travel	10,000 miles
Car end battery salvage value	10 percent
Cost of capital	10 percent per year

Car and battery purchases are 100 percent financed over their useful lives.

Electricity cost includes a road use tax equal to that paid by typical gasoline vehicles of equal weight via State and Federal gasoline taxes.

SOURCE: General Research Corp. Cost categories and many entries, such as tires, Insurance, garaging, etc., are based on periodic cost analyses by the Department of Transportation (see footnote 13). All costs shown were computed by the Electric Vehicle Weight and Cost Model (EVWAC) (see footnote 14).

Table 65.—Auto Industry Employment Data

Year	(1) Average annual unemployment rate in the motor vehicle industry SIC 371 (percent)	(2) Average annual employment in primary auto manufacturing and parts and accessories manufacturing, SIC 3711 and SIC 3714 (000)
1970. . . .	7.0	733.4
1971	5.1	781.3
1972	4.4	798.2
1973. . . .	2.4	891.5
1974	9.3	818.9
1975. . . .	16.0	727.8
1976. . . .	6.0	814.9
1977	3.9	869.5
1978. . . .	4.1	921.7
1979. . . .	7.4	908.6
1980	20.3	775.6

SOURCE Column 1 data are from the Bureau of Labor Statistics, household sample survey Column 2 data are from the Bureau of Labor Statistics establishment survey, Data in the two columns are not directly comparable. "SIC" refers to "Standard Industrial Classification."

der capacity, the capacity of the plants, and the degree to which production at affected plants is labor-intensive. The long-term effects on workers depend on personal characteristics such as skills (many production workers have few transferable skills), the levels of local and national unemployment, information about job opportunities, and personal mobility (greatest for the young, the skilled, and those with some money).

The Department of Transportation estimates that each unemployed autoworker costs Federal and State Governments almost $15,000 per year in transfer payments and lost tax revenues. This estimate implies, for example, that if 100,000 to 500,000 manufacturer and supplier workers are unemployed for a year their cost to government is about $1.5 billion to $7.5 billion. During 1980, payments to unemployed workers of General Motors (GM), Ford, and Chrysler in Michigan included about $380 million in unemployment insurance, $100 million in extended benefits, and $800 million in "trade adjustment assistance" (provided by a program established in the Trade Expansion Act of 1962 and modified by the Trade Act of 1974).[4]

Growing use of labor-saving machinery by auto manufacturers and major suppliers to implement complex technologies, cut costs, and improve product quality is reducing job opportunities in the auto industry. GM, for example, expects to invest almost $1 billion by 1990 for 13,000 new robots for automobile assembly and painting and parts handling. A new robotic clamping and welding system developed by GM and Robogate Systems, Inc., will enable GM to reduce labor costs for welding by about 70 percent, improve welding consistency, and reduce vibration and rattling in finished automobiles.[5]

MacLennan and O'Donnell, analysts at DOT, have calculated that today's new and refurbished plants can assemble 70 cars/hour with an average employment level of 4,500, while older plants typically produce 45 to 60 cars/hour using about 5,400 workers. Such plant modernization implies that three fewer assembly plants and 23,000 fewer workers are needed to assemble 2 million cars annually.[6] The United Auto Workers estimates that labor requirements in auto assembly, which has been a relatively labor-intensive aspect of auto manufacture, will be reduced by up to 50 percent by 1990 through the use of robots and other forms of automation.[7]

Foreign-designed automobiles manufactured in the United States also provide jobs. Current and anticipated local production by foreign firms (only Volkswagen (VW) to date) largely involves vehicle assembly, using primarily imported components and parts. VW's Pennsylvania plant employs 7,500 workers to assemble over 200,000 cars and contributes to about 15,000 domestic supplier jobs;[8] a comparably sized domestic--owned plant would support a total of about 35,000 domestic jobs. New U.S. manufacturing and supplier jobs will grow with local production and purchasing from U.S. suppliers by foreign firms in proportion to the amount of local production content in the automobiles. The planned increase in local content for Rabbits made here by VW—from 70 percent in model

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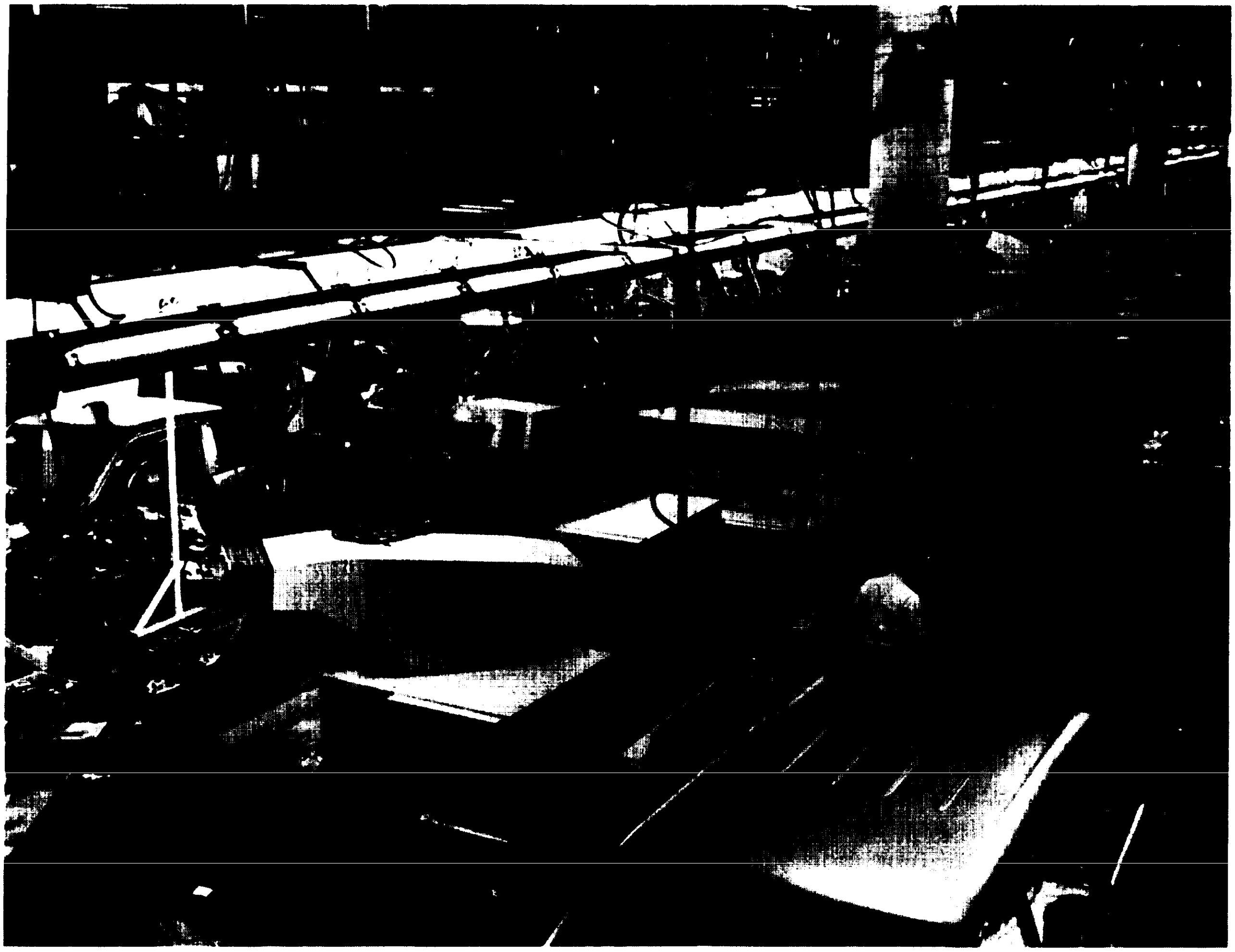
[4] Michigan Employment Security Commission, personal communication.

