CHAPTER II PROJECTED LONG-RANGE ENERGY OUTLOOK (1975-2000)

A. INTRODUCTION

This chapter provides a setting for an evaluation of the Synthetic Fuels Commercialization Program by:

- Presenting a picture of the possible energy future of the United States.
- Providing an understanding of the major factors that influence this future.

Although it is impossible to predict with certainty the future prices and consumption of types of energy, it is possible to understand the behavior of the energy system by:

- Developing a "nominal case" forecast of future prices and volumes, using the best assumptions available about the magnitude and relationship of factors that will affect energy use; and
- Evaluating the sensitivity of the nominal case forecast to variations of these assumptions.

Such a nominal case forecast, along with the assumptions used and the sensitivity analysis results, is presented below. First, however, it is useful to provide some perspective on the energy "crisis" and the role of the Synthetic Fuels Commercialization Program.

B. PERSPECTIVE

It is important to recognize that the United States is not now, nor is it likely to be in the near- to mid-term, experiencing massive fuel shortages. What is being experienced are short-term, fuel-specific adjustments in the energy supply/demand balance. Domestic oil and natural gas supplies are no longer adequate to meet demand at current prices. Therefore, substantial quantities of crude oil and petroleum products are being imported, leaving the United States vulnerable to embargoes.

In the longer-term (1985-2000), even with strong economic incentives, domestic oil and gas supplies will likely be inadequate to meet demand except at extremely high prices, which may have a significant impact on our economy. But the United States does have massive reserves of energy resources -- in the form of oil shale and coal. The problem is that these sources are not currently compatible with all end-uses. For instance, coal cannot be used directly to power automobiles, and the production of shale synthetic crude at a price competitive with world oil has not yet been shown to be feasible. The long-term supply/demand balance will require a combination of:

- Continued reliance on oil imports.
- A change in the energy system that allows oil and gas to be replaced by coal, oil shale, and nuclear fuel.

The mechanism for this change will be primarily economic. As domestic oil and gas resources are depleted, prices will rise, thus reducing demand and providing incentives for investment in new production and conversion facilities. Notable among the latter are plants for producing synthetic crude from oil shale and high Btu gas from coal. However, because of the magnitude of the investment required, this change can be expected to be relatively slow, leaving the country dependent on imports for some time to come.

Recognizing the desirability of achieving a high level of energy self-sufficiency for other than purely economic reasons, the United States government has a number of means for reducing dependence on imports. One of these is to provide special incentives to accelerate the introduction of synthetic fuels capacity, which is the essence of the Synthetic Fuels Commercialization Program.

C. NOMINAL CASE

1. Nominal Case Assumptions

The projections in this section were derived from the Stanford Research Institute Energy Model.[1] This model was selected for the following reasons:

- It computes a supply-demand balance through the year 2025.
- It is a disaggregated model incorporating all the major fuel types and specific regional demands.
- It incorporates dynamic effects such as delays in bringing new capacity on line or in changing demand patterns.
- The domestic resource base is treated in an economically realistic manner in that extraction costs increase as the resource base is depleted.
- Prices are based on interfuel competition.

The role of the SRI Energy Model in this analysis was:

- To provide a long-term supply-demand balance as a background against which to evaluate the future competitive position of synthetic fuels.
- To provide a framework that deals with demand, resource economics, and process economics in an internally consistent manner.
- To identify those variables that have a major effect on future synthetic fuels production and those that have a minor effect.
- To illustrate how synthetic fuel requirements may shift in time under different assumptions.

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[1] This model will be referred to as the SRI Energy Model. In other literature, it is often called the SRI-Gulf Energy Model. It was constructed by SRI and Gulf Oil to analyze a synthetic fuels decision for Gulf Oil. The original data base and model have been reviewed and substantially modified by both government and private individuals. The data base does not represent the official opinion of SRI.

- To describe the interactions among different fuel types as reflected in the economic decisions made by energy producers and energy consumers.
- To develop insight into the energy market in order to facilitate the decision analysis.
- To derive quantitative inputs for the cost benefit analysis.

It is important, however, to understand the focus and purpose of the model. The model is not designed to provide the resolution necessary to draw specific conclusions about the various Synthetic Fuels Commercialization Program options nor is it designed to make detailed economic comparisons in the first several years of its time horizon. The cost benefit analysis discussed later in this report is specifically designed to compare program options at the level of detail necessary to analyze the Synthetic Fuels Commercialization Program. The reader is cautioned not to make detailed judgments concerning the plant mix, specific incentive packages based on the program size, or viability of the synthetic fuels program based solely on the model outputs; such considerations can only be evaluated within the context of a decision focused analysis. What the model should not be used for are the following:

- To judge the relative attractiveness of synthetics, imports, or domestic production from the government's or the nation's point of view (the model does not attempt to quantify national values).
- To judge the relative attractiveness of a particular incentive package based on a high or low projection for a particular technology; such issues have been addressed in detail in Volume III of this report.

A more explicit description of the SRI Energy Model is provided in Appendix A.

Underlying the nominal case projection are the following important assumptions about the Energy Model's structure:

- Gas and oil prices are not regulated.
- All prices are marginal, not average (including electricity).

- Technologies are selected on the basis of the prices of their products
- Internalized environmental costs are included.
- Residual environmental costs are not included.
- No quotas or rationing of imports are used.
- Import prices are exogenously specified.
- Demand is exogenously specified.
- Cartel remains strong and the real price escalates from the current level.
- No restrictions are imposed on direct burning of western coal.
- There is a stable investment environment.
- There is a stable long-range national energy policy.

The data used in the nominal case projections can be categorized as demand data, resource data, and process economics data. A slightly modified version of the Ford Foundation demand forecasts has been used. Table 1 shows a comparison of several different well-known demand forecasts with the demand forecast used in this analysis (see Appendix H for more detail). The discrepancies between the different forecasts are due primarily to different assumptions about such variables as:

- State of the economy
- Population growth
- Response to changes in price
- Technological changes
- National energy policy
- Lifestyles and preferences

It is interesting to note that the demand in the nominal case is slightly above the FEA Project Independence Report's $11/bbl demand case. This represents an optimistic view of the 1985 U.S. energy

TABLE 1. COMPARISON OF DEMAND ESTIMATES (QUADS)

	1972	1985	2000	** Annual Growth Rate (Percent)
FEA ($11/bbl import price)	72.1	102.9	*	2.8%
FEA ($7/bbl import price)	72.1	109.1	*	3.2
Dupree-Waste (D-W)	72.1	116.6	*	3.7
Ford Foundation				
High Case	72.1	116.1	186.7	3.7
Low Case	72.1	91.3	124.0	1.8
National Petroleum Council (NPC)				
High Case	72.1	144.9	*	5.4
Low Case	72.1	124.9	*	4.2
Present Analysis				
High Demand	72.1	130.4	224.9	4.6
Nominal Case	72.1	105.7	156.9	2.9
Low Demand	72.1	95.0	129.5	2.1

*Not available

**1972 TO 1985

position. However, it also is the most restrictive case in determining the need for synthetics in that with low demand, the necessity for alternative sources of energy is less.

The availability of primary resources is described in the SRI Energy Model in terms of a marginal cost (lifting cost) versus cumulative production curve. Through the use of such a curve, the model includes the effects of depletion. As a resource base is depleted, the lifting cost of that resource increases because the more attractive and accessible deposits tend to be extracted first. Consequently, the price of that resource will ultimately rise to the point where other resources or technologies become competitive.

To relate the nominal case resource curves (shown in Figure 1) to published estimates of proved and potential reserves, refer to Table 2 for crude oil and Table 3 for gas. From Table 2, the nominal case resource curve for crude oil implies that there are 60 billion barrels of domestic crude oil that could be produced at about $6/bbl or less. This estimate is comparable to the new USGS estimates; the Project Independence estimate is somewhat more optimistic even at a lower price. From Table 3, the nominal case resource curve for gas implies that there are 815 trillion cubic feet of gas that would be produced at about $1.10 per thousand cubic feet or less. This estimate is comparable to Project Independence but signficantly lower than the new USGS estimate.

2. Nominal Case Projections

The volumes and prices that balance supply and demand at the primary resource level are pictured in Figures 2 and 3. Note that coal and nuclear fuel become increasingly important over time, while oil and gas remain roughly constant. The following statements are implied by Figures 2 and 3.

