Final Report

EPA-600/7-76-004B
July 1976

IMPACTS OF SYNTHETIC LIQUID FUEL DEVELOPMENT

Automotive Market

Volume II

by

Edward M. Dickson, Robert V. Steele, Evan E. Hughes, Barry L. Walton,
R. Allen Zink, Peter D. Miller, John W. Ryan, Patricia B. Simmon,
Buford Holt, Ronald K. White, Ernest C. Harvey, Ronald Cooper,
David F. Phillips (Consultant), Ward C. Stoneman (Consultant)

Stanford Research Institute
Menlo Park, California 94025

Contract No. 68-03-2016
SRI Project EGU-3505

Project Officer:

Gary J. Foley
Office of Energy, Minerals, and Industry
Office of Research and Development
U.S. Environmental Protection Agency
Washington, D.C. 20460

Prepared for:

Office of Research and Development
U.S. Environmental Protection Agency
Washington, D.C. 20460

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA-600/7-76-004B	2.	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE IMPACTS OF SYNTHETIC LIQUID FUEL DEVELOPMENT-- Automotive Market Volume II		5. REPORT DATE July 1976
		6. PERFORMING ORGANIZATION CODE EGU 3505
7. AUTHOR(S) E.M. Dickson, R.V. Steele, E.E. Hughes, B. L. Walton, R.A. Zink, P.D. Miller, J.W. Ryan, P.B. Simmon, B. R. Holt, R. K. White, E. C. Harvey, R. C R. Cooper, D. F. Phillips, W. C. Stoneman		8. PERFORMING ORGANIZATION REPORT NO. EGU 3505
9. PERFORMING ORGANIZATION NAME AND ADDRESS Stanford Research Institute Menlo Park, California 94025		10. PROGRAM ELEMENT NO. EHE 623
		11. CONTRACT/GRANT NO. 68-03-2016
12. SPONSORING AGENCY NAME AND ADDRESS Office of Research and Development U.S. Environmental Protection Agency Washington, D.C. 20460		13. TYPE OF REPORT AND PERIOD COVERED Final, Series 7
		14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES Work was completed by EPA contract entitled, "Impacts of Synthetic Liquid Fuel Development--Automotive Market," No. 68-03-2016, covering period June 20, 1974 to June 14, 1976. Work was completed as of June 14, 1976.

16. ABSTRACT

This study assesses the impacts of the development of synthetic liquid fuels from coal and oil shale; the fuels considered are synthetic crude oils from coal and oil shale and methanol from coal. Key issues examined in detail are the technology and all of its resource requirements, net energy analyses of the technological options, a maximum credible implementation schedule, legal mechanisms for access to coal and oil shale resources, financing of a synthetic liquid fuels industry, decision making in the petroleum industry, government incentive policies, local and national economic impacts, environmental effects of strip mining, urbanization of rural areas, air pollution control, water resources and their availability, and population growth and boom town effects in previously rural areas.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
coal, oil shale, synthetic fuels, methanol, air pollution, environmental impact, economic impacts, boom towns, water resources, strip mining, control technology, incentive policies	synthetic fuels technology, net energy analysis	

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS (This Report) UNCLASSIFIED	21.
	20. SECURITY CLASS (This page) UNCLASSIFIED	

EPA Form 2220-1 (9-73)

DISCLAIMER

This report has been reviewed by the Office of Energy, Minerals, and Industry, U.S. Environmental Protection Agency, and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the U.S. Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

1--PROLOGUE TO VOLUME II

A. Introduction

This study has its roots in the realization that historical growth in automotive* fuel demand cannot be sustained, especially if the U.S. intends to become increasingly self-reliant in energy. Unless fundamental reduction occurs in the demand for available fuels, the United States will be unable to satisfy all of its requirements for petroleum products. Since automotive vehicles consume about 46 percent of all petroleum used in this country, the future vitality of the automotive sector is at stake.

There are several approaches to satisfying desires for energy in general and petroleum products in particular:

- Conserve.
- Step-up domestic oil (and gas) production by increasing activity in new areas.
- Import crude oil and refined products.
- Develop synthetic liquid fuels based on abundant domestic coal and oil shale resources.

The last option is the focus of this study.

Two previous studies,† commissioned by the Alternative Automotive Power Systems Division of the U.S. Environmental Protection Agency,

---

*Cars, trucks, and buses.

†Kant, F., et al., "Feasibility Study of Alternative Fuels for Automotive Transportation," Environmental Protection Agency, Report EPA-460/3-74-009 (June 1974).

Pangborn, J., et al., "Feasibility Study of Alternative Fuels for Automotive Transportation," Environmental Protection Agency, Report EPA-460/3-74-012 (July 1974).

explored the economic and technical feasibility of a wide range of candidate synthetic automotive fuels ranging from hydrogen through methanol to gasoline. Various sources and production systems were considered. Both studies concluded that the leading candidates for automotive fuel for the future (1980 and beyond) were

- Coal-derived
  - Gasoline
  - Distillates
  - Methanol
- Oil shale-derived
  - Gasoline
  - Distillates.

B. Objectives

The basic objective of this study is to determine the feasibility of alternative automotive fuels production in a broader context--one that includes the environmental, societal, and institutional ramifications of synthetic fuels development. To provide a frame of reference in which to view these consequences, the environmental impacts of stepped-up domestic production and oil imports are also described. Both futures are based on the presumption that energy use growth rates are slackening as a result of increased conservation.

