3.0 FEDERAL ACTIVITIES

Although production and distribution of energy has been primarily the role of industry in U.S., the federal government has been involved in a variety of ways. This chapter examines the various federal government programs established through mid-1980, that directly support the development and use of evolving synfuels technologies. The federal government's other activities in energy resource management, production and use — for example: leasing federal petroleum, coal and oil shale lands, environmental and economic regulations, federal production such as the Naval Petroleum Reserves, and the energy systems operations such as TVA — although of great importance to the creation of a synfuels industry, are not subjects of this document.

Federal programs directly related to the development and use of synfuels technologies have included: (1) long-term assessments of U.S. energy resources such as coal and oil shale; (2) sponsorship and conduct of R&D for the development and improvement of synfuels technologies; (3) construction of first-of-a-kind synfuel demonstration plants; (4) financial assistance to the private sector for project design and planning; and, (5) direct financial support to reduce the business risk of synfuel plants in the uncertain world energy market.

3.1 RESOURCE ASSESSMENTS

The federal government has long been active in assisting and evaluating the mineral resources of the nation. Much of this work historically has been carried out within the Department of the Interior through the United States Geological Survey and the Bureau of Mines. Under the Department of Energy Organization Act certain of these resource assessment and data gathering activities were transferred to the new Department of Energy.

The Geological Survey conducts continual estimates of coal resources and classified them initially as identified resources or undiscovered resources. The Geological Survey and the Bureau of Mines have adopted

a uniform set of criteria for measuring resources. *Identified resources* refer to deposits of coal whose location, quality and quantity have been mapped and are known to exist from geologic evidence supported by engineering measurements of known reliability. *Undiscovered resources* are surmised deposits of coal believed to exist in ummapped and unexplored areas on the basis of broad geologic knowledge and theory.

The term *reserves* refers to portions of identified coal resources that can be mined under current engineering and economic conditions; estimates are referred to as the demonstrated reserve base. The *demonstrated reserve base* relates to coal deposits at depths and seam thicknesses similar to those from which coal is currently being mined. That portion of the demonstrated reserve base which can actually be mined given present technological, economic and legal constraints is termed *recoverable reserves*.

The Bureau of Mines has conducted additional assessments of the domestic coal resource base on such bases as sulfur content, strippable reserves, coking and metallurgical properties.

3.2 SYNFUELS R&D

The federal government's activities in synthetic fuels research and development are combined in the Department of Energy.

The DOE synfuels research program dates back many decades and several agencies. During and following World War II, the Bureau of Mines in the U.S. Department of the Interior conducted an ambitious program on synfuels from coal and oil shale. Work was performed primarily at federal research centers located in Pittsburgh, PA, Morgantown, WV, Laramie, WY, and, Grand Forks, ND; and at field locations, such as Louisiana, MO, and Rifle, CO. The Bureau of Mines synfuels program ebbed, however, when extensive reserves of natural gas and petroleum were discovered in this country and abroad during the 1950's.

The Office of Coal Research (OCR) was created by the Interior Department during the early 1960's as a response to the declining domestic markets for coal. The focus of this office was environmentally clean fuels from coal. The major emphasis was the production of pipeline-quality synthetic natural gas from coal and the production of a low-ash, low-sulfur, solid refined coal. OCR had no in-house laboratories and performed its work through contracts with the private sector, including a major joint program with the American Gas Association for coal gasification projects.

In the early 1970's synfuels research activities in both the Bureau of Mines and the OCR grew rapidly. The two organizations were merged in early 1975 to form the nucleus of the fossil energy program in the new Energy Research and Development Administration. The program continued and grew with the creation of the Department of Energy in 1977.

In late 1979, a new senior-level position was established — that of Assistant Secretary for Fossil Energy. Research and development (but not demonstrations) of synfuels from coal became the responsibility of the Deputy Assistant Secretary for Coal Technology. Oil shale and tar sands R&D were placed under the Deputy Assistant Secretary for Oil, Gas and Shale Technology.