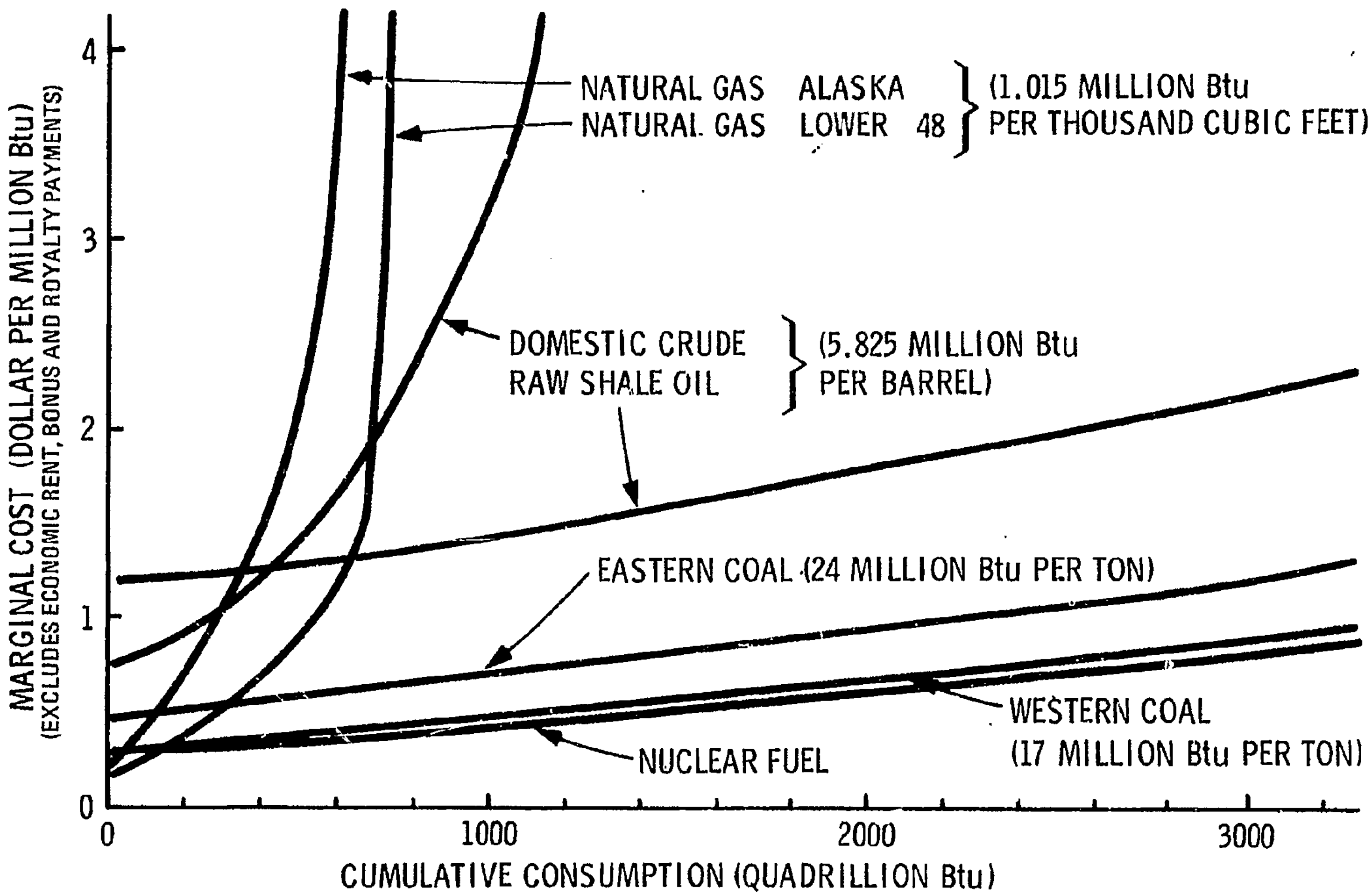

FIGURE 1. NOMINAL CASE - RESOURCE CURVES

TABLE 2. U.S. CRUDE OIL RESOURCE ESTIMATES (BILLIONS OF BARRELS)

	(1) Cumulative Production to Date	(2) Proven Reserves	(3) Remaining Potential Reserves	(4) Ultimate Recoverable Reserves (1) + (2) + (3)	(5) Cumulative Future Production (2) + (3)
Nominal Case Data					
@ $6.03/bbl	105	34	26	165	60
@ $9.84/bbl	105	34	69	208	103
@ $25/bbl	105	34	161	300	195
NAS quoted studies					
Company A (1960)	105	34	125	264	159
Company C (1974)	105	34	51	190	85
Company D (1974)	105	34	87	226	121
Company E	105	34	90	229	124
Hendricks (1965)	105	34	315	454	349
Theobald (1972)	105	34	454	593	488
Consensus	105	34	113	252	147
FEA					
@ $5/bbl	105	34	64	203	98
@ $8.75/bbl	105	34	97	236	131
@ $13.75/bbl	105	34	122	261	156
Hubbert (extrapolation)	105	34	33	172	67
Moore (extrapolation)	105	34	214	353	248
Linden (extrapolation)	105	34	311	450	345
USGS (volumetric)					
Low	105	34	212	351	246
High	105	34	410	549	444
NPC (volumetric)					
@ 33% recovery					
Probable/possible	105	34	52	191	86
Plus speculative	105	34	85	224	119
@ 60% recovery					
Probable/possible	105	34	230	369	264
Plus speculative	105	34	293	432	327
USGS (new)					
Low	105	34	50	169	84
High	105	34	130	269	164

TABLE 3. U.S. NATURAL GAS RESOURCE ESTIMATES (TRILLION CUBIC FEET)

	(1) Cumulative Production to Date	(2) Proven Reserves	(3) Remaining Potential Reserves	(4) Ultimate Recoverable Reserves (1) + (2) + (3)	(5) Cumulative Future Production (2) + (3)
Nominal Case Data					
@ $ .49/Mcf	488	236	99	823	335
@ $1.11/Mcf	488	236	579	1,303	815
@ $3.69/Mcf	488	236	1,037	1,761	1,273
@ $7.38/Mcf	488	236	1,145	1,869	1,381
USGS					
Low	488	236	324	1,048	560
High	488	236	663	1,387	899
NAS-quoted studies					
Company D (1974)	488	236	446	1,170	682
Hendrick (1965)	488	236	1,155	1,879	1,391
Theobald (1972)	488	236	1,989	2,713	2,225
Consensus	488	236	536	1,260	772
FEA (cumulative footage)					
$ .50/Mcf, $8.75/bbl oil	488	236	105	829	341
$1.00/Mcf, $13.75/bbl oil	488	236	435	1,159	671
$2.38/Mcf, $13.75/bbl oil	488	236	466	1,190	702
Hubbert (extrapolation)	488	236	490	1,214	726
Moore (extrapolation)	488	236	845	1,569	1,081
Linc'en (extrapolation)	488	236	1,037	1,761	1,273
USGS (volumetric)					
Low	489	236	1,138	1,862	1,374
High	489	236	2,261	2,985	2,497
PGC (volumetric)					
Probable	488	236	253	977	489
Plus possible	488	236	642	1,366	878
Plus speculative	488	236	1,144	1,868	1,379