To achieve the basic objective, several general goals were set:

- Determine the impacts of a major deployment of synthetic liquid fuels technology
- Prepare a scenario of the maximum possible rate of deployment
- Identify the critical impacts that might decide the question of deployment, prove intolerable unless mitigated, or prove not to be amenable to mitigation

- Identify governmental policies that might lessen or avoid adverse impacts or enhance prospects for deployment of synthetic fuels capability
- Develop criteria on which to base comparison of alternative synthetic fuels options.

C. Study Approach

The study was organized as a technology impact assessment. The study core team consisted of a group of professionals with expertise in chemistry, physics, economics, sociology, and law. For supplemental expertise, the team drew on professionals in chemical engineering, meteorology, and biology. The team received inputs from experts at SRI, the staff of two coordinate contractors (Exxon Research and Engineering and The Institute of Gas Technology), industry, universities, and stakeholder groups. The EPA project officers maintained a close working liaison with the team and participated in a major observation trip in the field and many working sessions.

To facilitate the sharing of information within the team and review by outside parties, intermediate findings were put in the form of working papers. These working papers were revised to reflect subsequent findings, improvements in information, criticism from reviewers, and stakeholder inputs, and in their form revised the backbone chapters of Volume II.

The chapters are the following:

2. Automotive Fuel Supply and Demand Forecasts
3. Reference Supply Case
4. Synthetic Liquid Fuels: The Technology, Resource Requirements, and Pollutant Emissions
5. Net Energy Analysis of Synthetic Liquid Fuels Production

6. Maximum Credible Implementation Scenario for Synthetic Liquid Fuels from Coal and Oil Shale

7. Legal Mechanisms for Access to Coal and Oil Shale

8. Financing the Synthetic Liquid Fuels Industry by the U.S. Capital Markets

9. Market Penetration of Synthetic Liquid Fuels--The Key Role of the Decision-Making Process Leading to Deployment

10. Government Policies to Encourage the Production of Synthetic Liquid Fuels

11. National Economic Impacts of the Synthetic Fuels Industry

12. Economic Impacts in Resource Development Regions

13. Comparative Environmental Inputs of Coal Strip Mining

14. Oil Shale Mining and Spent Shale Disposal

15. Region Specific Biological Inputs of Resource Development

16. Air Pollution Control for Synthetic Liquid Fuel Plants

17. Secondary Environmental Inputs from Urbanization

18. Health Issues in Synthetic Liquid Fuels Development

19. Water Availability in the Western United States

20. Water Availability in the Eastern United States

21. The Impact of Industrial Growth on Rural Society

22. Population Growth Constrained Synthetic Liquid Fuel Implementation Scenarios

23. Comparative Inputs of Controlled and Uncontrolled Urbanization

The following paragraphs describe the relationship of each chapter to the study as a whole.

D. Basic Information

The study required certain basic information as inputs to other analyses: (The relevant chapters are indicated by the number in parentheses.)

- Domestic automotive fuel demand and supply projections from 1975 to 2000 within a consistent total energy balance for the United States. (2)
- Projections of the (geographical) sources of future conventional domestic oil supplies to serve as the basis for the reference impact case. (3)
- Descriptions of synthetic fuels production processes, capital investments, labor forces, materials requirements, etc. (4)
- Information on the locations and amounts of coal resources. (5)
- Understanding of the institutional structure of the automotive fuels supply system. (9)

The study also required development of the following:

- Impacts description of the reference case for supplying conventional crude oil. (3)
- An implementation scenario for synthetic liquid fuels at the maximum rate of deployment that can be credibly imagined. (6)
- A description of how corporate stakeholders in the fuels industry perceive the prospective synthetic fuels industry would mesh with the existing system. (9)

E. Critical Factors

From the outset, information obtained from the literature and stakeholders made it clear that the following factors were critical and they were emphasized in the study:

- Availability of water for energy development--especially in the arid West. (19, 20)
- Strip mining practices and reclamation potential. (13, 14, 15)
- Mineral leasing procedures and constraints (since much of the relevant resource is owned by the federal government). (7)
- Control of air pollution from mines and conversion facilities. (16)
- Availability of capital for synthetic liquid fuels investments. (8)
- Transportation of coal between mines and liquefaction plants. (19)
- Corporate decisions about whether and when to deploy synthetic fuels. (9)
- The creation of boom towns in coal and oil shale regions--especially in sparsely populated regions of the West--and the effects of constraining growth. (21, 22, 23)
- Governmental incentives for synthetic liquid fuels production. (10)

F. Complementing Work

To provide a complete picture and to complement the analysis, it was necessary to prepare:

- Descriptions of the environmental impacts of urbanization specific to the most likely regions of expected synthetic fuels activity. (17)
- National and regional economic descriptions of synthetic fuels industry development. (11, 12)
- Impacts of deployment of synthetic fuels facilities at the maximum credible rate. (8, 11, 12, 18, 19, 23)

G. Applicability

Although this study is oriented toward fuels for the automotive sector, many of the analyses in the following chapters have more general applicability. The results of the analyses have equal relevance to understanding the consequences of strip mining for coal, of synthetic gas production, and of water intensive industrial development of the West.

2--AUTOMOTIVE FUEL SUPPLY AND DEMAND FORECASTS

By Edward M. Dickson

This study is concerned with the development of synthetic liquid fuels for the automotive market. Here the word automotive is taken to include cars, trucks, and buses. Together, these vehicles consume about 46 percent of all petroleum used in the United States.[1] Cars, of course, account for the majority of this use--some 70 percent. Figures 2-1 and 2-2 place automotive fuel use in perspective, both as a proportion of total energy use and as a proportion of total oil use.