R&D activities relating to coal liquefaction cover a range of topics: improved indirect liquefaction processes; advanced direct liquefaction processes; use of high-solids liquefaction residuals for hydrogen production; durability of materials and auxiliary equipment; characterization and control of potentially toxic components; catalyst development; reactor modeling; coal liquids thermodynamics; coal liquids refining and upgrading; and, lignite liquefaction.

Gasification R&D addresses both surface and *in situ* technologies. Surface activities include third-generation processes, peat gasification, engineering evaluations of competing processes, operational programs using low-Btu gasifiers in industry, and hot-gas cleanup. *In situ* activities include field tests with various coal seams and

geology, underground instrumentation development, laboratory research and modeling, and environmental monitoring of field tests.

In the oil shale area, the principal R&D thrust is to develop *in situ* processes to exploit relatively lean or deep shales. Supporting laboratory research is conducted on advanced surface retorting concepts, process modeling, and environmental characterization.

In addition, a comprehensive program of basic and exploratory process research is conducted to support all synfuels technologies. This program gathers basic chemical and engineering data; explores new process concepts; and supports improved catalysts, materials, instruments, and controls.

A variety of mechanisms is employed to implement these R&D activities. Work is performed at the six federal energy technology centers, several national laboratories, industrial firms under contract, universities, and non-profit research organizations.

3.3 SYNFUELS DEMONSTRATIONS

Under the Assistant Secretary for Fossil Energy, the synthetic fuels demonstration effort is centered in the Office of the Program Director for Project Management. This program includes both large pilot plants and demonstration plants.

Large pilot and demonstration projects are intended primarily to provide data as well as to produce substantial quantities of synfuels. The information which they yield will establish equipment and product reliability, validate engineering concepts, and determine environmental acceptability and economic feasibility. Both pilot and demonstration projects are complex undertakings, highly capital intensive and expensive. The costs of building and operating a single large pilot or demonstration plant may range from several hundred million to over one billion dollars.

Both types of plants require several years to design and construct, and both will operate for several years for testing and data-gathering purposes. When the information-gathering phase is completed, however, a successful demonstration plant may become the initial module of a commercial facility at the same site. By contrast, a pilot plant is envisioned ultimately as being dismantled to recover the salvage value of the equipment or as being converted for use in some new testing programs.

Thus, the site for a demonstration plant is selected in anticipation of long-term commercial expansion and operation. The demonstration plant is designed to include the same scale and types of equipment and the same-full scale environmental control systems that would go into a commercial plant. It is a complete, stand-alone facility, designed for sustained operations over extended periods.

The pilot plant, on the other hand, is sited and designed to minimize costs over its relatively short information-gathering lifetime. The H-Coal and the Exxon Donor Solvent pilot plants are both located adjacent to existing refineries. The gaseous and liquid wastes treatment facilities at these refineries are used to clean up several of the residue streams from the pilot plants, avoiding the costs of separate pilot plant treatment systems. This is a prudent economy because a pilot plant characteristically operates only intermittently and the downtime is sometimes prolonged while the plant is being modified for the next test run.

Table 3.1 shows the projects that were included in the DOE synfuels demonstration program, as of mid-1980.

Table 3.1: DOE Demonstration Program Projects

Location	Technology	Type	Location	Status
SRC I	Direct Liquefaction	Demonstration	Kentucky	Approved
SRC II	Direct Liquefaction	Demonstration	West Virginia	Approved
H-Coal	Direct Liquefaction	Pilot	Kentucky	Operating
EDS	Direct Liquefaction	Pilot	Texas	Operating
CONOCO	High-Btu Gasification	Demonstration	Ohio	Planned
ICGG	High-Btu Gasification	Demonstration	Illinois	Planned
Memphis	Medium-Btu Gasification	Demonstration	Tennessee	Approved
W.R. Grace	Indirect Liquefaction	Demonstration	Kentucky	Planned

3.4 COMMERCIALIZATION ASSISTANCE

In the fall of 1979, Congressional leaders included in the Interior and Related Agencies Appropriation Bill (PL96-126) provisions establishing an Energy Security Reserve within the Treasury and appropriating $19 billion. Within this appropriation, $200 million were made available to DOE for the funding of feasibility studies and cooperative agreement programs. Commitments for each of these programs were limited to $100 million, and the maximum grant was set at $4 million for feasibility studies and $25 million for cooperative agreements.