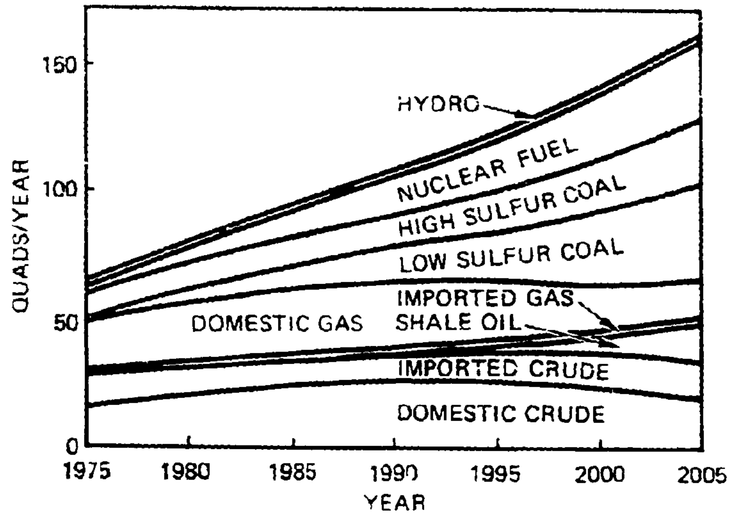

FIGURE 2. PRIMARY ENERGY RESOURCE PRODUCTION

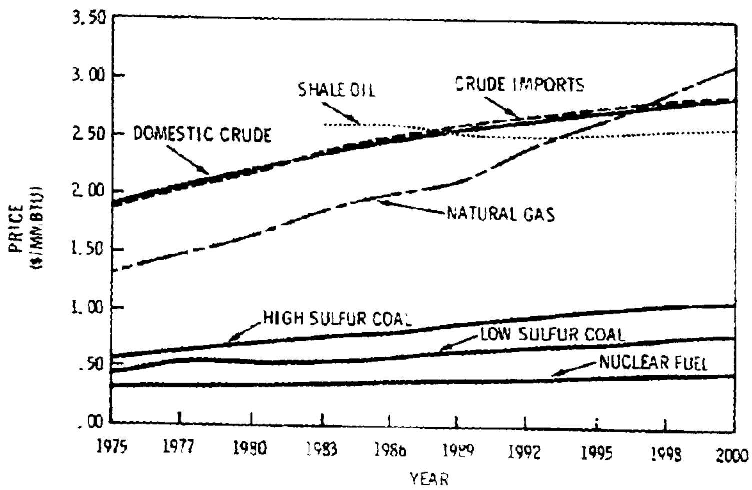

FIGURE 3. PRIMARY ENERGY RESOURCE PRICES

- Primary energy grows from 72.1 quads in 1972 to 156.9 quads in 2000; this is roughly a 2.7 percent annual growth rate.
- Eastern coal production in 1995 is 15.9 quads or 660 million tons per year (roughly today's total coal production).
- Western coal production in 1995 is 19.8 quads or 1.2 billion tons per year.
- Nuclear power generation is 6.5 quads of electricity in 1995; at 70 percent loading, this requires about 310 plants of 1,000 MWe capacity.
- Prices of coal, shale, and nuclear are relatively constant; prices of gas and oil rise substantially.

In the primary resource projection shown in Figure 1, solar energy is not shown but is included in determining the overall energy balance. Similarly, specific non-energy products such as lube oils or coking coal are implicity accounted for by the model but not explicitly shown in the figures.

Synthetic fuels will compete with natural gas, crude oil, and refinery products. Although they indirectly affect demand for all fuel types through interfuel substitution, synthetic fuels can be categorized as either liquid or gaseous fuels, and their most important effect is to become direct substitutes for conventional liquid or gaseous fuels. To illustrate the effect of the substitution of synthetics for liquid and gaseous fuels, Figure 4 shows the aggregate liquid and gaseous fuels market for the nominal case. There is a decline in production of domestic fuels due to rising prices (depletion) and the corresponding increase in the production of synthetic fuels as they become price competitive.

Figure 5 shows the average prices at the wellhead or mine-mouth of domestic, imported, and synthetic oil and gas that correspond to the production levels in Figure 4. For example, the price of domestic oil is an average of oil prices from both the North Slope and the lower 48 states. The curves in Figures 4 and 5 represent the market clearing volumes and prices in the total liquid and gaseous fuels market. As such, they reflect the effects of competition among all fuels, not just between oil and gas.

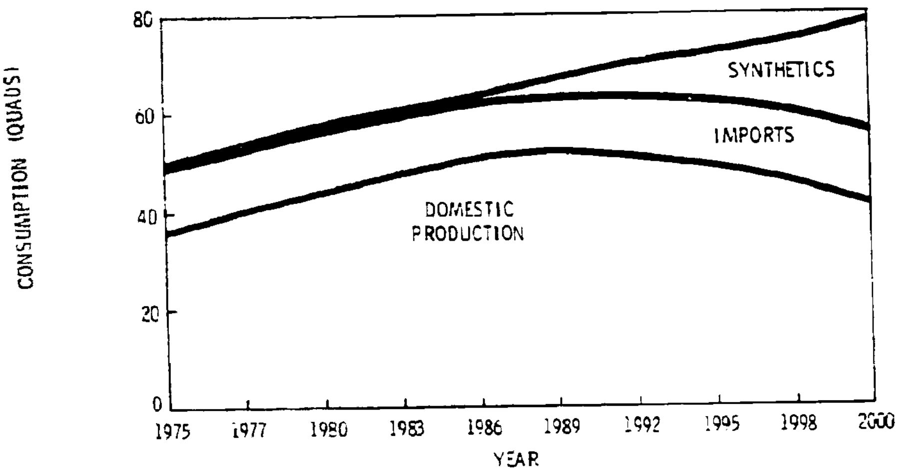

FIGURE 4. TOTAL CONSUMPTION OF LIQUIDS AND GASES

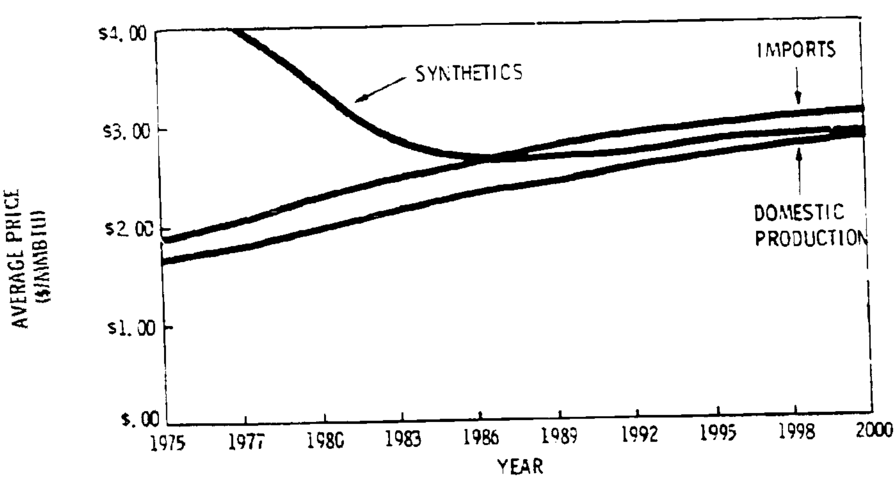

FIGURE 5. PRICES OF LIQUIDS AND GASES

The cumulative production levels for domestic oil and gas computed in the nominal case are illustrated in Figures 6 and 7. The production levels indicated in Figures 6 and 7 represent the total estimated production from mid-1975 through 2000. Note that for the year 2000, the cumulative production of oil and gas is 106 billion barrels and 205 tcf respectively. These numbers translate into 613 quads of crude oil and 614 quads of natural gas. Compared to the numbers in Tables 2 and 3, they are well below most of the estimates of potential reserves (some of which are depicted in Figures 6 and 7).

To focus on the individual synthetic fuels processes, Figure 8 presents the equilibrium volumes for synthetic fuels. The following statements are implied by Figure 8:

- The most important synthetic fuels in the 1975-2000 period are high Btu gas from coal and synthetic crude from shale.
- Synthetic high Btu gas production is projected to be:
  - 0.01 quads in 1985
  - 3.1 quads in 1995, which will require 39 plants of 250 MMcf/day capacity and 90 percent stream factor (250 MMcf/day is equivalent to 41,600 bbl/day crude oil equivalent).
- Shale synthetic crude production is projected to be:
  - 0.34 quads in 1985
  - 2.5 quads in 1995, which will require 26 plants of 50,000 bbl/day capacity and 90 percent stream factor.
- Hydrogen, low Btu gas, coal liquids, and solvent-refined coal are relatively less attractive.
- Total synthetics production (as distinguished from capacity) is estimated to be 850,000 bbl/day in 1985 and 5.1 million bbl/day in 1995.