There are many forecasts of future automotive fuel demand in the literature,[2-9] but few of them are based on anything more sophisticated than simple trend extrapolation.* Most, moreover, implicitly assume constant energy prices (in real terms). This assumption is understandable because, as shown in Table 2-1, between 1950 and 1973 the real price of motor fuels remained essentially constant with even a slight downward trend. Since the Arab oil embargo, however, it is no longer credible to assume either constant petroleum prices or availability of supplies to meet the desires† of motorists. Consequently, interest has begun to focus on synthetic liquid fuels.

---

*One recent, more sophisticated projection[10] is described in the appendix.

†We use the word desires here rather than demand because, in the language of economics, supply must equal demand in an equilibrium economy, but desires may exceed supplies.

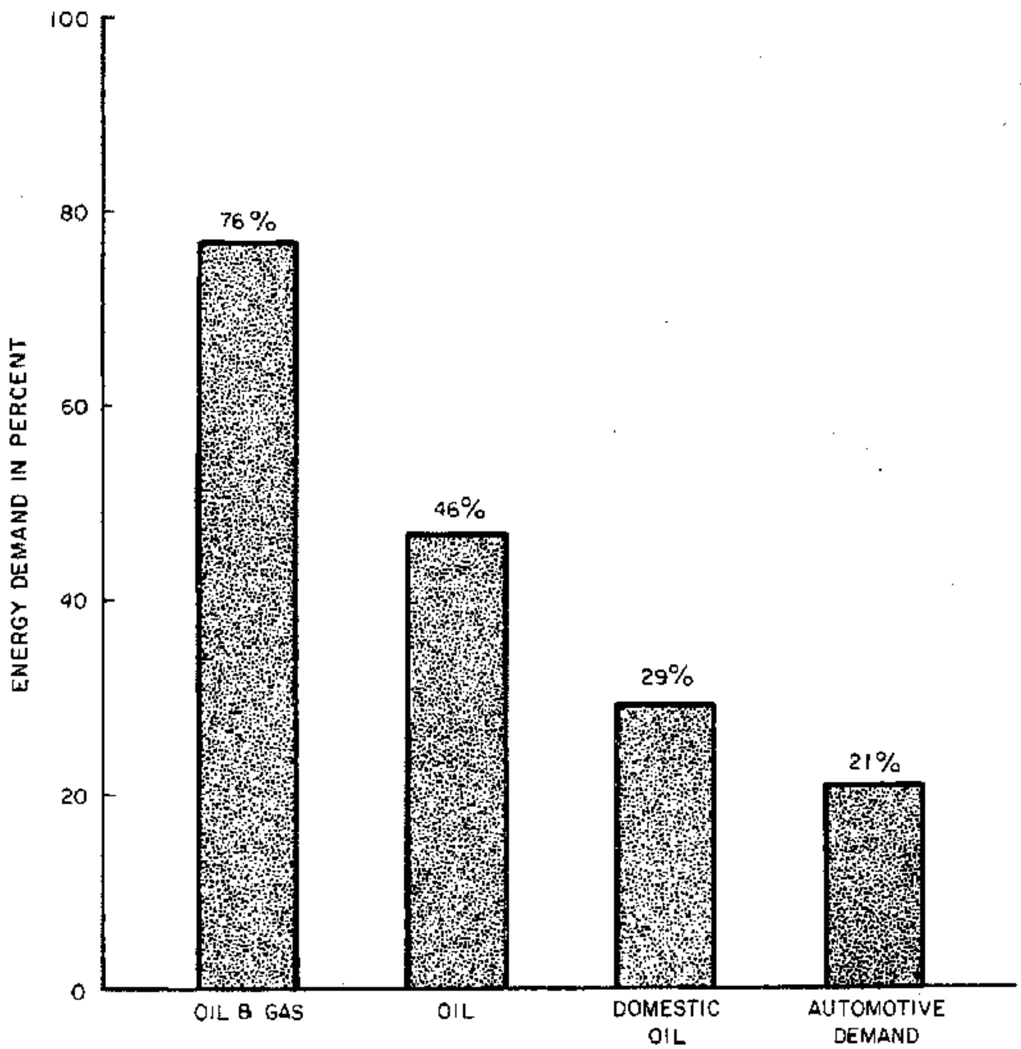

FIGURE 2-1. AUTOMOTIVE ENERGY DEMAND COMPARED TO 1974 PETROLEUM SUPPLY AND DEMAND

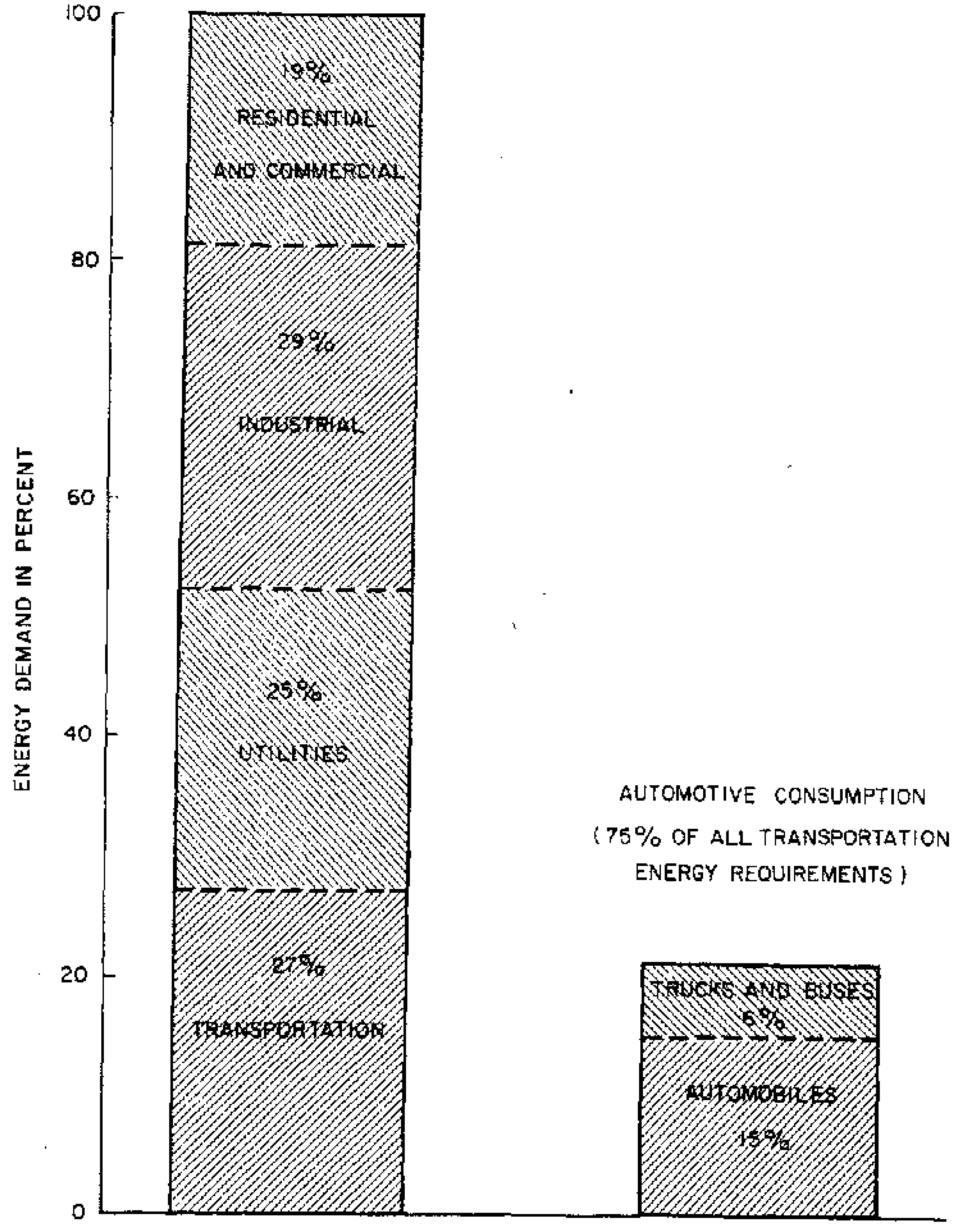

FIGURE 2-2. AUTOMOTIVE ENERGY DEMAND COMPARED TO TOTAL U.S. ENERGY DEMAND

Table 2-1

GASOLINE PRICES AND FUEL COST PER MILE
1950-74

Source: Reference 10

Year	Real Price (1967 dollars) ($/gal)	Real Fuel Cost ($/Mile)*
1950	0.37	0.0248
1955	0.36	0.0250
1960	0.35	0.0246
1965	0.33	0.0234
1970	0.31	0.0226
1973	0.29	0.0223
1974	0.35	0.0271†

*Based on fuel economy of vehicles in operation.

†Assumed 1973 fuel economy.

To appreciate the quantity of synthetic liquid fuels that the U.S. might wish to produce in the years ahead, a forecast of both supply and demand is needed and these components must be coupled through a common and realistic assumption about fuel price. In addition, over a long period, such as 1980-2000, considerable interfuel competition could take place, which could result in substantial fuel switching. Thus, it is also necessary to use a forecast in which automotive use of petroleum (or equivalent) products is but a portion of a total energy economy balance.