As an indication of Congressional intent in getting this program moving quickly, the Act directed the Secretary of Energy to issue a solicitation for feasibility studies within 90 days of enactment. This deadline of February 25, 1980 was met by the DOE Assistant Secretary for Resource Applications. Although the program solicitation for cooperative agreements was not required at the same time as the feasibility studies solicitation, it was issued simultaneously.

On July 9, 1980, DOE announced the selection of 99 proposed feasibility studies and 11 proposed cooperative agreements for funding.

To expand the interim program even more, Congress, in its 1980 Supplemental Appropriations bill (PL96-304) signed by President Carter on July 8, 1980, made available to DOE an additional $300 million for feasibility studies and cooperative agreements. Thereof, $100 million was approved for feasibility studies, and the limit for individual awards was raised to $10 million. The limit remains at $25 million for the remaining $200 million in cooperative agreements.

The purpose of the feasibility studies was to support efforts leading to the construction and operation of commercial scale alternative fuel production facilities by non-federal entities. The proposers had to demonstrate their capability to carry out those efforts leading to the construction and operation of the project at an early date. The feasibility studies were to be performed in sufficient detail to allow DOE to define the means by which they would proceed toward construction and operation, considering:

- Technical and economic feasibility
- Financing alternatives
- Resource assessment and availability
- Ability to construct and operate a commerical plant in an environmentally acceptable manner on a selected site.

This incentive was designed to support project studies directed towards the acceleration of critical path efforts preliminary to commercial site development and plant construction.

The cooperative agreements were targeted to projects that were in the advanced development state, with specific emphasis placed on funding engineering designs and site development. As with feasibility studies, strong preference was given to projects with early commercial potential.

The conference report on this legislation specified that $22 million of the $100 million be made availabe for the Great Plains Gasification Associates' High-Btu Gasification Project and this was done shortly after the bill was signed into law. The Department had previously

provided this project with $3 million in support through a cooperative agreement with a repayment feature.

For both feasibility grants and cooperative agreements, repayment to the government is required if the proposed project is constructed.

3.5 INDUSTRY SUPPORT

The major vehicle for providing federal financial support for the production of synfuels is the Synthetic Fuels Corporation (SFC), established by the 1980 Energy Security Act. Initially, while SFC is getting organized, DOE is authorized to commence a similar synfuels industry support program that will then be turned over to SFC.

3.5.1 DOE Industry Support Program

The DOE industry support effort is based on the product purchases, price support, and loan guarantee parts of the Interior and Related Agencies Appropriation Bill (PL96-126).

Purchase commitments and price guarantees are designed to mitigate the risks associated with alternative fuels which may not be price competitive with conventional fuels in the near-term. The major benefit lies in stimulating private industry financing of first-of-kind commercial plants by guaranteeing protection against unfavorable fluctuations in the supply and price of petroleum and natural gas.

The $1.5 billion appropriated for purchase commitments and/or price guarantees is probably sufficient to promote private financing for one or two commercial plants in the 50,000 barrels per day range. To use the available funds for the largest possible quantity of product, it is likely that DOE will give strong preference to price guarantees *vis a vis* purchase commitments.

Loan guarantees are considered most appropriate for technologies that should be economically viable in terms of product price, but which face technical or institutional uncertainties that imperil the completion of plant construction and start-up. In effect, loan guarantees

permit the federal government to share the front-end capital risks with industry on projects that, once in production, should be price competitive. The $1.5 billion ceiling on loan guarantees, as the FY '80 DOE appropriation provides, is probably adequate for a single large synthetic fuels plant.

The Energy Security Act (PL96-294), signed into law on June 30, 1980, authorizes an additional $3.0 billion to continue this interim program pursuant to the Defense Production Act of 1950. These funds are made available for FY '80 by Supplemental Appropriations (PL96-304).