[5] "GM's Ambitious Plans to Employ Robots," Business Week, Mar. 16, 1981.

[6] Carol MacLennan and John O' Donnell, "The Effects of the Automotive Transition on Employment: A Plant and Community Study" (Washington, D.C: U.S. Department of Transportation, December 1980).

[7] *Business* Week, op. cit.

[8] Department of Transportation, op. cit.



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year 1981 to 74 percent in model year 1983–implies more work in the United States.[9]

The Departments of Labor and Transportation estimate that there are between one and two supplier jobs overall for each primary auto manufacturing job.[10] Change in supplier employment associated with declining manufacturing employment is uncertain, and will depend on the nature of the supplied product, how it is made, and the amount that auto manufacturers buy. While some supplier jobs, like auto manufacturing jobs, depenal on production volume, other supplier jobs (e.g., in machine tool manufacture and plastics processing) are tied to the implementation of new technology. Trends toward foreign sourcing and vehicle production and automation among suppliers suggest that supplier employment overall will decline.

Steel and rubber industry jobs are especially vulnerable to automotive weight and volume reductions. Many of these supplier jobs have already been lost with automotive weight reductions during the 1970's. For example, MacLennan and O' Donnell estimate that reduced automotive use of iron and steel in 1975 to 1980 led to a permanent loss of 20,000 jobs, a loss only

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[9] "VW Projects Increases in U.S. Content," *Ward's* Automotive Reports, May 27, 1981.

[10] MacLennan and O'Donnell, Op. cit.

partially offset by a gain of 8,000 jobs in processing plastics and aluminum for automotive use.[11] During the same period, employment in the tire and rubber industry declined at a compound annual rate of 4.1 percent.[12]

Jobs with parts and component manufacturers are also relatively vulnerable, although, again, many have already been lost. Mac Lennan and O'Donnell estimate that the closing of almost 100 materials, parts, and component plants in 1979 to 1980 eliminated over 80,000 supplier jobs.[13] Because of the predominance of small firms among auto suppliers, near-term supplier job losses may occur incrementally.

Automobile importation supports some domestic jobs and results in the loss of others. There are over 125,000 people employed by importers, primarily in dealerships.[14] Growth in import-related employment stems from increases in the number and market shares of importers, in the number of dealerships per importer, and in employment per dealership. On the other hand, imports cause loss of industrial jobs. DOT estimates that loss of 100,000 vehicle sales to imports results in the loss of about 8,500 primary manufacturing and 13,000 to 16,000 supplier jobs.[15] This implies, for example, that the almost 400,000-unit increase in import sales in 1978 to 1980 caused a loss of 34,000 jobs in automobile manufacturing and up to 64,000 supplier jobs.

Employment in automotive services, including repair, parking, renting and leasing, washing, and other services (Standard Industrial Classification 75) grew at a compound annual rate of 5.7 percent in 1975 to 1980 to a total level of almost 540,000 people, according to the Department of Commerce.[16] Employment in these areas is expected to continue to grow.

Occupational and Regional Issues

Improvements in automotive technology cause changes in the skills required for production jobs. Major design and technology changes increase demands for engineers, who have been in short supply, while cost-cutting strategies eliminate other white-collar positions. GM, for example, eliminated about 10,000 white-collar jobs beginning in 1980 to save about $300 million, and may eliminate up to 20,000 more.[17] Automation reduces the number of routine and hazardous tasks, while increasing equipment maintenance and service tasks. GM, for example, plans to have equal numbers of skilled and unskilled workers by the 1990's, although it presently has one skilled worker for each five to six unskilled workers.[18]

Auto production jobs are concentrated in Michigan, Ohio, Indiana, New York, and Illinois (see fig. 20). The geographic distribution of auto-related jobs is likely to change somewhat for several reasons. First, some nontraditional auto suppliers are located away from traditional areas of auto production. Major plastics-producing States, for example, include California, New Jersey, and Texas as well as Ohio and Illinois. Furthermore, many of today's suppliers are located abroad and many U.S. suppliers are opening plants abroad. Second, foreign or domestic firms may establish production facilities outside of the East-North Central area to gain lower labor and utility costs, For example, Nissan chose to build a plant in Tennessee. Third, domestic firms are closing inefficient and unneeded plants. Table 66 summarizes the factors considered in locating parts-supplier plants.