Since construction of such a complete forecast was beyond the scope of this study, we have chosen to adapt for our use the three supply and demand scenarios of the Energy Policy Project of the Ford Foundation because they were the only such forecasts publicly available for the time frame 1980-2000.[11] Although they are flawed,* the Ford scenarios are sufficient to indicate the general magnitude of the future shortfall of domestically produced petroleum compared with the desired supplies. This shortfall is a measure of the amount of future petroleum imports that will be required, of synthetic fuel production needed, or a combination of these two alternatives.

The three Ford scenarios are entitled Historical Growth (HG), Technical Fix (TF), and Zero Energy Growth (ZEG).[11] Basically, the HG scenario assumes that consumers of fuels ignore the current high prices of fuels and return to historical high consumption rates with no government restrictions on consumption. Under the HG scenario, oil prices fall back to the

---

*For example, the forecasts of aviation demand are generally agreed to be excessively high and the assumptions of fuel price are never made explicit. Moreover, the Ford study makes the unrealistic assumption that synthetic fuels could be developed (without governmental subsidies) at a cost of $4-$6 per barrel.

$4 to $6 per barrel range, which is low enough to maintain demand at historical rates. The HG scenario assumes that fuels from nonconventional fossil sources (e.g., oil shale) would have to be developed because of the rapid growth of demand. However, one difficulty with the HG scenario is the doubtful assumption that synthetic fuels could be produced (without governmental subsidy) at a price range of $4 to $6 per barrel. Moreover, it is unlikely that these low prices could hold in the face of the projected continued rapid growth in demand.

The TF scenario assumes that fuel consumers will respond to the current high prices of energy and take steps to reduce fuel use over the 1975-2000 period and that the government will order mandatory conservation measures. With conservation measures in effect, the annual growth rate of total demand for energy is reduced from 3.4 percent under HG to 1.9 percent under TF. Primary factors in conserving energy are better insulation of buildings and better automotive fuel economy. For example, automobiles are assumed to achieve an improved fuel economy from the current 14 mpg to 20 mpg by 1985 and to 25 mpg by 2000. The study maintains that this could be achieved without giving up large automobiles and with existing technology.