3.5.2 U.S. Synthetic Fuels Corporation

Title I of the Energy Security Act creates the United States Synthetic Fuels Corporation (SFC) in addition to providing additional interim authority for operation of the synthetic fuels development program described in Section 3.5.1. The United States Synthetic Fuels Corporation is created as a "special purpose federal entity" to provide financial assistance to the private sector in order to stimulate production of synthetic fuels.

The Energy Security Act specifies the preference given to the various forms of assistance in decreasing order of priority:

1. purchase agreements, price guarantees and loan guarantees
2. loans
3. joint ventures

The Corporation is headed by a Chairman and six additional members of a Board of Directors, appointed by the President and subject to Senate confirmation. Members serve seven-year staggered terms with one seat coming up for appointment each year. The Act requires only that the Chairman serve in a full-time capacity. Other members of the Board may serve in a part- or full-time capacity at the discretion of the President. No more than four members may be members of the same political party.

The Act establishes a national synthetic fuels production goal of 500,000 barrels per day by 1987 and 2 million barrels per day equivalent crude oil capacity by 1992. The Act authorizes $20 billion to initiate the construction of plants in the first phase. The Corporation has four years from date of enactment to submit to the Congress for approval a comprehensive strategy for achieving the 1992 goal.

Expedited procedures are provided for Congressional consideration of the strategy. An additional $68 billion is contingent on Congressional acceptance of the strategy.

Financial assistance will be awarded to qualified concerns whose proposals are most responsive to the procurement solicitations, require the least SFC financial commitment, and represent the lowest unit or production cost within a technological process, taking into consideration the amount and value of the products to be produced. The Corporation is also directed to consider more general criteria, such as the promotion of a diversity of technologies; overall production potential of the technology, considering the potential for replication, extent of the resource and the need for the end product; and the potential for the technology complying with the applicable environmental requirements.

The Corporation has broad authority to award and administer the various forms of financial assistance provided for in the Act. However, cost overruns on projects funded by loans or loan guarantees may be subject to Congressional review under certain conditions. Extensions not specifically disapproved by either House within 30 days after submission are deemed approved under expedited Congressional review procedures contained in the Act.

Total obligational authority provided for the Corporation thus far is $17.5 billion. This included $2 billion provided DOE for FY '80 under PL96-126 and $3 billion made available in PL96-304 pursuant to the Defense Production Act of 1950 for the interim program discussed in Section 3.5.1.

PL96-304 provides that of the $17.5 billion available to the Corpcration, $6 billion will be available when it commences operations, the unexpended balances from the interim program (up to $5.3 billion) will be transferred from DOE on June 30, 1981 and an additional $6.2 billion shall be made available on June 30, 1982.

The Corporation may make no new commitments of financial assistance after September 30, 1992 and the Corporation shall terminate on September 30, 1997. The President, by Executive Order, may terminate it earlier, but no sooner than September 30, 1992.

4.0 MARKETS

The key to success for the U.S. synfuels program is the entrance of synfuel products into the energy market and a resultant displacement of foreign oil. This does not imply that only fuels should be produced. For example, chemical feedstocks are another important market need. Chemical feedstocks include light olefins, alcohols, aromatics, CO-H_2 gases and other compounds. The production and sale of synfuel products may not always displace foreign oil. For example, the use of synthetic boiler fuel for an existing oil-fired power plant that would otherwise convert to domestic coal would not displace foreign oil nor would the use of synthetic natural gas in a pipeline system that does not expand its sales beyond available domestic natural gas production.

Synfuel types and quantities are constrained by the available energy sources. These are covered in the next chapter.

The question for individual synthetic fuels in the U.S. energy system is not <u>can</u> the fuel displace foreign oil but <u>will</u> it. The U.S. energy system is complex — the answer is not simple.

4.1 MARKET CHARACTERISTICS

The market for energy can be characterized in a variety of ways. Figure 4.1 is a relatively simple diagram of the U.S. energy market and its supplies for 1978.

The energy system starts with the primary sources; coal, natural gas, petroleum, nuclear, hydropower and solar energy. The total energy available from the primary sources is diminished by the energy needed to obtain and process the raw energy into marketable forms. In 1978, 21.0 quad was used to process the 77.2 quad of primary energy to provide 56.2 quad to the ultimate consumer. The 21.0 quad was used for extraction, refining, and electric energy production, with the latter accounting for nearly three-quarters of the total.