Automotive plant closings primarily affect employment in the East-North Central region, because automobile production is concentrated there. Ongoing and future losses of automobile-related employment in this region are largely a reflection of the structural changes in the auto industry described earlier in this chapter, although there will continue to be cyclical changes

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[11] Ibid.

[12] U.S. Department of commerce, *1981 U.S. Industrial Outlook* (Washington, D.C: Department of Commerce, 1981).

[13] Mac Len nan and O' Donnell, Op. cit.

[14] Patricia Hinsberg, "Study Finds Imports Create U.S. Jobs," *Automotive News*, Aug. 20, 1979.

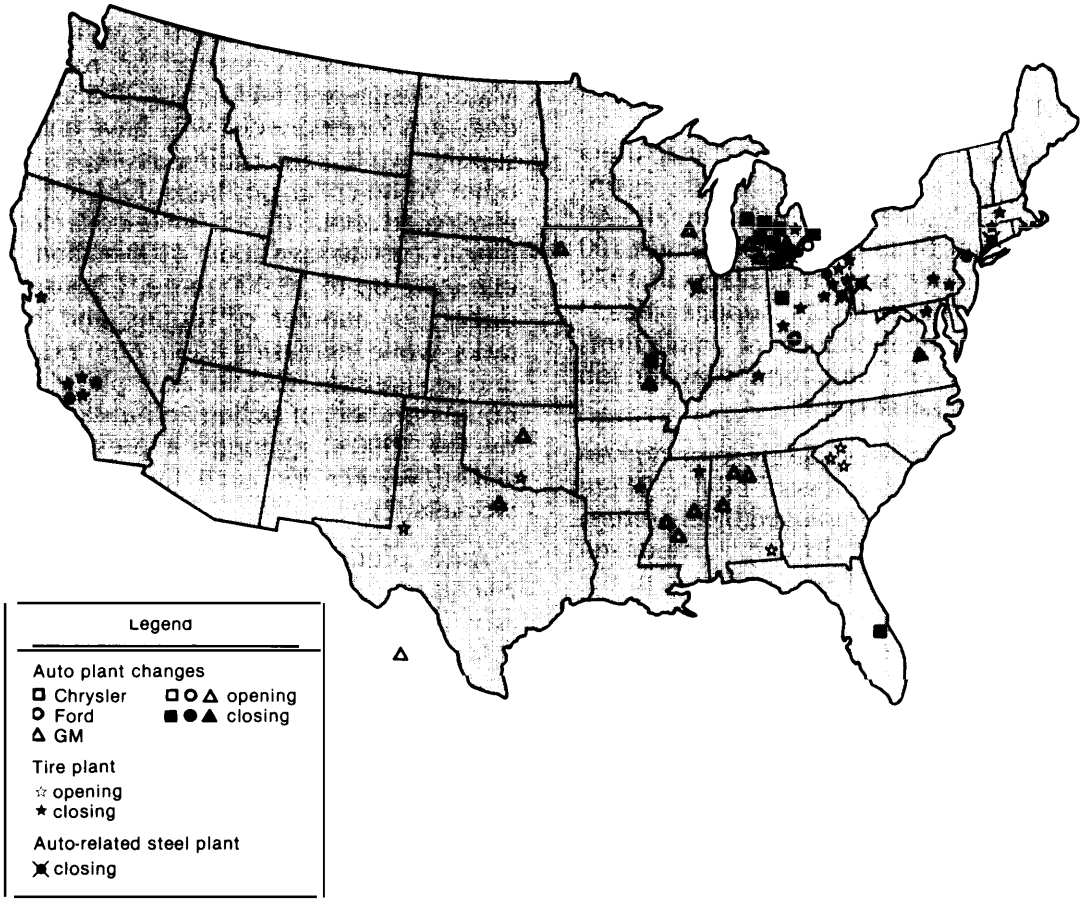
[15] Department of Transportation, op. cit.

[16] Department of Commerce, op. cit.

[17] "GM May Chop Another 19,000 Salaried jobs, " Automotive News, Mar. 2, 1981.

[18] *Wall Street Journal*, January 1981.

Figure 20.–Auto, Steel, and Tire Plant Changes, 1975=80



SOURCE: U.S. Department of Transportation, "The U.S. Automobile industry, 1980," DOT-P-1 O-81-O2, p. xviii, January 1981.

Table 66.—Factors to Consider in Locating Parts-Supplier Plants

Factor	Relative ranking 1970's	Relative ranking 1980's
Availability and cost of skilled labor		1
Availability and cost of energy	2;	2
State and local taxes, incentives	3	3
Availability and cost of raw materials . . .	2	4
Work ethic of area	4	5
State and local permits, regulations	5	6
Worker's compensation insurance	7	7
Availability and cost of capital	7	8
Right-to-work state (union relations)	6	9
Freight costs	10	10
Quality of living environment	8	11
Community attitude ., ...	9	11
Customer service	12	11
Available land	11	12

SOURCE: Arthur Andersen & Co. and the Michigan Manufacturer Association, ***Worldwide Competitiveness of the*** U.S. ***Automotive*** Industry ***and Its*** Parts Suppliers ***During*** the ***1980s,* February** 1981.

in automobile-related employment. Because of local and regional employment dependence on one industry—motor vehicles—other businesses (such as retail and service establishments) and their employment also suffer as employment in the local population declines.

Unemployment and out-migration will jeopardize other businesses and strain local tax bases, and Michigan will be especially vulnerable. Loss of employment, population, and business recently induced Moody's Investers Service, Inc., to lower bond ratings for Akron, Ohio, which has depended on the tire and rubber industry for its economic vitality; bond ratings for other auto-dependent cities have also been lowered.