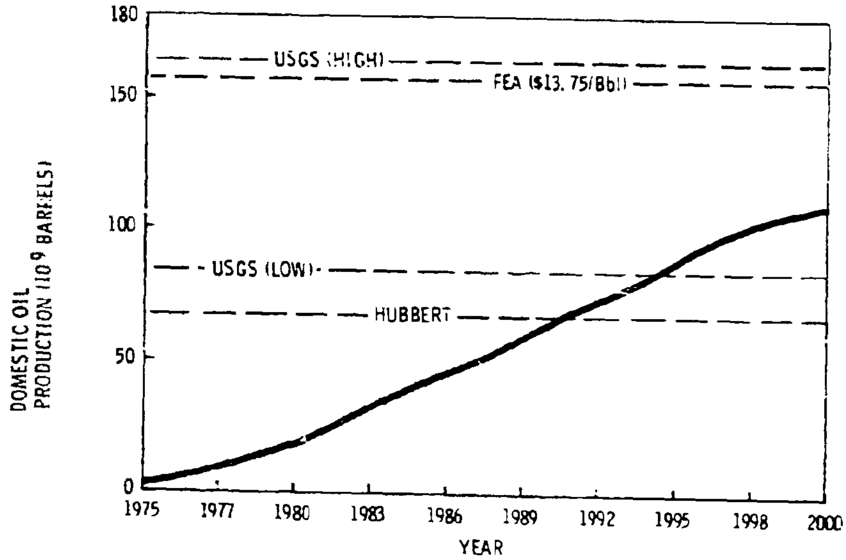

FIGURE 6. CUMULATIVE FUTURE DOMESTIC OIL PRODUCTION

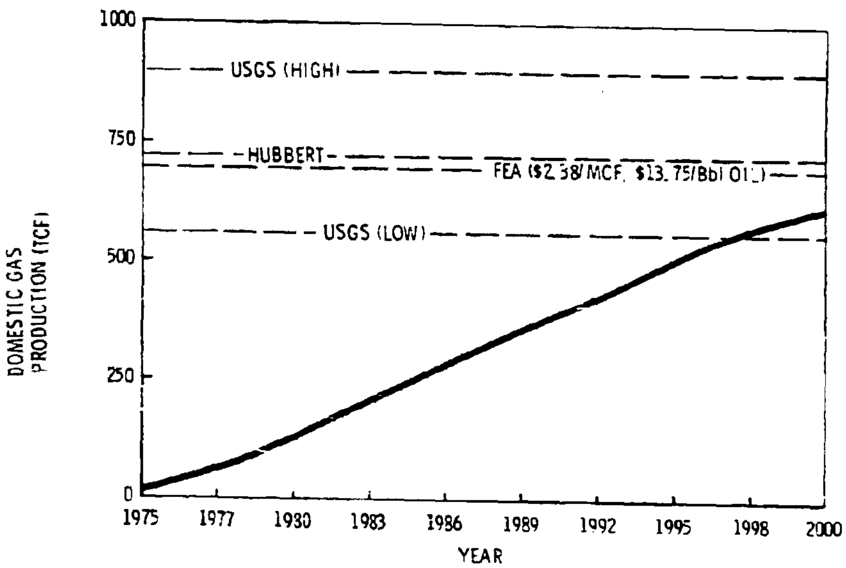

FIGURE 7. CUMULATIVE FUTURE DOMESTIC GAS PRODUCTION

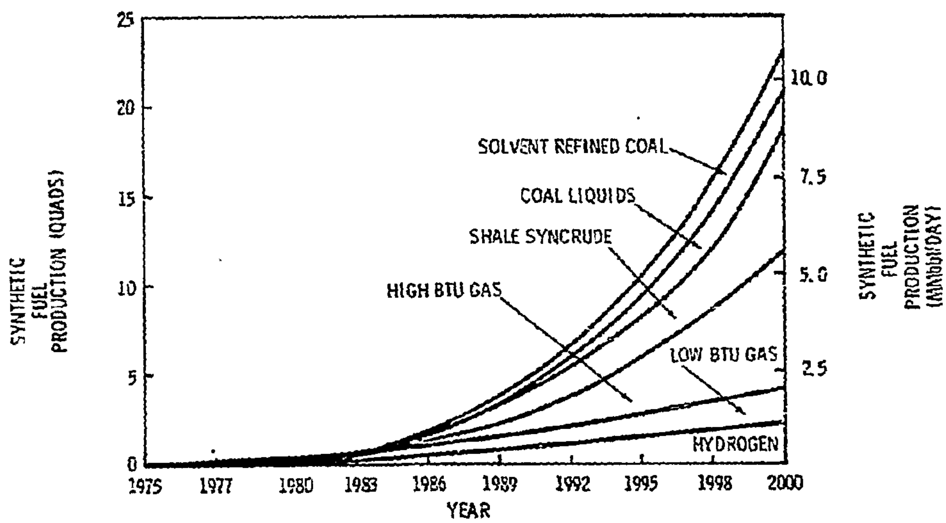

FIGURE 8. SYNTHETIC FUEL PRODUCTION FOR NOMINAL CASE

D. SENSITIVITY ANALYSIS

1. Introduction

The key consideration that determines when synthetic fuels will be economic is the price of synthetics relative to the prices of domestic production and imports. The point at which synthetic fuels become attractive is the point where the downward sloping synthetics price curve of Figure 5 crosses the upward sloping domestic production price curve. The purpose of the sensitivity analysis was to test how uncertainty in key variables might shift the equilibrium point. Shortages of domestic sources, high import prices, or low synthetic costs might shift the crossing point to the left (earlier in time). The opposite effects would shift the crossing point to the right (later in time). The following factors were examined to determine the impact of changes in their values on the need for synthetic fuels:

- Price of imports
- Availability of domestic oil and gas
- Cost of synthetic fuels
- Demand for energy in the United States
- Availability of nuclear energy

The above five considerations were varied over a broad range of values. In all cases, the ultimate need for synthetic fuels appears clear, the question becomes one of timing.

The timing question can be expressed as estimating when the prices of domestic oil, domestic gas, and imports will rise to the point where synthetic fuels are competitive. The question with regard to the Synthetic Fuels Commercialization Program is whether synthetic fuels development can be accelerated so that they are price competitive earlier than would be expected.

2. Import Prices

The future of synthetic fuels is determined by their cost relative to the cost of competing fuels. Probably the most important competing fuel in the near-term is imported crude oil. Since the price of imported crude is set by a combination of cartel behavior, world energy demand, and to a lesser extent U.S. energy demand, the price of imports is uncertain. To test the effect of import prices, a low import price and a high import price scenario were examined. The high, nominal, and low import price cases are pictured in Figure 9. In Figures 10 and 11 synthetic fuels production and imports are shown for the low, nominal, and high cases. Given 1975 prices for synthetic fuels (1st generation technology), the obvious result occurs where the production of synthetic fuels is strongly affected by high import prices. Note also, however, that synthetic fuel production is not entirely eliminated even in the low import price case of Figure 10. Although not explicitly shown, there is still a need for synthetic gases because imported LNG is more expensive than synthetic gas and domestic gas prices are being driven up by depletion. The effect of low import prices essentially delays