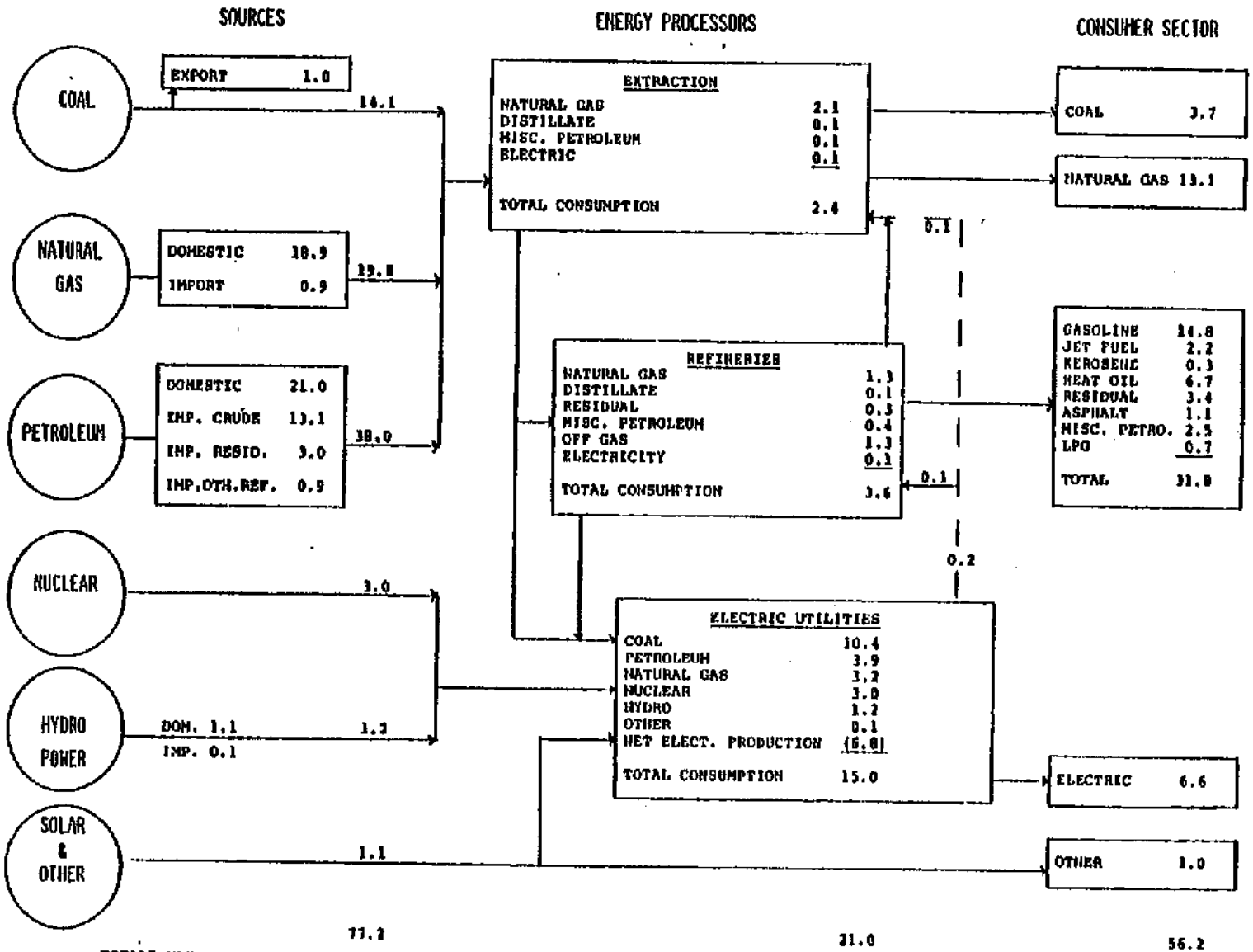

Figure 4.1: 1978 U.S. Energy Flow (quad) (Ref. 9)

Table 4.1 shows the end use energy distribution in 1978 among the residential/commercial, transportation, and industry sectors. It is interesting to note the nearly uniform distribution of energy use among these three major market sectors. It is important to note the dominance of petroleum products in the transportation sector.