Photo credit: Michigan Employment Security Commission

Shifts in plant location associated with investments in fuel efficiency may create unemployment problems in traditional manufacturing centers

SOCIAL IMPACTS OF SYNFUELS DEVELOPMENT

Overview

The principal social consequences of developing a synthetic fuels industry arise from large and rapid population increases and fluctuations caused by the changing needs of industry for employees during a facility's useful life. Such population changes disproportionately affect small, rural communities that have limited capacity to absorb and manage the scale of growth involved; these types of communities characterize the locations where oil shale and many coal deposits are found.

In general, whether the consequences of growth from synfuels development will be beneficial or adverse will depend on the ability of communities to manage the stresses which accompany rapid change. Although impacts can be generally characterized, the extent and nature of their occurrence will be site-specific depending on both community factors (size, location, tax base) and technology-related factors (the location, size, number, and type of synfuels facilities; the rate and timing of development; and associated labor requirements).

Growth will tend to concentrate in established communities where services are already available, if they are within commuting distance to synfuels facilities. New towns may be established to accommodate growth in some areas. Large towns will serve as regional service centers. Isolated communities will more likely experience greater impacts than areas where well-linked communities can share the population influx. Energy conversion facilities which are sited near mines will result in the greatest concentration of local impacts.

Most synfuels production from oil shale in the Nation will be concentrated in four Western counties, affecting about a dozen communities in sparsely populated areas of northwestern Colorado and northeastern Utah, and eventually southwestern Wyoming. These communities are widely separated, are connected by a skeletal transportation network, and have had historically small populations. Oil shale cannot be economically transported offsite because of the large quantities of shale involved per barrel of product.

Coal presents a more flexible set of options than oil shale with respect to the location of conversion facilities in relation to mines. The coal used for synfuels production will most likely be dispersed among all the Nation's major coal regions.

In the West, coal sites will be in the oil shale States (Colorado, Utah, and Wyoming) as well as in Montana, North Dakota, and New Mexico. Most of the increase in Western coal production for synfuels will be in Wyoming and Montana.[19] Midwestern sites will most likely be in Illinois, western Kentucky, and Indiana. The coal counties to be most severely affected in Appalachia will be in rural parts of southwestern Pennsylvania, southern West Virginia, and eastern Kentucky. Parts of Illinois will also be affected. In central Appalachia, communities are typically small, congested, and in rural mountain valleys.

The major differences between the Eastern and Western coalfields, in general, are that in the West, counties are larger, towns are smaller and more scattered, the economic base is more diversified, more land is under Federal jurisdiction, water is relatively more scarce, and the terrain is less rugged and variable. To the extent that coal is transported, there could be additional environmental and safety hazards, noise, and disruption or fragmentation of communities, farms, and ranch lands.

The social consequences of producing synthetic fuels from biomass are discussed in detail in a previous OTA report, Energy From Biological Processes. Unlike the social consequences associated with fossil fuels, the social impacts of biomass arise from production rather than processing. For example, 90 percent of the employment impacts from biomass are expected from cultivation and harvesting (mostly forestry).

Manpower Requirements

Manpower requirements for synfuels production are generally of two types: 1) labor is required for the construction of energy facilities and supporting service infrastructures, and 2) workers are needed for the operation and maintenance of facilities. As discussed in chapter 8, the ability to attract and retain an adequate labor force—particularly experienced chemical engineers and skilled craftsmen, who are already in short supply—could become a constraint on synfuels development.

Construction manpower requirements for single projects lead to large, rapid, yet temporary, increases in the local population. The construction phase usually lasts 4 to 6 years, peaking over a 2- to 4-year period as construction activities near completion.[20] The shorter the scheduled construction period, the higher the peak labor force.[21] Labor requirements will change significantly during the construction phase, in terms of both size and occupational mix. Labor requirements for the daily, routine operation and maintenance of a plant are relatively stable during the useful life of the facility; scheduled yearly and major maintenance work would cause only brief increases in the operations labor force.

Estimates of manpower requirements for generic 50,000 barrel per day (bbl/d) synthetic fuel

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[19] E. J. Bentz & Associates, Inc., "Selected Technical and Economic Comparisons of Synfuel Options," contractor report to OTA, April 1981.

[20] Ibid.

[21] peter D. Miller, "stability, Diversity, and Equity: A Comparison of Coal, Oil Shale, and Synfuels," in Supporting Paper 5: Sociopolitical Effects of Energy Use and Policy, CONAES, Washington, D. C., 1979.

plants are shown in table 67. They are highly uncertain, in large part because of the lack of experience with commercial-size plants. In addition, major components of uncertainty in the construction manpower estimates include such unpredictable situations as regulatory delays, lawsuits, delays in the receipt of materials, labor unrest, and the weather; and major components of uncertainty in the estimates of operations manpower relate to the age of the plant, maturity of the technology, and novelty of the plant design.

Even for well-known technologies such as coal-fueled electric powerplants, initial estimates of the peak construction labor force required for selected rural-sited plants have varied from about 50 to 270 percent of the actual peak levels.[22] This range of uncertainty may be applicable to the estimates of construction manpower requirements for synfuels plants in general, but should prove to be overly broad when considering a specific technology. The uncertainty surrounding requirements for operational manpower is expected to be narrower, perhaps on the order of + 25 percent.[23]

The estimates shown in table 67 are plant-gate employment requirements; other synfuels-related activities such as mining, beneficiation, and transportation are not included unless indicated. The manpower requirements for these additional activities will be site-specific and could alter the relative ordering of alternative technologies. For example, on the national average, production per miner per day is approximately three times greater in surface mines than in underground mines. This ratio can be expected to vary, depending on many factors including types of methods and equipment used and geology for underground mining, and geology and environmental considerations for surface mining.[24]

Population Growth

Local population will grow where synfuels are produced because workers directly employed at the synfuels plants, employees in secondary industries and services, and accompanying families will move into these areas. Population growth rates will depend on the nature of the area where the plant is located and on the phase of plant development.