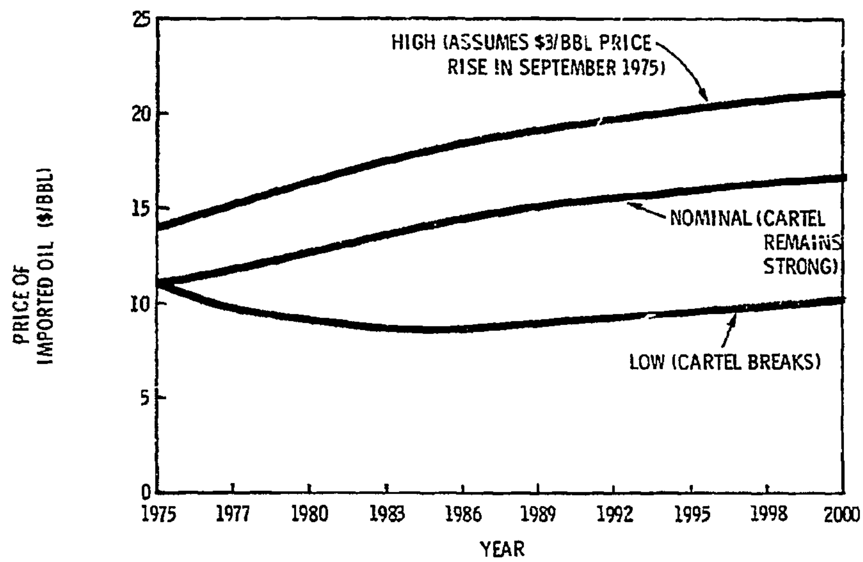

FIGURE 9. IMPORTED OIL PRICE

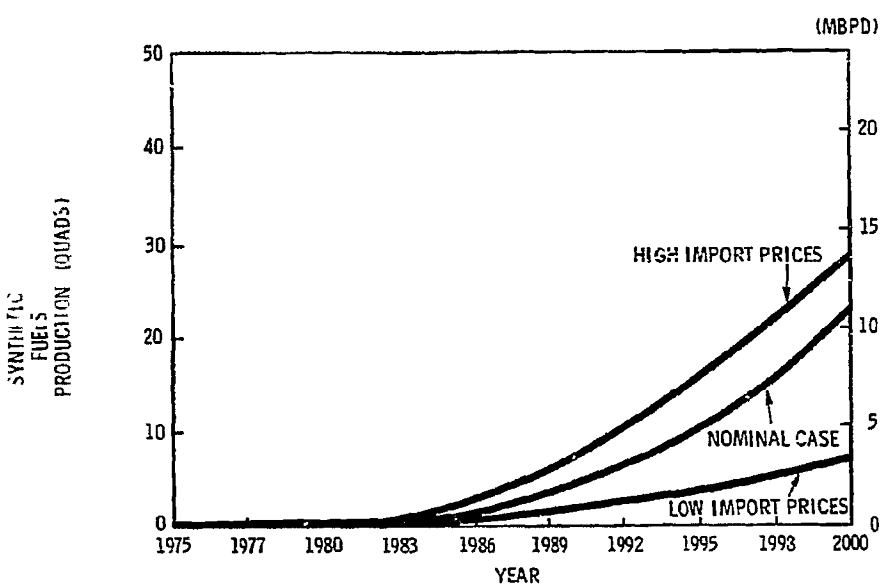

FIGURE 10. SYNTHETIC FUEL PRODUCTION SENSITIVITY TO IMPORT PRICES

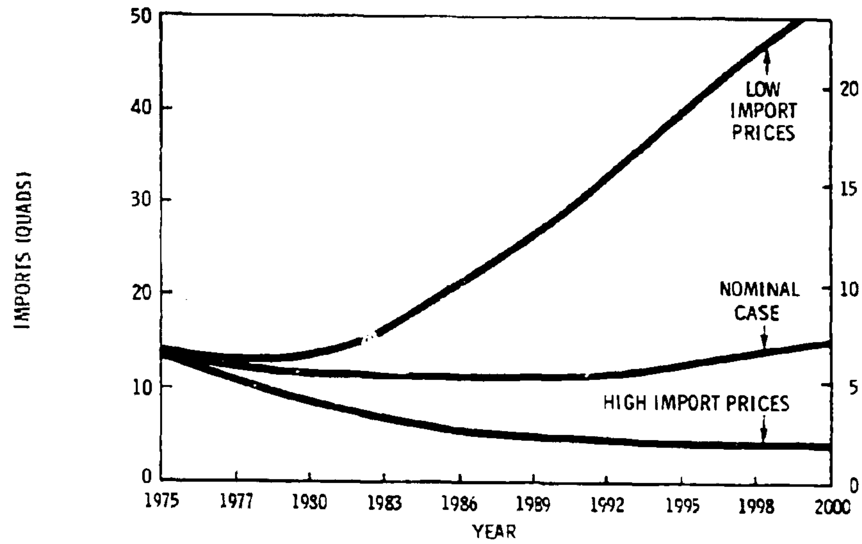

FIGURE 11. IMPORT SENSITIVITY TO IMPORT PRICES

the need for synthetic fuels until world oil prices are driven up by depletion. The sensitivity runs underlying Figures 10 and 11 also illustrate the following key points if prices are unregulated: the domestic crude oil price and level of production are set principally in competition with imported crude; the domestic gas price and production are set principally in competition with synthetic gases once they become available. If import prices are low through 1995, import volumes will be up 310 percent over the nominal case in 1995 while synthetic fuel production will be down 66 percent. If, on the other hand, imported prices are high, import volumes will be down 64 percent in 1995 but synthetic fuel production will be up 49 percent.

The important insight from this sensitivity analysis is that the imported crude oil price drives the liquid fuels market and consequently has a major effect on the entire energy market.

Synthetic fuels or imports will eventually, to a degree yet to be determined, replace conventional domestic oil and gas production. The time and rate of this replacement depends on the amount of domestic oil and gas available at or below the price of synthetic fuels and imports. In order to determine how future synthetic fuels production might be affected by higher or lower domestic gas and oil supplies, the sensitivity of synthetic fuels and imports to the availability of domestic oil and gas was tested. Figures 12 and 13 show the nominal case, a low resource availability case (20 percent less reserves than nominal) and a high resource availability case (50 percent more reserves) for oil and natural gas respectively.

The sensitivity of synthetic fuels production and imports to high and low domestic oil and gas availability is shown in Figures 14 and 15. The quantities of both imports and synthetics are both quite sensitive to the availability of domestic oil and gas. Even though not explicitly shown in these two plots, the two cases illustrate that the most attractive source of gaseous and liquid fuels is domestic production. In the high oil and gas availability case, synthetic fuel production is 50 percent below nominal in 1995. However, if oil and gas are 20 percent scarcer than the nominal case, synthetic fuels production is up 38 percent over nominal in 1995.

4. Synthetic Fuels Cost

The cost to produce synthetic fuels determines their competitive position relative to imports and domestic production. The Synthetic Fuels Commercialization Program is designed to accelerate synthetic fuels development (technology) and to make second generation commercial-size plants available sooner. However, since many synthetic technologies remain largely undemonstrated on a commercial scale, there is considerable uncertainly about the ultimate cost of synthetic fuels. To study the sensitivity of synthetic fuels production to the ultimate cost, a high cost synthetic fuels case (capital and non-feedstock operating costs