Table 4.1: 1978 Consumer Energy Use (quad) (Ref. 9)

	Residential/ Commercial	Transportation	Industry	Total
Coal	0.3	—	3.4	3.7
Natural Gas	7.7	—	5.4	13.1
Petroleum Products	7.2	20.0	4.5	31.8
Electricity	4.1	—	2.6	6.6
Solar & Other	—	—	1.0	1.0
Total	19.2	20.0	16.9	56.2
	(34%)	(36%)	(30%)	

Totals may not add due to rounding

Several observations can be made based on Table 4.1 and Figure 4.1:

- The electric utilities are the major users of coal, consuming three-quarters of the total U.S. consumption. Coal provides slightly less than half of the total primary energy but about 60% of the total fossil energy for electric power generation.
- Transportation consumes slightly over 60% of the end use U.S. petroleum consumption. The energy consumed by the transportation of people and goods is approximately equal to the total energy in our oil imports.
- Both the residential/commercial and industrial sectors depend heavily on oil and natural gas for their energy supplies. These two fuels provide approximately 75% and 60%, respectively, of the total residential/commercial and industrial energy needs.

In summary, at the consumer level the U.S. energy market depends heavily — critically in the transportation sector — on liquid or gaseous fuels. As domestic production drops in the years ahead and imports become more costly and less reliable, the importance of an

effective synfuels industry is difficult to overstate.

4.2 LIQUID AND GASEOUS FUELS TO CONSUMERS

In order to evaluate the potential for synfuels to displace foreign oil and help meet the nation's future energy needs, a more detailed look at the market demand for liquid and gaseous fuels is needed.

4.2.1 Market for Liquid Fuels

In 1978, gasoline, used mainly for private passenger automobiles, constituted 47% of all petroleum products, with heating oil at 21% in second place. Gasoline, jet fuel, kerosene, and heating oil, together commonly referred to as transportation fuels even though heating oil (sometimes called the middle distillate fraction) includes both engine fuels and No. 2 heating oil, constituted slightly more than 75% of all petroleum products in 1978.

Detailed consumption data indicate that approximately 40% of the heating oil (the so-called middle distillate) is used in engines — mainly diesel engines — and most of the balance as heating oil. Thus, accounting for gasoline, jet fuel and diesel fuel, the liquid fuels used for the transportation of goods and people represents over 60% of the total U.S. petroleum consumption.

Residual fuel oil is the heavy oil which remains after the distillate fractions of the crude are taken out in the refinery. Either alone or blended with variable amounts of distillate, it may go by such names as No. 5 and No. 6 boiler fuel, or Bunker C oil. Its main use is as a boiler fuel in electric utilities, but it is also used to produce steam in large industrial and marine boilers, as a fuel for large, low-speed diesel engines, and as a fuel for industrial operations.

The U.S. currently imports over one million bbl/day of residual oil. Since over 10% of the crude oil refined, including that imported as crude, becomes residual oil, the fuels derived from residual are an important energy source. The major importation of heavy fuel oil is

for utility use in the Northeast where coal has not been widely used to generate electricity. As oil is phased out as a boiler fuel under the impetus of the Fuel Use Act, residual fuel will diminish in importance. In the present energy market, residual can be further processed economically in refineries to produce gasoline and distillate fuel oil. Refineries are already adding the hydrocracking units needed to handle the expected increased availability of residual oil.

4.2.2 Market for Gaseous Fuels

The residential/commercial and industrial markets each absorb approximately 33% of the natural gas used in the U.S. electric utilities consume about 16% and the balance is used for natural gas production and transportation and for petroleum refining. The electric utilities are now required by the Fuel Use Act to essentially eliminate their natural gas use by 1990. Although this requirement may be relaxed somewhat, clearly the trend is away from natural gas as an electric utility boiler fuel. Industry is also under pressure to reduce its use of natural gas as a boiler fuel. Since the passage of the Natural Gas Policy Act in 1978, supplies are adequate to meet present market demands. Furthermore, less than 5% of our current natural gas consumption is imported, and most of that by pipeline from Canada, hence the balance of payments and reliability problems associated with liquid fuels do not exist.