Estimates of population growth due to synfuels development usually assume that for each new worker entering an area, the population increases between three and five persons.[25] The demand

Table 67.—Manpower Requirements for a 50,000 bbl/d Generic Synfuels Plant

	Liquefaction			
	Direct	Indirect	Coal gases	Oil shale
Total construction (person-years).	11,000	20,000	11,000	11,000[a]
Peak construction (persons)	3,500	6,800[b]	3,800	3,500[a]
Operations and maintenance (persons)	360[c] 2,300[d]	360[c] 3,800[d]	360[c] 1 ,200[d]	2,000[e]

[a]**Surface retorting will generally** have higher construction manpower requirements than modified in-Situ Processes.
[b]Manpower requirements of 17,000 persons have been projected by Fluor Corp. based on a **SASOL** tYPe **coal conversion plant** ("A Fluor Perspective on Synthetic Liquids: Their Potential and Problems").
[c]**Daily,** routine O&M **requirments (E.** J. **Bentz** & Associates, **Inc.,** "Selected Technical and Economic Comparisons of **Synfuels** Options," April **1981).**
[d]**Annual** aggregation **of** scheduled **yearly and major** maintenance work. Technology **specific (Bechtel National, Inc.,** "production of Synthetic Liquids From Coal: 19S0-2000," December 1979).
[e]Oil **shale** requirements include **mining.** Modified **in-situ (MIS) processes** will **generally have higher** O&M **requirements** than **surface** retorting (e.g., MIS Involves an ongoing mining process).

SOURCE: Office of Technology Assessment

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[22] John S. Gilmore, "Socioeconomic Impact Management: Are Impact Assessments Good Enough to Help?" paper presented at the Conference on Computer Models and Forecasting Impacts of Growth and Development, University of Alberta, Jasper Park Lodge, Alberta, Apr. 21, 1980 (revised June 1980).

[23] George Wang, Bechtel Group, Inc., personal communication.

[24] The average national production per miner per day was 8.38 tons in underground mines and 25.78 tons in surface mines for bituminous and lignite in 1978. Nationwide, productivity varied: for underground mining, from approximately 2 to 15 average tons per miner per day and, for surface mining, from approximately 7 to 98 average tons per miner per day. (Department of Energy, Energy Information Administration, Bituminous *Coal* and Lignite Production and Mine Operations— 1978, Energy Data Report, June 16, 1980.)

[25] As an example, White, et al., use a population/employment multiplier of 3.0 for the construction phase and 4.0 for the operation phase (Energy From *the West,* Science and Public Policy Program, University of Oklahoma, prepared for the Environmental Protection Agency, March 1979). Miller uses a uniform "conservative" population/employ merit multiplier of 5.o (see footnote 21 above).

for support services in nearby communities increases with the absolute size of the work force during the peak construction period. The larger the work force required during peak construction relative to that required for operations and maintenance, the greater the likelihood that nearby communities will experience large population fluctuations.

In general, if several facilities are located in the same area, the impacts from population growth and fluctuation could be disproportionately large unless construction and operation activities are coordinated; on the other hand, population growth associated with construction can be stabilized if an indigenous construction work force develops. *

Estimates of population increases associated with the fossil synfuels development scenarios presented in chapter 6 are shown in table 68. On a regional basis, population growth associated with oil shale will be concentrated in only several counties in the Mountain Region (see fig. 21). population increases associated with coal-based synfuels will be dispersed throughout the Nation, with the East North Central experiencing the biggest population increases and the West South Central experiencing the smallest population increases.

Table 69 shows energy-related population growth during the last decade in selected communities. In small communities, and in sparsely populated counties and States, energy-related population growth could represent a significant proportion of future population growth. For example, official population projections by the Colorado West Area Council of Governments (CWACOG) show increases by 1985, relative to 1977, of up to 400 percent in Rio Blanco County (1977 special census population was 5,100) and 300 percent in Garfield County (1 977 special census population was 18,800), assuming the industry develops according to the 1979 plans of companies active in the area.

Table 68.—Estimates of Regional Population Growth Associated With Fossil Synfuels Development [a] (thousands)

	1990	1995	2000
Low estimate:			
South Atlantic	4-6	12-20	30-51
East North Central	14-24	46-76	115-192
East South Central	5-9	17-28	42-71
West North Central	5-9	17-28	42-71
West South Central	2-3	6-10	15-25
Mountain:			
Coal	7-12	23-38	58-96
Shale	66-110	90-150	81-135
Total	103-173	211-350	383-641
High estimate:			
South Atlantic	11-18	33-55	86-144
East North Central	33-56	105-174	275-458
East South Central	11-18	33-55	86-144
West North Central	17-29	54-90	141-235
West South Central	5-8	15-25	39-65
Mountain:			
Coal	19-32	60-100	122-203
Shale	132-220	213-355	108-180
Total	228-381	513-854	857-1,429

[a] Estimate are relative to 1985 (for plants coming online in the Year shown) and are based on OTA's development scenarios presented in ch. 8. Population multipliers of 3 and 5 were applied to develop the ranges shown. Aggregated estimates should not be extrapolated to determine the ability of any State or locality. to absorb this population.

[b] Production is distributed among the regions, according to the low and high scenario distributions used In the Bechtel report for, respectively, the low and high scenarios developed herein (Bechtel National, Inc., December 1979). It is further assumed that direct and indirect liquids will be representad equally. Only dally, routine O&M requirements are included.

Regional estimates are for coal processes unless other wise indicated.

SOURCE: Office of Technology Assessment.