The ZEG scenario is similar to the TF but with more stringent governmental controls. For example, the efficiency of automobiles increases from its current 14 mpg to 33 mpg by 2000.

The Ford Foundation Energy Policy Project gives a complete energy balance for the U.S. economy in all three scenarios. Table 2-2 shows the annual fuel demand by the entire transportation sector and the annual fuel demand by autos, trucks, and buses in the three Ford scenarios HG, TF, and ZEG.

On the supply side, the Ford study not only presents different assumed domestic petroleum supplies under the three main scenarios, but

Table 2-2

PROJECTED ANNUAL FUEL CONSUMPTION BY SECTOR
Quadrillion Btu per year (million B/D product equivalent)*

Source: Reference 11 (Tables 1, 5, 16, and A-8)

		1970	1975	1985	2000
	Total all sectors	66.0	78.0		
	Transportation	15.7	19.1		
	Autos, trucks, and buses	11.9 (6.2)	14.4 (7.5)		
	Percentage of transportation	76%	75%		
HG	Total all sectors			116.1	186.7
	Transportation			26.0	38.4
	Autos, trucks, and buses			18.0(9.3)	21.9(11.4)
	Percentage of transportation			69%	57%
TF	Total all sectors			91.3	124.0
	Transportation			19.6	24.7
	Autos, trucks, and buses			12.7(6.6)	11.4(5.9)
	Percentage of transportation			65%	46%
ZEG	Total all sectors			88.1	100.0
	Transportation			18.4	17.2
	Autos, trucks, and buses			12.5(6.5)	8.5(4.4)
	Percentage of transportation			68%	49%

*We use 1 bbl oil product (typically gasoline) = 5.25×10^6 Btu, so that 1 quad (10^{15} Btu) per year equals about 0.5 million B/D; 1 quad is also approximately equal to 10^9 GJ.

subscenarios are also given. Under HG, three subscenarios are presented --normal development (HG1), accelerated nuvlear development (HG2), and high imports (HG3); these subscenarios are shown in Figure 2-3.* In HG2, accelerated nuclear development substitutes for domestic oil in power generation; in HG3, imported oil substitutes for the development of domestic oil. The greatest assumed development of domestic oil occurs under scenario HG1. Under TF, two subscenarios are presented--TF1 and TF2. Under TF1, the United States moves toward self-sufficiency by reducing imports by almost one-half.† Under TF2, dependency on imports is not reduced but some environmental restrictions are included. The TF scenario is shown in Figure 2-4. The ZEG scenario, shown in Figure 2-5, includes stringent environmental controls, which then restrict the development of offshore and outer continental shelf areas. The various supply scenarios are summarized in Table 2-3. As discussed extensively in Chapter 3, of the three assumed supply cases of HG, only the HG3 domestic supply scenario has reasonable likelihood of being realized in light of the most recent U.S. Geological Survey estimates of the total recoverable U.S. reserves of petroleum.

Figures 2-3 to 2-5 indicate that an automotive fuel shortfall of about 6 million B/D (HG1 demand minus HG3 supply) to 2 million B/D (TF demand minus TF2 supply) might occur in the year 2000. Table 2-3 shows that the total (for all sectors) liquid fuel shortfall (listed as imports) might be in the range of 4 to 18 million B/D. This leaves a considerable

---

*Figures 2-3 to 2-5 assume that domestic crude production has been distributed among all use sectors in proportion to the demand of that sector compared to total petroleum demand. This proportion varies with time.

†The original projections in the Ford Foundation study assume that imports are cut exactly in half from the levels given in the HG case. In this table, all production of synthetic fuels shown in the Ford study has been added to imports of crude oil.