In the long run — beyond the next decade or two — domestic resources of natural gas will probably also be facing depletion. At that time, the production of synthetic gas from coal, shale or biomass will be needed to meet the needs of consumers and to maintain the viability of the very large and efficient gas transmission and utilization infrastructure.

4.3 FUTURE ENERGY NEEDS

The difficulty in estimating future energy needs was discussed in Chapter 2. In view of this uncertainty any quantitative measure of the need for and place of synfuels in the nation's energy future must be treated with caution. In spite of this caution, however,

early in 1980 ESCOE made a projection of the energy market for 1990.[9] This projection was made on the basis of existing federal law and policy.

The ESCOE report[9] compared the 1978 and projected 1990 use of each of the primary energy sources. The major changes would be a 20 quad increase in coal, a 7.5 quad decrease in imported oil, and a 1.9 quad increase in nuclear generated electricity. The expected shift from imported oil to more plentiful domestic resources is clearly evident. As explained in that report, the projections for synfuels in 1990 total 4.0 quad (3.2 quad from coal, 0.8 quad from oil shale). This 4.0 quad is equal to 1.8 million barrels per day oil equivalent, in line with the Energy Security Act objectives of 0.5 million by 1987 and 2.0 million by 1992.

Table 4.2 shows the distribution of the end use energy forms among the major consuming sectors for 1990 compared with 1978 (the 1978 data is the same as shown previously in Table 4.1). The major changes exhibited in this table include an 80% increase in the direct use of coal in industry, a dramatic shift from petroleum products to natural gas and electricity in the residential/commercial and industrial sectors, and a more than doubling in the use of solar and other renewable resources by industry. Implicit in these projected changes is a major switch from gas and oil to coal and nuclear energy by the electric utilities, in order to free gas and oil for other uses. The thrust of all the new directions is less dependence on imported oil and the maintenance of available supplies of liquid fuels for use in the transportation sector — the one sector with the least ability to use alternate energy forms.

Table 4.3 examines in some detail the liquid fuel situation and identifies the areas where synfuels would be required. The projections were based on the assumptions that consumers would require the same mix of liquid fuels in 1990 as in 1978, that imports would be reduced from 17.0 quad in 1978 to 9.5 quad in 1990, and that domestic production of oil and gas would be maintained at 1978 levels. The shortfalls resulting from these assumptions were assumed to be made

up by synfuels. Again, the transportation area is identified as critical, with the projected shortfalls in petroleum supplies occurring in the gasoline, jet fuel, and heating oils (which include diesel fuel) areas. Thus, synfuels would, under the assumptions of the study, be needed mainly for the essential movement of goods and people.

The critical need for a synfuels program is further emphasized when one examines the implications of the projections in Table 4.2. The projected growth in end use energy consumption has been reduced to approximately 1.5% per year, implying a greatly accelerated effort at conservation in all its forms. The projected 1990 residential/commercial consumption is actually 0.1 quad less than that in 1978 in spite of the fact that an estimated 12 to 20 million new residential units and many commercial structures will be added over the 12-year period. Transportation energy is projected to increase by only 1.7 quad, for an average growth rate of 0.7%/year. Clearly, many changes in our energy habits will be required if the modest growth rates assumed in these projections are to be met.