Under CWACOG's high-growth scenario (500,000 bbl/d in 1990 and 750,000 bbl/d in 1995 and 2000), increases of up to 800 percent in Rio Blanco County and 350 percent in Garfield County are projected.[26] In three counties in Kentucky where the construction of four major synfuels plants had recently been planned to commence (H-Coal, SRC-1, W. R. Grace, and Texas Eastern), the expected maximum number of synfuels workers (excluding accompanying family members) was projected to increase 1980 population levels by about 3 percent in Daviess County (1 980 census population was 86,000) to over 30 percent in Breckinridge County (1980 census population was 17,000) and over 50 percent in Henderson County (1980 census population was 41 ,000); population increases during the operation phase

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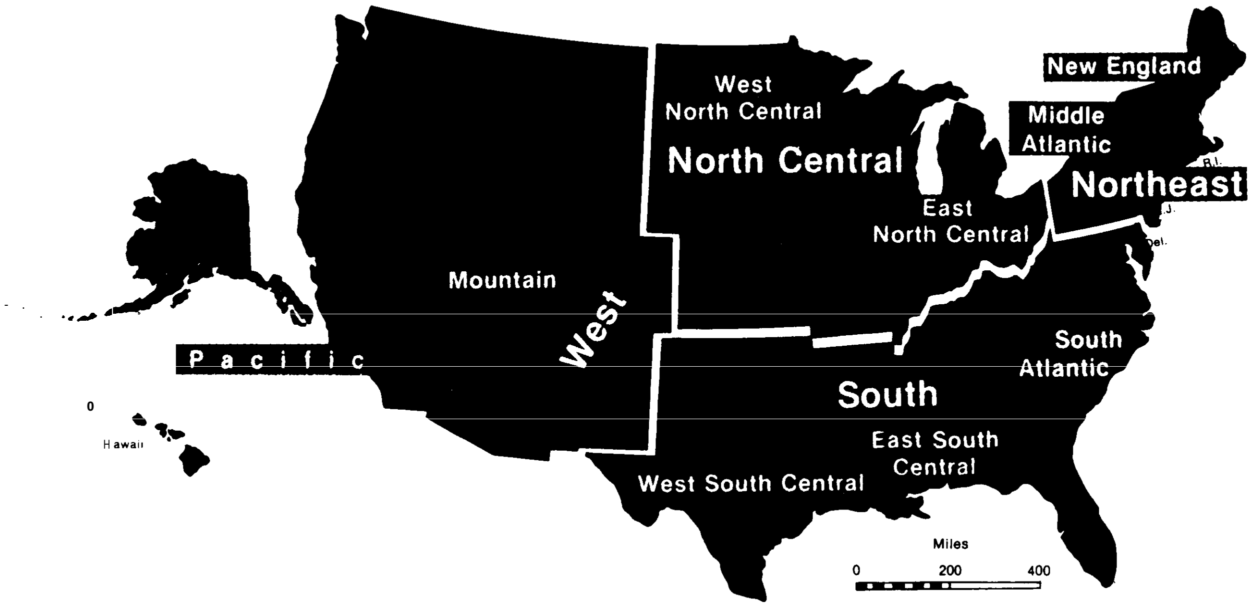
*A succession of projects in an area should lead to an indigenous and more stable construction manpower work force, depending on whether workers perceive a permanence of industrial expansion in the area. Some proportion of the construction work force may also be employed in operations and maintenance activities once construction is completed.

[26] *An* Assessment of *Oil* Shale Technologies, OTA-M-118 (Washington, D. C.: U.S. Congress, Office of Technology Assessment, June 1980).

Figure 21 .—Census Regions and Geographic Divisions of the United States



SOURCE: U.S. Department of Commerce, Bureau of the Census.

Table 69.–Population Growth in Selected Communities, 1970-80

State	City	Energy resource impact [a]	Population [b] 1970	Population [b] 1980	Percent increase Total	Percent increase Average annual (compounded)
West Virginia	Buckhannon, Upshur County (Union District)	coal	248	587	136.7	9.0
Kentucky	Caseyville, Union County	coal			87.0	6.5
Utah	Huntington, Emergy County	coal, powerplant	857	2,316	170.2	10.5
	Orangeville, Emery County	coal, powerplant	511	1,309	156.2	9.9
	Helper, Carbon County	coal	1,964	2,724	38.7	3.3
Wyoming	Douglas, Converse County	coal, uranium, oil, gas	2,677	6,030	125.3	8.5
	Gillette, Campbell County	coal	7,194	12,134	68.7	5.4
	Rocksprings, Sweetwater County	coal, oil, gas, trona, powerplant, uranium	11,657	19,458	66.9	5.3
North Dakota	Washburn, McLean County	coal, powerplant	804	1,767	119.8	8.2
	Beulah, Mercer County	coal, powerplant	1,344	2,878	114.1	7.9
Montana	Forsyth, Rosebud County	coal, powerplant	1,873	2,553	36.3	3.2
	Hardin, Big Horn County	coal	2,733	3,300	20.7	1.9
	Colstrip, Rosebud County [c]	coal, powerplant	<200	3,500	1,650.0	33.1
Colorado	Craig, Moffat County	coal, powerplant	4,205	8,133	93.4	6.8
	Rifle, Garfield County	oil shale, minerals, coal	2,150	3,215	49.5	4.1
	Hayden, Routt County	coal, powerplant	763	1,720	125.4	8.5

[a] Identified by the Department of community Development within the respective States.
[b] Bureau of the Census, *1980 Census* of Population and Housing, *Advance Reports*.
[c] Estimates by Sunlight Development, Inc.

SOURCE: Office of Technology Assessment.

were projected to be respectively 0.4, 4, and 15 percent (excluding accompanying family members).[27] Table 70 shows statewide population estimates, based on an extrapolation of only demographic trends, for some of the States that are most likely to experience population increases from synfuels development.

Small rural communities (under 10,000 residents) that experience high population growth rates are vulnerable to institutional breakdowns. Such breakdowns could occur in the labor market, housing market, local business activities, public services, and systems for planning and financing public facilities. Symptoms of social stress (such as crime, divorce, child abuse, alcoholism, and suicide) can be expected to increase.

The term “modern boomtown” has been used to describe communities that experience strains on their social and institutional structure from sudden increases and fluctuations in the population. Communities are also concerned about the possibility of a subsequent “bust.” Large fluctuations in population size could lead to a situation where a community expands services at one point in time only to have such services underutilized in the future if demands fail to materialize or be sustained.