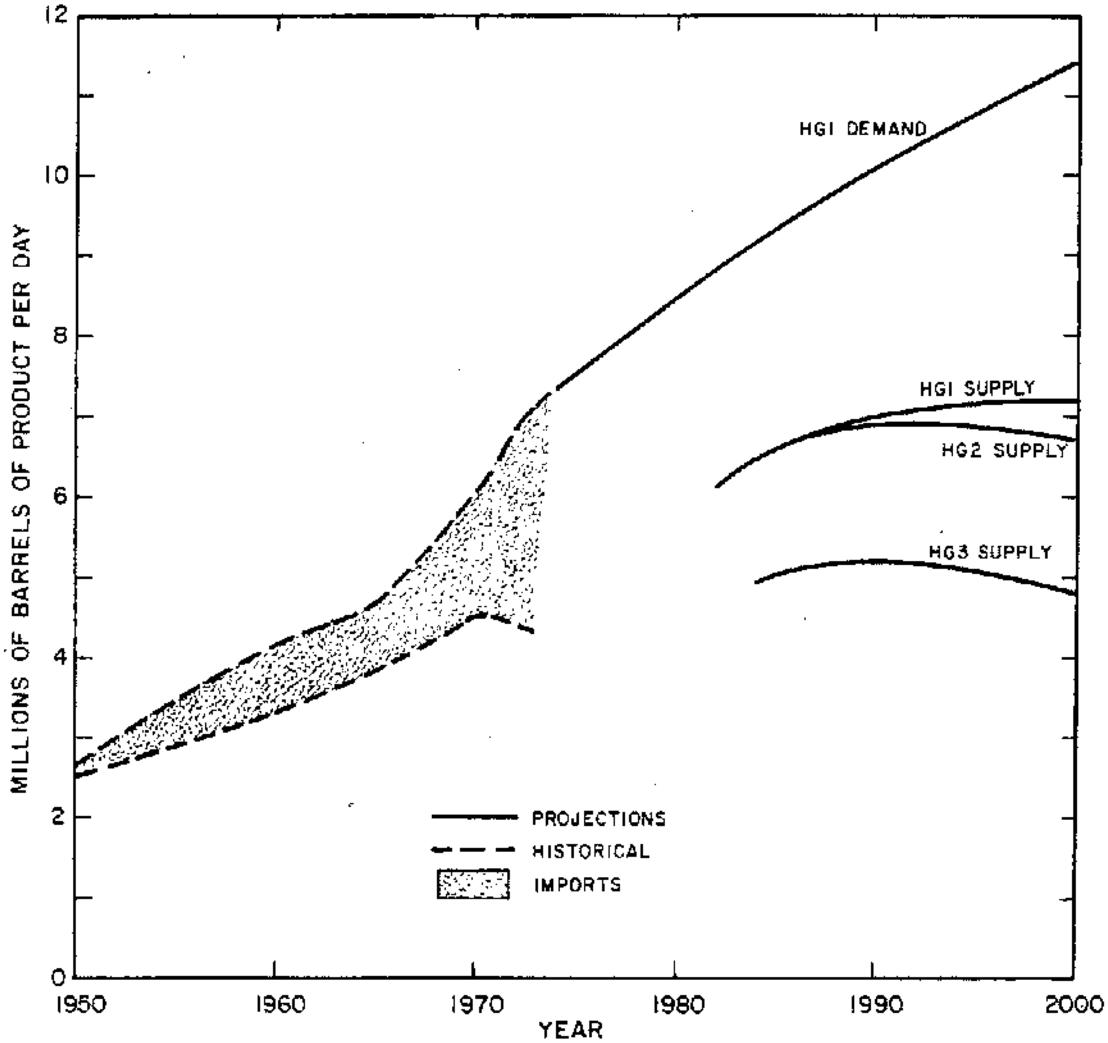

FIGURE 2-3. HISTORICAL GROWTH SCENARIO – AUTOMOTIVE FUEL DEMAND AND DOMESTIC SUPPLY PROJECTIONS

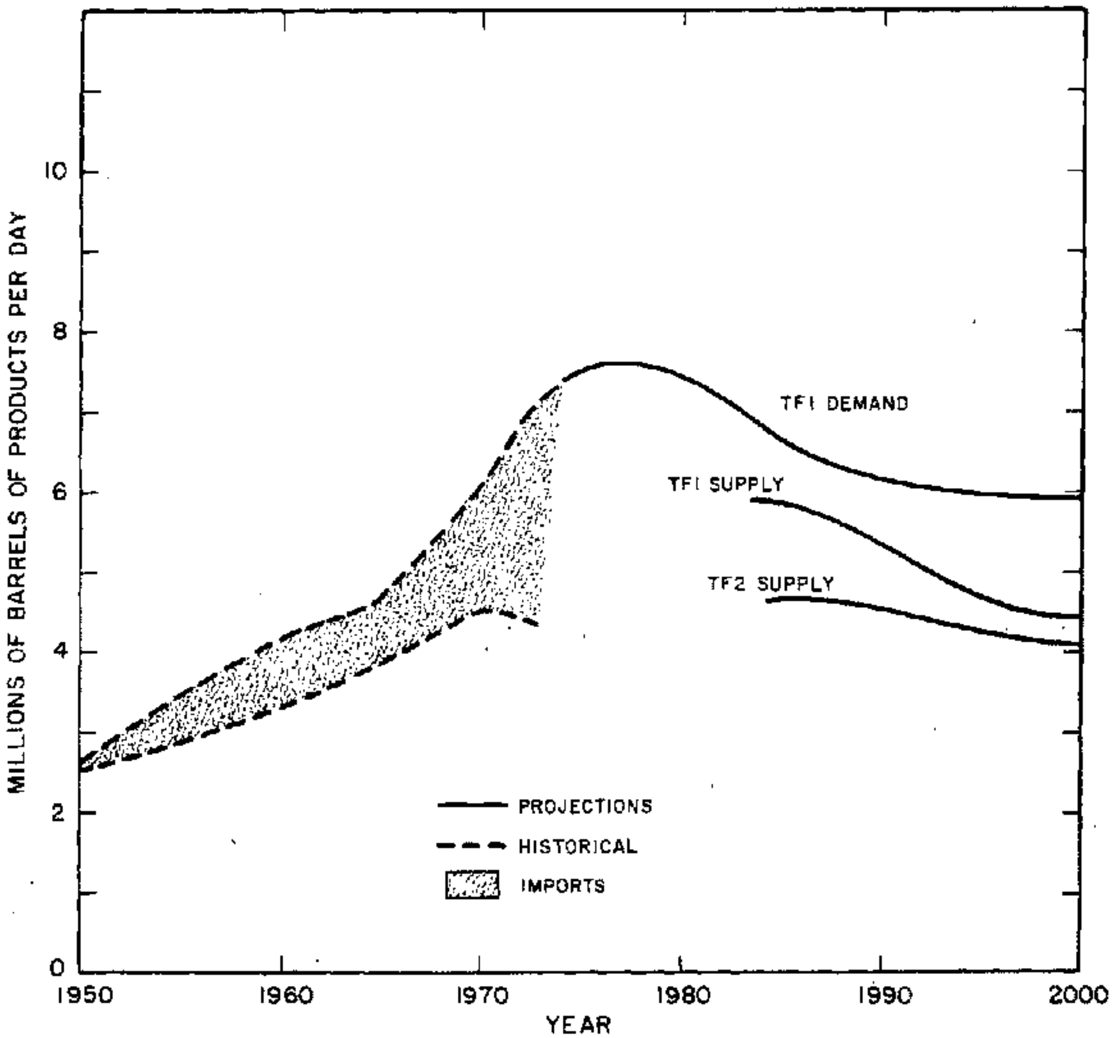

FIGURE 2-4. TECHNICAL FIX SCENARIO – AUTOMOTIVE FUEL DEMAND AND DOMESTIC SUPPLY PROJECTIONS

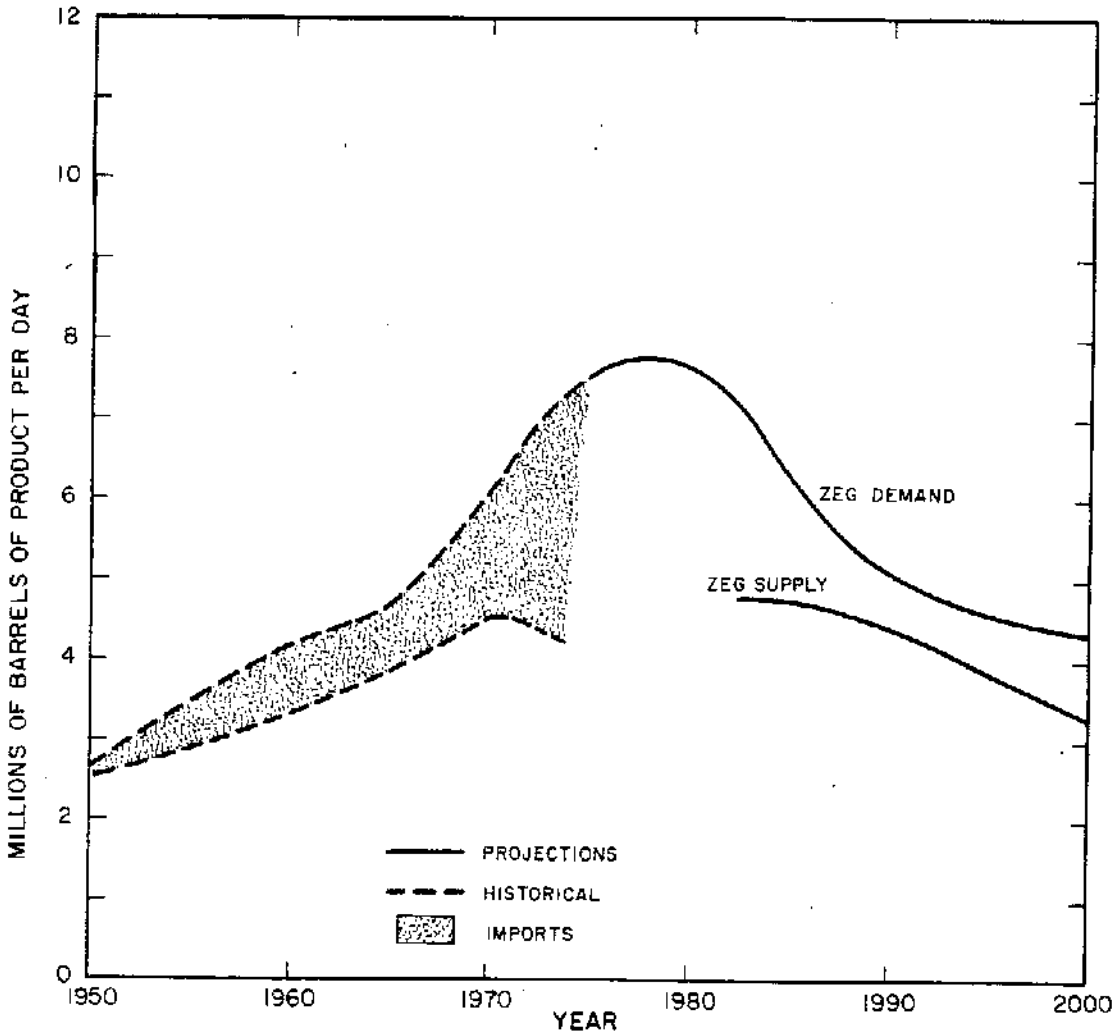

FIGURE 2-5. ZERO ENERGY GROWTH SCENARIO–AUTOMOTIVE FUEL DEMAND AND DOMESTIC SUPPLY PROJECTIONS

Table 2-3

OIL SUPPLY PROJECTIONS
Million B/D (Quadrillion Btu)

	1973	1985	2000
Domestic oil			
HG1	11.0 (22)	15.9 (32)	20.9 (40)
HG2		15.9 (32)	17.7 (34)
HG3		13.4 (27)	13.4 (27)
TF1		14.9 (30)	17.9 (36)
TF2		14.4 (29)	17.4 (35)
ZEG		13.9 (28)	14.9 (30)
Oil imports*			
HG1	6.0 (12)	6.5 (13)	12.0 (24)
HG2		6.5 (13)	12.0 (24)
HG3		11.5 (23)	18.4 (37)
TF1		3.2 (7)	6.0 (12)
TF2		6.0 (12)	8.0 (16)
ZEG		4.5 (9)	4.5 (9)

HG1: Historical growth
HG2: High nuclear
HG3: High imports
TF1: Self-sufficiency (rapid coal development; cut imports in half)
TF2: Environmental controls (no synthetic fuels)

*The synthetic liquid fuels in the Ford scenarios have been shifted to this category.

amount of uncertainty in the projected shortfall, an uncertainty matched in global geopolitics and U.S. energy policy, which will largely determine both the U.S. supply and demand for fuels.