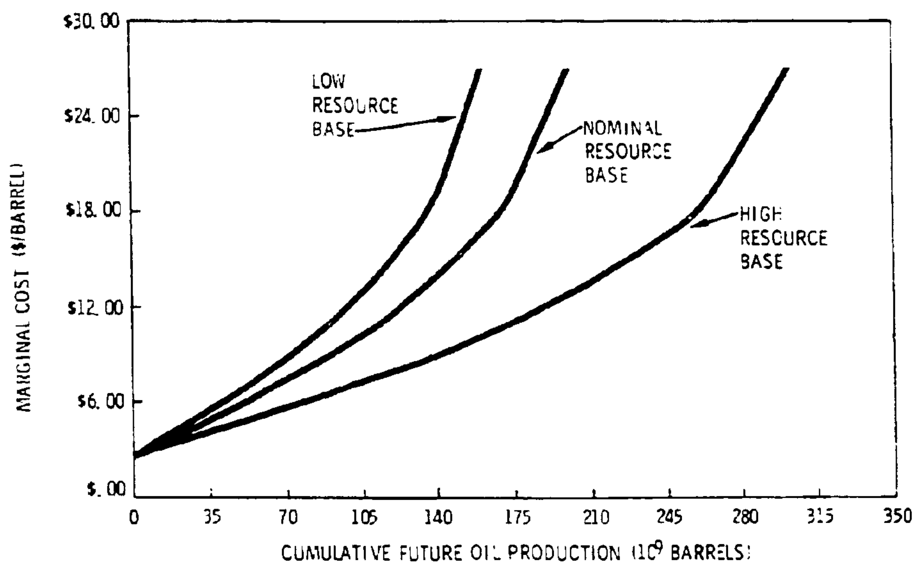

FIGURE 12. U.S. OIL RESOURCE CURVE

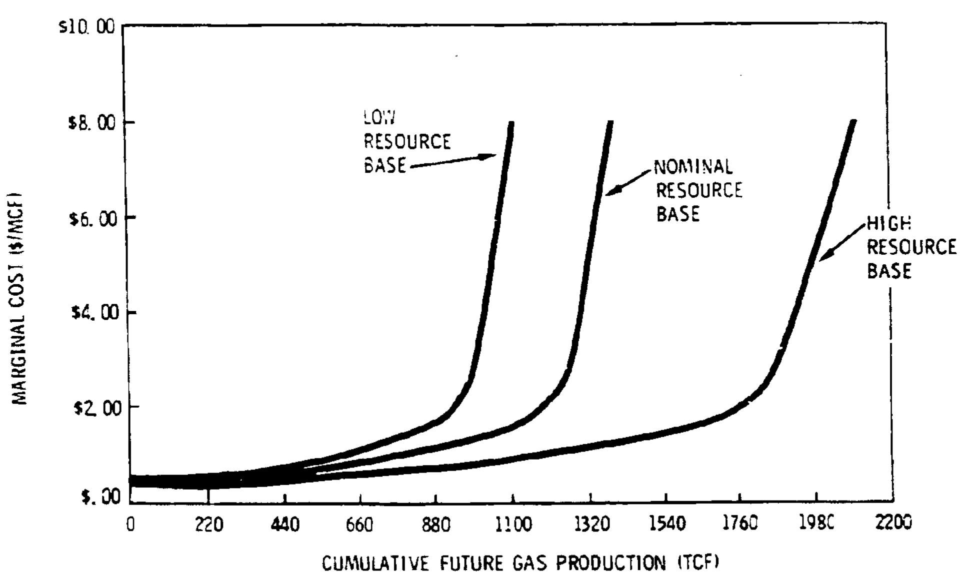

FIGURE 13. U.S. GAS RESOURCE CURVE

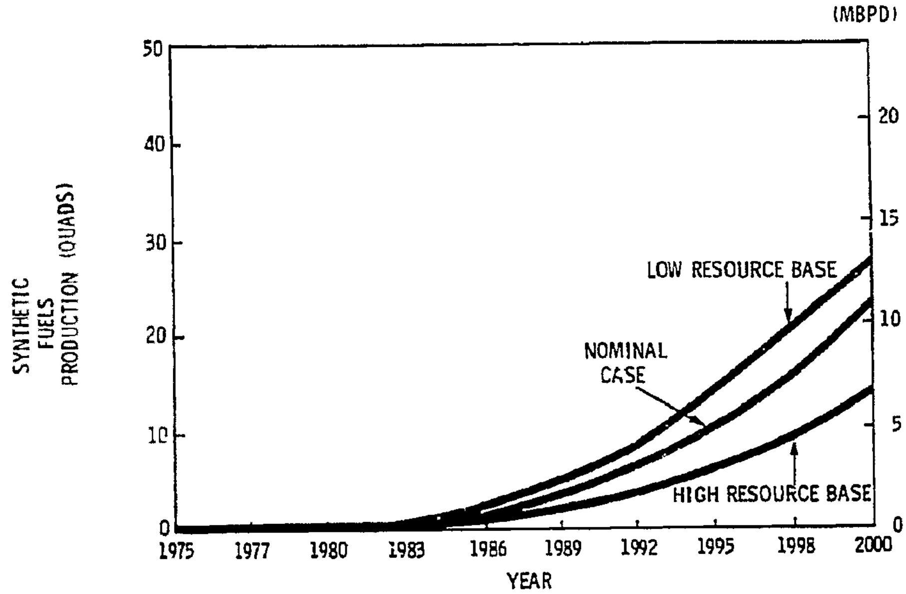

FIGURE 14. SYNTHETIC FUEL PRODUCTION SENSITIVITY TO U. S. OIL & GAS RESOURCES

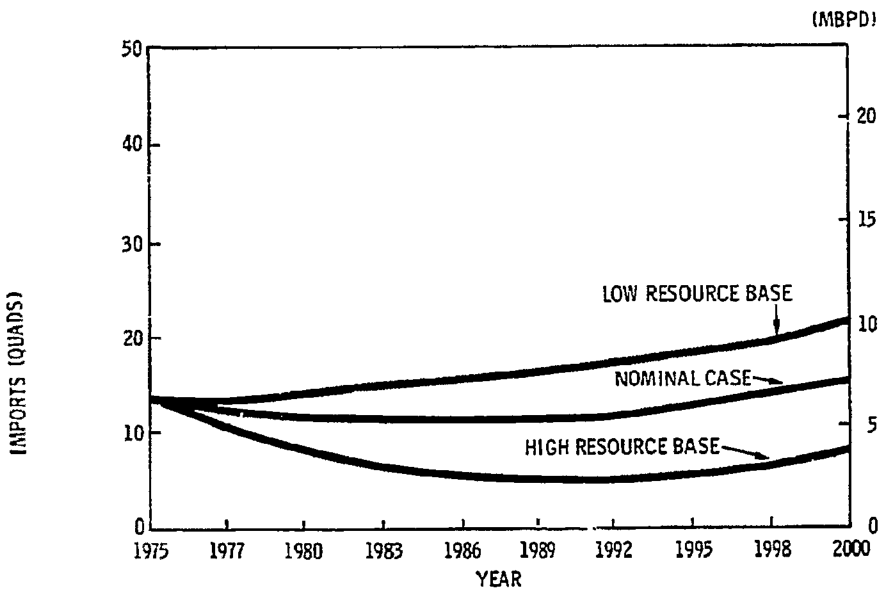

FIGURE 15. IMPORT SENSITIVITY TO U. S. OIL & GAS RESOURCES

increased by 50 percent) and a low cost synthetic fuels case (capital and non-feedstock operating costs are reduced 20 percent) were examined. Figures 16 and 17 illustrate the change in synthetic fuels production and imports for the two different cost cases. The higher cost of synthetic fuels makes their competitive position much less favorable and delays production six to eight years. Specifically, synthetic fuels production is 65 percent below the nominal case in 1995 in the high synthetic fuels cost case but 40 percent above the nominal in the low synthetic fuels cost case. The implication is that most of the demand in the nominal case that is satisfied by synthetic fuels will be satisfied by imports if synthetic fuels turn out to be expensive to produce. On the other hand, if synthetic fuels costs are low, imports can be significantly reduced.

5. Demand

One of the most often discussed topics regarding energy policy is that of demand. In order to test the effects of successful energy conservation programs or continued high use of energy, two cases of demand for usable energy were examined. The low demand case corresponds to zero per capita growth in energy consumption; the high demand case is simply an extrapolation of the historical population and per capita energy growth. The high demand case reaches 224.9 quads by 2000 while the low case reaches 129.5 quads (nominal demand in 2000 was assumed to be 156.9 quads).

The sensitivity runs for high, nominal, and low demand appear in Figures 18 and 19. Note that imports are down 31 percent in 1995 for low demand but are up 95 percent for high demand. On the other hand, synthetic fuel production is down 18 percent in 1995 for low demand and up 54 percent for high demand. The important point is that imports respond more than synthetic fuels to demand changes. The reason is that synthetic fuels require more planning and are more capital intensive. As a result, conservation has much more effect on imports than on either synthetic fuels or domestic oil and gas.