Table 4.2: 1978/1990 Consumer Use Pattern (Ref. 9)
(quad)

	RESIDENTIAL/ COMMERCIAL	TRANSPORTATION	INDUSTRY	TOTAL
COAL	0.3/-	-/-	3.4/6.1	3.7/6.1
NATURAL GAS	7.7/9.4	-/-	5.4/8.6	13.1/18.0
LIQUID FUELS	7.2/3.8	20.0/21.7	4.5/4.8	31.8/30.3
ELECTRICITY	4.1/5.6	-/-	2.6/4.5	6.6/10.1
SOLAR & OTHER	-/0.3	-/-	1.0/2.3	1.0/2.6
TOTAL	19.3/19.1 (34%/29%)	20.0/21.7 (36%/32%)	16.9/26.3 (30%/39%)	56.2/67.1

Table 4.3: Anticipated 1990 Liquid Fuel Products (Ref. 9)
(quad)

	SUPPLIED TO CONSUMERS	PETROLEUM SUPPLIES	SYNFUELS
GASOLINE	14.2	12.7	1.5
JET FUEL	2.1	1.8	0.3
HEATING OILS	6.4	5.7	0.7
ASPHALT & RESIDUAL	4.2	4.2	—
MISC. PRODUCTS	2.4	2.0	0.4
LPG & KEROSENE	1.0	1.0	—
	30.3	27.4	2.9

4.4 VARIATIONS AND FLEXIBILITY IN THE SYSTEM

To accomodate both short-term and long-term fluctuations in supply and demand, some flexibility in the energy system is required. Anything which can be done to increase the flexibility will help immeasurably in meeting supply fluctuations such as those caused by interruptions in oil imports.

One important source of flexibility has already been mentioned — the ability of some end uses to be met by a variety of energy sources. Space and water heating needs, for example, can be met by gas, oil, solar or electricity, and to the extent that alternatives are available, oil can be released for essential transportation. Currently, both the gas and electric utilities have the capacity to absorb some additional load, but both industries are anticipating problems with capacity in the years ahead.

Some variability exists in the liquid fuel supply system due to the widely varying nature of crude oil. The heavier crudes, which will provide a growing fraction of the total crude stock as the light crudes are exhausted, produce a small yield of the light and middle distillates which make up the diesel and home heating fuels. However, the heavier ends can be converted by intensive cracking to high

octane gasolines, thus increasing the ratio of gasoline to light fuel oil in the refinery runs. This trend is, unfortunately, contrary to the expected need as the small diesel engine gains in popularity for automobile and other low power needs. The addition of hydrorefining facilities can, however, handle this problem and permit market needs to be met.

For a given crude, a moderate leeway exists within the refinery processes for altering the yield of the various components. In general, this leeway does not exceed a range of about 10% between extremes. This range is sufficient, however, so that industry planners can, by beginning early enough, and assuming the availability of adequate liquid storage capacity, build up the large winter heating oil stocks by early fall, and the necessary gasoline supply as the heavy summer travel season approaches.

Beyond uncontrollable variations in crude properties, and scheduled changes in refinery operation, fuel interchangeability is the major method available to add flexibility to the energy system. The possibilities which exist in this direction and the flexibility which will be added to the range of crude properties by the judicious choice of available synfuels will be discussed next.

4.5 SYNFUEL PROPERTIES AND APPLICATIONS

The properties of synthetic fuels vary over a wide range depending on the source material and conversion method employed. These properties determine, in turn, the best application for the specific synfuel. For example, high Btu gas can be used as a direct replacement for natural gas in all applications. Economics and the availability of other fuels, natural and synthetic, determines the use for the synfuel.

The problems associated with synfuels from oil shale and direct liquefaction of coal are more complex. These synfuels differ markedly in both physical and chemical properties from petroleum fuels and from each other and these properties play a role in determining the

best use for each specific fuel.

The major difference between petroleum and fuels derived directly from non-petroleum sources lies in the amount and nature of the hydrocarbon species and in the overall hydrogen-carbon ratio in the mixture. The ratio of hydrogen to carbon atoms is almost two in petroleum fuels and only slightly lower for shale oil. In raw coal-derived liquids, however, it may drop below one.

How soon the problem of handling alternative fuels will arise, and how difficult it will be in the initial stages, will depend on how these fuels enter the marketplace. If grassroots stand-alone conversion plants are built to accept coal, shale, or biomass, and are properly equipped to produce finished fuels, then the engines which must burn these fuels will meet the problem soon and in its most drastic form.

Indirect coal liquefaction plants are by their nature essentially stand-alone plants if they contain adequate product refining steps. It is expected that these plants will be designed for product slates that will enter directly into the consumer market as finished fuels.