Private Sector Impacts

The principal social gains from synfuels development in the private sector are increased wages and profits; direct and secondary employment opportunities will be created and expanded; disposable income will increase; profits from energy investments should be realized; and local trade and service sectors will be stimulated. The ability of the private sector to absorb growth will depend, in large part, on the degree of economic diversification already present. Western communities, in general, have more diversified economies and broader service bases than those in the East, where many communities (as in central Appalachia) have historically been economically dependent on coal.

Many private sector benefits, however, will not be distributed to local communities, at least during the early periods of rapid growth. For example, synfuels development would be located in areas where the required manpower skills are already scarce; unemployment in local communities may thus not be significantly lowered unless local populations can be suitably trained. Where synfuels development competes with other sectors for scarce labor, fuel and material inputs, and capital resources, traditional activities may be curtailed and the price of the scarce resources inflated. Local retail trade and service industries may experience difficulties in providing and expanding services to keep pace with demands, re-

Table 70.—Statewide Population Estimates

State	Total State population 1980 [a] (millions)	Statewide population percent increase 1970-80 Total	Annual compounded	Projected State population 2000 [b] 1990	2000
Kentucky	3.66	13.7	1.3	4.08	4.43
West Virginia.	1.95	11.8	1.1	2.08	2.20
Colorado	2.89	30.7	2.7	3.50	4.00
Montana.	0.79	13.3	1.3	0.90	0.98
North Dakota.	0.65	5.6	0.5	0.70	0.73
Wyoming	0.47	41.6	3.5	0.54	0.60
Utah	1.46	37.9	3.3	1,73	1.95

[a] Bureau of the Census, *1980 Census* of Population and Housing, Advanced *Reports.*

[b] Bureau of the census, *Illustrative* Projections of State Populations by Age, Race, and Sex: *1975 to 2000.* Projected estimates are from Series II-B which assumes a continuation from 1975 through 2000 of the civilian non-college interstate migration patterns by age, race, and sex observed for the 1970-75 period. Has been corrected by the percent difference between the 1980 projections and the 19S0 census. Note that these projections are extensions of recent trends with respect to demographic factors only.

SOURCE: Office of Technology Assessment.

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[27] C. Gilmore Dutton, “Synfuel Plants and Local Government Fiscal Issues,” memorandum to the Interim Joint Committee on Appropriations and Revenue, Frankfort, Ky., Dec. 18, 1980.

cruiting and retaining employees, and competing with out-of-State concerns. Both the Eastern and western sites for synfuels development have generally depended on imported capital, and profits to and reinvestments of the energy companies are likely to be distributed to locations remote from plant sites.

High local inflation rates often accompany rapid growth, due to both excess demand for goods and services and high industrial wage rates. Local inflation penalizes those whose wages are independent of energy development and those on fixed incomes.[28]

Housing can be a major problem for the private sector in areas that grow rapidly from synfuels development: the existing housing stock is usually already in short supply and often of poor quality; local builders often lack the experience and capability to undertake projects of the large scale required; shortages of construction financing and mortgage money are common; and land may not be available for new construction because of terrain, land prices, or overall patterns of ownership. Housing shortages have already led to dramatic price increases in the Western oil shale areas. The need for temporary housing for construction workers aggravates housing supply problems, and mobile homes are often used by both temporary and permanent workers.

Public Sector Impacts

Communities experiencing rapid growth are vulnerable to the overloading of public facilities and services, due both to large front-end capital costs and to constraints which limit a community's ability to make the necessary investments in a timely fashion. * Ability of a community to absorb and provide for a growing population will be community-specific and depend on many factors—such as the size of the predevelopment tax base, availability of developable land, existing social and institutional structure, extent and rate of growth of demand for public services, local planning capabilities and management skills, and political attitudes.

In the long run, local governments should benefit from expanded tax bases arising from the capital intensity of energy facilities and the establishment of associated economic activity. In the aggregate, sufficient additional tax revenue should be produced to pay for the upgrading and expansion of public facilities and services as required for the growing population.[29] In the short run, however, raising local revenues under conditions of rapid growth is often made difficult because of the unequal distribution of incurred costs and revenue-generating capacity among different levels of government.

For example, energy development activities are typically sited outside municipal boundaries, with the result that revenues go to the county, school district, and/or State. However, the population growth accompanying this energy development, and hence the need for services, typically occurs within cities and towns that do not receive additional revenues from the new industry. The separation between taxing authority and public service responsibility can also occur across State lines. In addition, the availability of local tax revenues can lag behind the need for services, because industrial taxes are often based on assessed property values and are not received until full plant operation. * Note also that the total tax burden on the mineral industry and the proportion of State taxes distributed to localities vary from State to State.

There is no clear consensus on the cost of providing additional new public facilities and services in communities affected by energy development. The economics of the decision to expand from an existing service base, or to build a new town, will depend on such factors as the availability of land, accessibility to employment, extent and

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[28] *An* Assessment of *Oil* Shale Technologies, op. cit.

*investments in the public sector can be constrained by, as examples, existing tax bases, debt limitations, bonding capacity, and the 2- to 5-year leadtime typically required for planning and implementing services. In addition, ceilings are often established on the rate of expansion of local government budgets, and there is a tendency either not to tax or to undervalue undeveloped mineral wealth.

[29] *Management* of *Fuel* and *Nonfuel* Minerals in Federal Lands, OTA-M-88 (Washington, D. C.: U.S. Congress, Office of Technology Assessment, April 1979).

*Note that mobile homes generate little, if any, property taxes; and local governments have had difficulty in providing services to such sites.