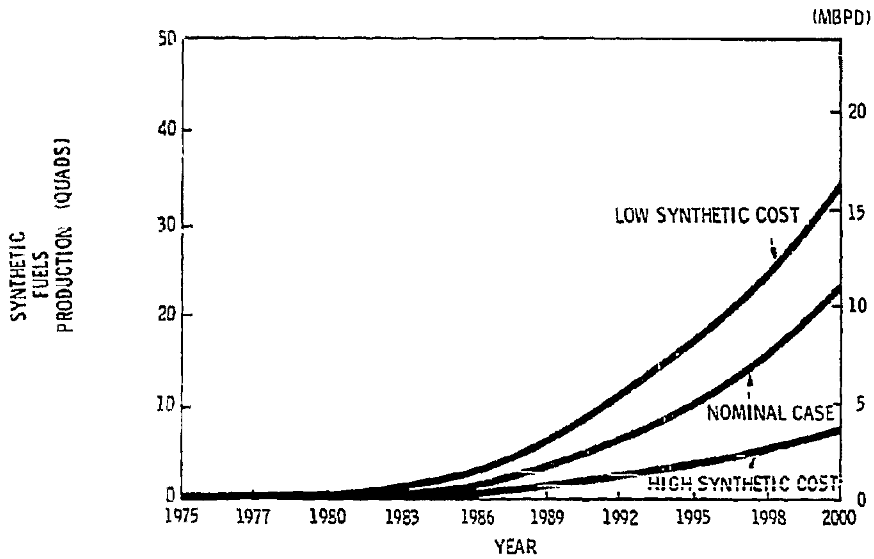

FIGURE 16. SYNTHETIC FUEL PRODUCTION SENSITIVITY TO SYNTHETIC FUEL COST

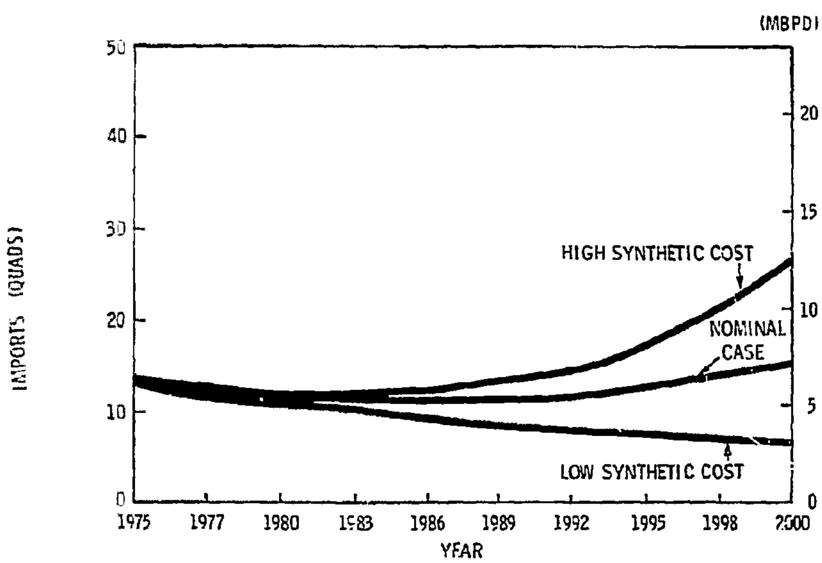

FIGURE 17. IMPORT SENSITIVITY TO SYNTHETIC FUEL COST

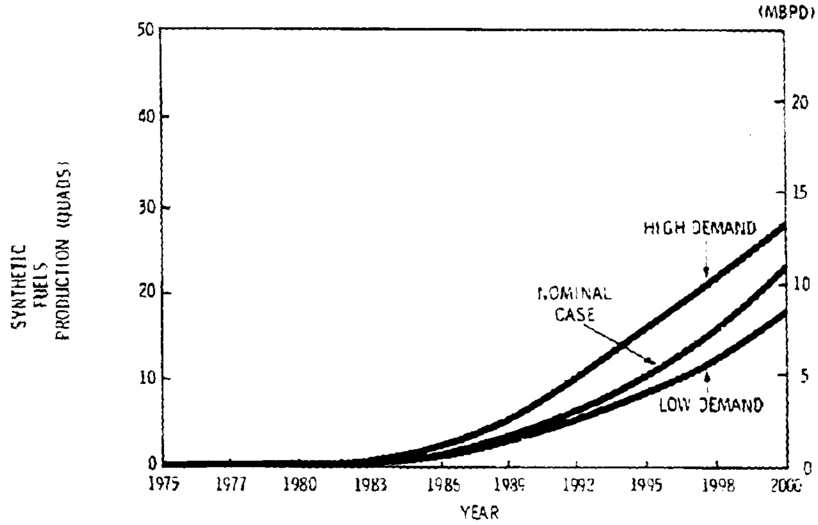

FIGURE 18. SYNTHETIC FUEL PRODUCTION SENSITIVITY TO TOTAL DEMAND

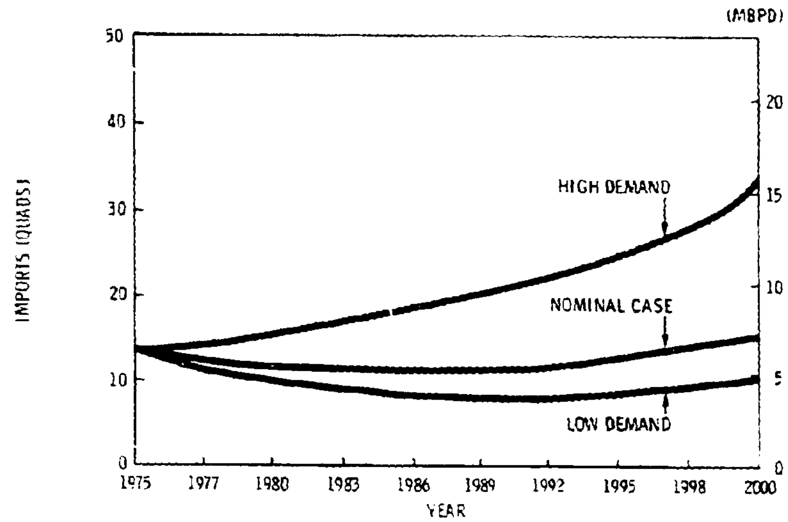

FIGURE 19. IMPORT SENSITIVITY TO TOTAL DEMAND

6. Synthetic Fuels Delay

From the standpoint of the Synthetic Fuels Commercialization Program, the most important consideration is what is the value of accelerating the commercial development of synthetic fuels. In order to explore this, a five-year delay in synthetic fuels availability was examined. The drop in synthetics and increase in imports due to delaying synthetic fuels five years gives an indication of the potential value of having a Synthetic Fuels Commercialization Program. The sensitivity to a five-year delay in synthetic fuels production is illustrated in Figures 20 and 21. The key effects of the delay are:

- Synthetic fuels production is reduced 60 percent in 1985 and 30 percent in 1995 from the nominal case.
- Imports of crude oil are up 7 percent in 1985 and 17 percent in 1995 from the nominal case.

From this analysis, it appears that delaying the availability of synthetic fuels five years would result in an increase in imports of approximately 335,000 barrels per day in 1985 and 850,000 Bbls/day in 1995. There are other factors that may have more effect on the decision to accelerate the development of synthetics such as: the reduction in energy costs to consumers, the reduction of dependence on foreign supplies, conservation, domestic oil and gas availability, and import prices. This issue will be the subject of a more detailed analysis to be presented later in this volume.

E. NUCLEAR AVAILABILITY

The availability of nuclear power has relatively little effect on synthetic fuels, but the effect it does have is somewhat surprising. A low nuclear availability and a high nuclear availability case were examined by assuming a nuclear moratorium in the former case and by significantly reducing nuclear cost in the latter. In the low nuclear availability case, no new nuclear plant construction is allowed; the existing plants are allowed to operate through their normal lives. In the high nuclear availability case, the capital cost of the light water reactor is reduced from the nominal value of $550/kw to $400/kw which represents relatively inexpensive nuclear power.

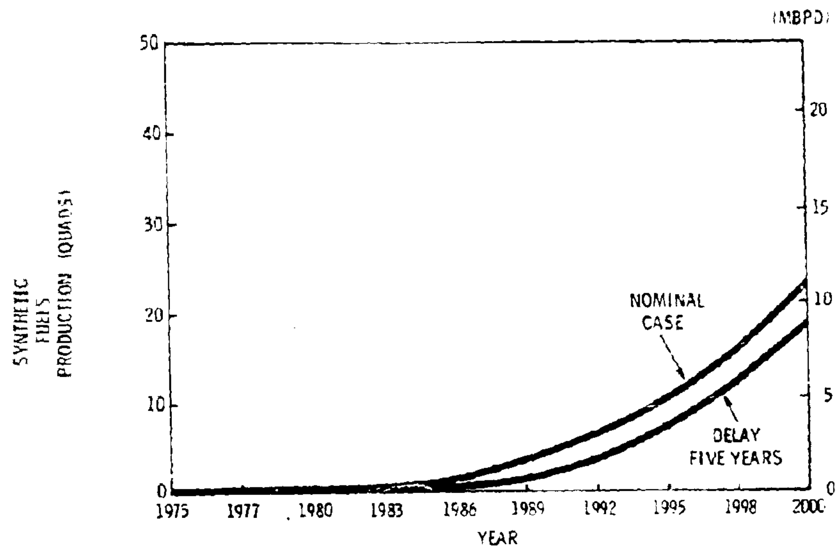

FIGURE 20. SYNTHETIC FUEL PRODUCTION SENSITIVITY TO DELAYED SYNTHETIC FUEL PRODUCTION

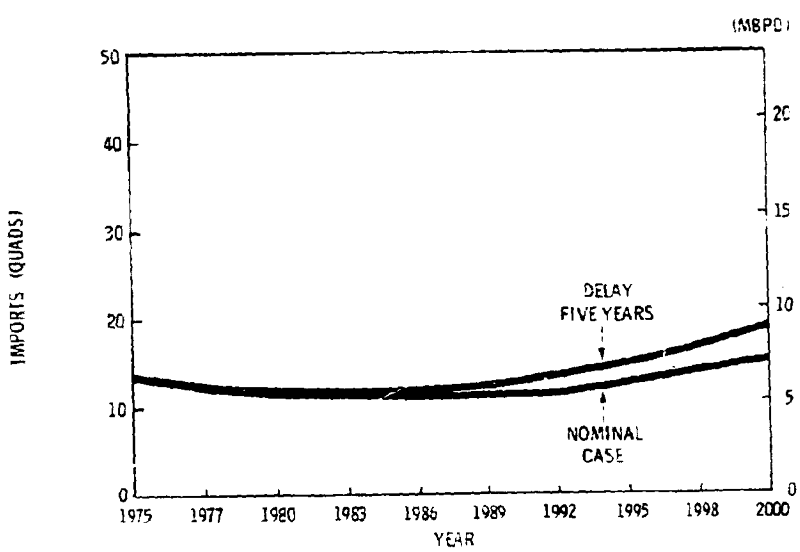

FIGURE 21. IMPORT SENSITIVITY TO DELAYED SYNTHETIC FUEL PRODUCTION

The effects on synthetics and imports of the low, nominal, and high nuclear availability cases are shown in Figure 22 and Figure 23. For both the low and high nuclear availability cases, synthetics are less attractive than in the nominal case.