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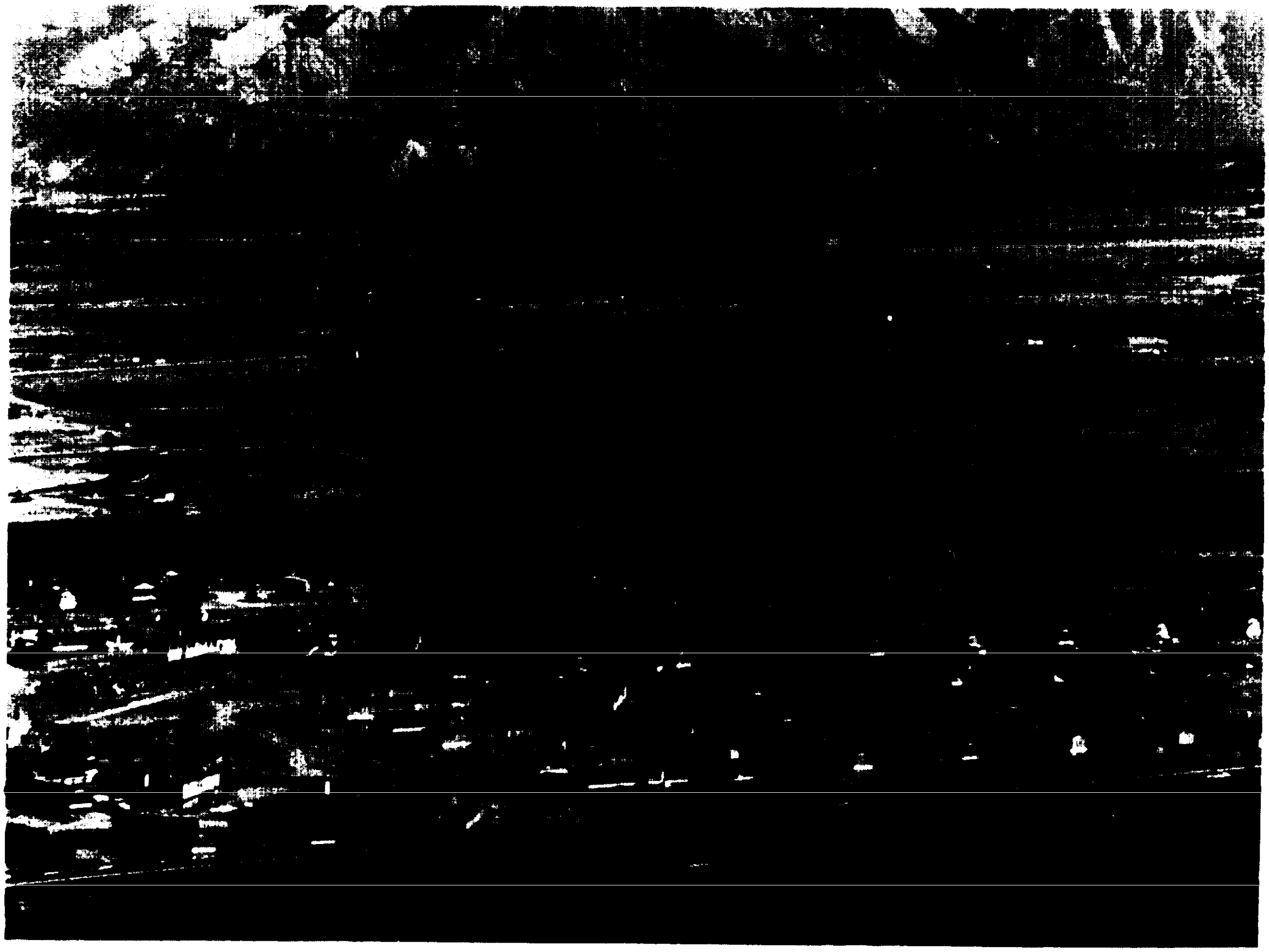

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Synfuels development will require the creation of new communities in sparsely populated areas recovery or other funding/revenue mechanisms have been applied.

Health care is particularly vulnerable to overloading from rapid growth because rural communities often have inadequate health services prior to development and experience difficulties in attracting and retaining physicians. Synfuels development will change the health care needs of local communities because of the influx of young families, the increase in sources of social stress, and new occupational environments that will give rise to special health care needs. Hospital facilities as well as health, mental health, and social services will be required. Educational facilities are also likely to be overloaded. Both Eastern coal communities and Western oil shale communities are presently having difficulty in attracting and retaining personnel and in funding the provision and expansion of facilities and programs,

Public sector dislocations caused by synfuels development on Indian lands could be more severe than on other rural areas. Tribes have limited ability to generate revenues, there will be large cultural differences between tribal members and workers who immigrate to an area to work on a project, and land has religious significance to some tribes and individual landownership is commonly prohibited (so that, for example, conventional patterns of housing development may not be possible).

Most reservations are also sparsely populated, with few towns, and public services and facilities are severely inadequate and overburdened. Significant amounts of coal are owned by Indians in New Mexico and Arizona, lesser amounts in Montana, North and South Dakota, and Colorado. Although in the aggregate current coal leases represent only a fraction of the total coal under lease, Indian leases are important because of their size and coherence. About 8 percent of the oil-shale mineral rights in the Uinta Basin are owned by Indians, but most of the associated deposits are of low grade.[32]

Managing Growth

Unmanaged growth, although not well understood, appears nevertheless to be a leading source of conflict and stress associated with energy development. All involved parties-the Federal, State, and local governments; industry; and the public—have an interest in and are contributing in varying degrees to growth management by providing planning, technical, and financial assistance to communities experiencing the effects of synfuels development. These mechanisms, which vary among States in terms of their scope, detail, and development, are discussed in detail in previous OTA reports.[33] [34] [35] In general, the effectiveness of existing mechanisms has yet to be tested in the face of rapid and sustained industrial expansion. Major issues to be resolved include who will bear the costs of and responsibilities for both anticipating and managing social impacts, and how up-front capital will be made available when needed to finance public services.

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[32] U.S. Geological Survey, Synthetic Fuels Development, Earth-Science Considerations, 1979.

[33] An Assessment of Oil Shale Technologies, op.cit.

[34] Management of Fuel and Nonfuel Minerals in Federal Lands, op. cit.

[35] The Direct Use of Coal: Prospects and Problems of Production and Combustion, OTA-E-86 (Washington, D. C.: U.S. Congress, Office of Technology Assessment, April 1979).