In the low nuclear availability case, all base load power will be generated from coal. The result will be substantially higner coal prices due to rapid expansion. At these higher coal prices, synthetics based on coal are less competitive; thus, the demand for synthetic fuels declines. This decline in synthetic fuels is made up principally by imports and increased domestic production.

In the high nuclear availability case, the cost of base load power is significantly lower due to the lower cost of nuclear power. This cheaper power then captures a slightly larger share of the residential and industrial markets, displacing liquids and gases. As liquids and gases are displaced, the demand for both synthetics and imports declines. Thus, the nominal case creates the largest demand for synthetic fuels as the cost of coal is low enough so that synthetic fuels are competitive, but the cost of nuclear power is high enough so that electricity cannot capture a large share of the residential and industrial markets at the expense of liquids and gases.

F. OTHER ENERGY SOURCES

As demonstrated in the preceding sections, a significant amount of this nation's future energy requirements may come from synthetic fuels over the 1985-2000 time frame. The Task Force determined from various sources that there were several new potential contributors to energy supply with great promise. However, these new energy sources are not expected to go into extensive commercial operation during the 1980-1990 time frame.

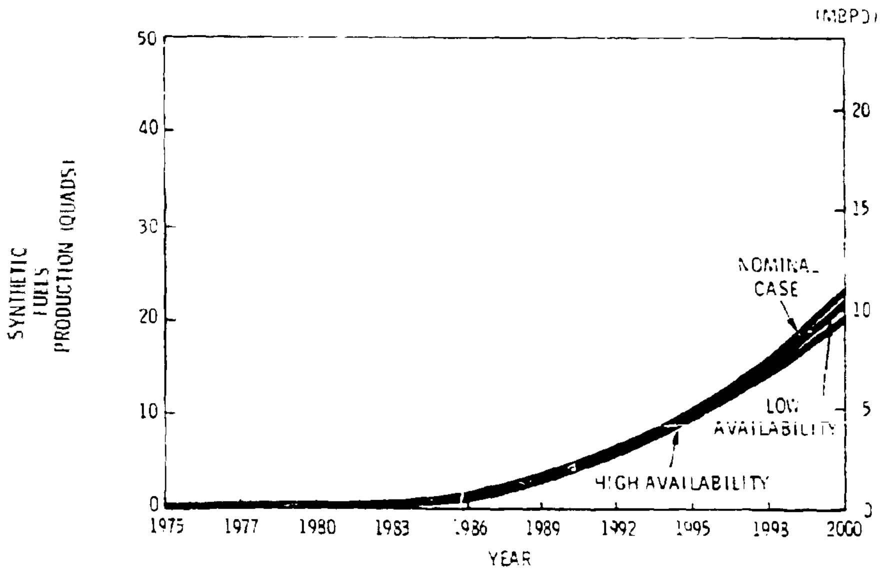

FIGURE 22. SYNTHETIC FUEL PRODUCTION SENSITIVITY TO NUCLEAR AVAILABILITY

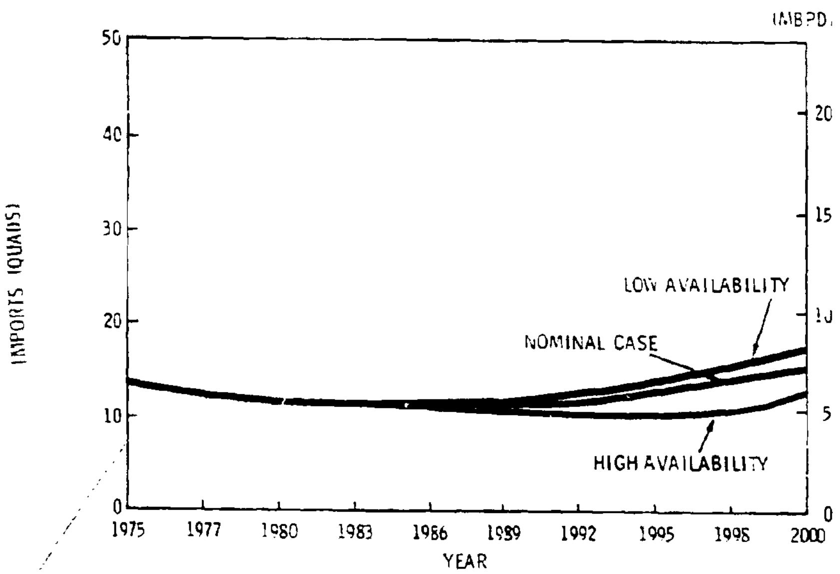

FIGURE 23. IMPORT SENSITIVITY TO NUCLEAR AVAILABILITY

1. Solar

Solar energy has been shown to have technical feasibility as a replacement for conventional energy sources, for both thermal and electrical applications. Only the thermal (i.e., non-electrical) applications appear likely to have any significant commercial applications during the 1980s. These include heating and cooling of buildings and heating of water for residential purposes. The photovoltaic, thermal-electric, and large wind-electric systems still appear unattractive and sometime away on the basis of cost competitiveness.

The Project Independence Task Force Report on Solar Energy estimated that the appropriate point for market acceptance is about $5/sq.ft. of solar collector area (including backup heat storage and pumping facilities). The actual cost of solar collectors estimated by the private sector (G.E., TRW, Westinghouse) was cited to be as high as $19/sq.ft. It is estimated that less than the equivalen of 300,000 barrels of oil of solar energy will be collected annually by 1985.

2. Nuclear Fusion

Nuclear fusion is expected to be in an advanced research and development stage in the period 1980-1990, with no capability for sustained commercial power production. The first commercial applications are not expected until the late 1990s.

3. Breeder Reactor

The breeder reactor is expected to be in a pre-commercial demonstration program status about 1985-1990, with perhaps a few plants (1-2) in the entire nation operating on an experi· ıtal basis but feeding a very limited amount of power into the network.

On the other hand, the following more conventional energy sources will have a more important role in the 1980's.

4. Accelerated Coal Development

Coal will supply a growing share of fuel consumption for electricity generation for the foreseeable future. Coal will also be moving strongly into industrial process heat demand where oil and gas are now being used. The Project Independence Report estimated that coal production would rise from its early 1970s level of 550-600 million tons to over 1.1 billion tons in the base case and could go as high as 2 billion tons under accelerated production conditions by 1985. The technology to burn at least medium-sulfur coals within emission standards is commercially available at this time. There are three key non-structural constraints on coal production and consumption:

- Environmental regulations
- Price and availability of competing fuels
- Electricity demand

It is estimated that if the authorities granted to FEA under the Energy Supply and Environmental Coordination Act (ESECA) are fully carried out, oil-fired utility and industrial plant conversions to coal will result in an "oil-savings" of between 600,000 to 900,000 bbl/day by 1985. This conversion program does not include converting gas-fired boilers to coal which offers the potential for a significant "savings" but which have not yet been quantified.

It should be noted that with large scale utility and industrial conversions, significant new coal-fired utility capacity, and a synthetic fuels commercialization program coal supplies, manpower, and capital goods supplying sectors may be extremely tight. The Federal Government, along with the appropriate state bodies, will have to proceed carefully in order to avoid the situation where these constraints manifest themselves in the form of a classic demand-pull inflation. Appendix B specifies these concerns in more detail.

5. Nuclear Fission

While the use of nuclear energy will increase in the next 10 years, actual levels of consumption will be lower than originally forecast due to economic, technological and environmental constraints. Current (June 1975) nuclear generating capacity on line is about 37,000 MWe. The Project Independence Nuclear Task Force Report estimated 260,000 MWe on line by 1985. Since that time (October 1974) reduced demand, increased costs, and technological and environmental problems have caused utilities to either stretch out construction or cancel entirely much of earlier planned nuclear capacity.

Current unofficial estimates of nuclear electric generating capacity for 1985 range from a low of 160,000 MWe to a high of 245,000 MWe. Given the lengthening construction times, increasing capital costs, and unresolved spent fuel disposal problems, the high estimate could only be reached with extensive Federal Government intervention. The low estimate appears to be the most reasonable current estimate since only a little over 100,000 MWe of capacity has actually been licensed or permits granted for construction. With a leadtime in the neighborhood of seven years for commercial operation, time is becoming increasingly short.