In Chapter 6, we advance a Maximum Credible Implementation (MCI) scenario for synthetic liquid fuels derived from coal and oil shale that yields 10 million B/D.* Thus, the MCI would be capable of filling a substantial part of the total anticipated shortfall for liquid fuels.

---

*of oil equivalent energy.

REFERENCES

1. "Summary of National Transportation Statistics," Department of Transportation, DOT-TSC-OST-74-8 (June 1974).

2. "Research and Development Opportunities for Improved Transportation Usage," Transportation Energy Panel (September 1972).

3. Pangborn, J., et al., "Feasibility Study of Alternative Fuels for Automotive Transportation," Environmental Protection Agency, Institute of Gas Technology (1974).

4. Winger, J.G., et al., "Outlook for Energy in the United States to 1985," Chase Manhattan Bank (June 1972).

5. Dole, H.M., et al., "United States Energy, a Summary Review," U.S. Department of the Interior (January 1972).

6. Malliaris, A.C. and Strombotne, R.L., "Demand for Energy by the Transportation Sector and Opportunities for Energy Conservation," in Energy, edited by Michael S. Macrakis (1974).

7. Jacobson and Stone, Energy/Environment, Factors in Transportation, MITRE Corporation (April 1973).

8. Peterson, R.W., Chairman, Council on Environmental Quality, "A National Energy Conservation Program: The Half and Half Plan," (March 1974).

9. Kant, F.H., et al., "Feasibility Study of Alternative Fuels for Automotive Transportation," Environmental Protection Agency (June 1974).

10. Hemphill, R.F. and Difiglio, C., "Future Demand of Automotive Fuels," a paper presented at the General Motors Research Symposium, "Future Automotive Fuels--Prospects, Performance, Perspectives," October 6-7, 1975.

11. A Time to Choose: America's Energy Future, Energy Policy Project of the Ford Foundation (Ballinger, Cambridge, Massachusetts, 1974).

APPENDIX

Reference 10 presents a sophisticated econometric model that projects future automotive fuel demand taking into account the following variables:

- Automobile ownership
  - -The real price of automobiles by class
  - -The fuel efficiency of automobiles by class
  - -The real price of gasoline
  - -Total real disposable income
  - -Total number of households in each income group
  - -The unemployment rate.
- Travel demand
  - -household income
  - -trip purpose by income class
  - -cost factors.

The model relates five basic submodels:

- An estimator for market shares of new car sales (sales-weighted fuel economy of new cars).
- An estimator for new car sales.
- An estimator for scrappage (fleet size, fleet fuel economy).
- An estimator for miles traveled.
- A fleet model to calculate fuel consumption.

The fuel demand projections are made with three assumed fuel price schedules: constant fuel prices, rising fuel prices, and falling fuel prices. Table A-1 summarizes the fuel price assumptions.

Table A-1

FUEL PRICE ASSUMPTIONS
(per gallon)

Source: Reference 10

Year	Constant	Rising
1976	$0.61	$0.61
1980	0.61	0.72
1985	0.61	0.87
1990	0.61	0.88
1995	0.61	0.90
2000	0.61	0.90

The model projects only car fuel demand, but this can be corrected to total automotive fuel demand by assuming that cars use 70 percent of all automotive fuel in all years. This conversion, shown in Table A-2, allows easy comparison with the projections shown in Figures 2-3 to 2-5 in the text.

Table A-2

PROJECTED AUTOMOTIVE FUEL DEMAND
FOR CONSTANT AND RISING PRICES
(million B/D)

Source: Reference 10

Year	For Constant Price	For Rising Price
1976	7.4	7.4
1980	7.6	7.5
1985	8.3	7.8
1990	9.2	8.5
1995	10.3	9.4
2000	11.4	10.3

3--REFERENCE SUPPLY CASE

By Barry L. Walton

A. Introduction

Meeting the anticipated fuel demands for autos, trucks, and buses will require the development of oil resources in new areas together with vigorous activity to enhance oil recovery from known fields. With continuing high prices for imports (about $11 per barrel of crude in 1974 dollars) and governmental price regulation of a kind to encourage new production, stepped up attempts to develop domestic oil resources are likely. However, even with increased production, domestic supplies of oil will not meet demands for the entire period between now and the year 2000, and, in the absence of synthetic fuels, imports will be necessary to supply the difference between domestic oil supplies and domestic oil demands.

1. Content of the Reference Case

As a measure against which to set the topics treated in this technology assessment, we have developed a reference case in which the expected shortfall in U. S. automotive fuels is met by increased production within the existing petroleum industry, without the use of synthetic fuels. Specifically, the demand is met by

- Onshore production--lower 48 states onshore and near-shore production from state leases.
- Offshore production--outer continental shelf (OCS) production from federal leases off the coasts of the lower 48 states.
- Alaskan production--onshore and offshore production.
- Imports--both crude oil and refined products.

Figure 3-1 shows the boundaries of the reference case considered in this chapter. Under the assumption of these sources of oil for the United States to the year 2000, the reference case contains a projection of (1) domestic oil supply by region and the requirements for imported oil, (2) the resources required to increase domestic oil production without recourse to synthetic fuels development, and (3) the environmental impacts that could result from this production and importation. Environmental impacts are given in terms of quantified indicators derived from scaling factors applied to the projections of oil supply and demand and the resource requirements for an intensive U.S. oil recovery program.

2. Scenarios: Bases for Projections of Supply and Demand

In selecting a domestic fuel supply scenario for the reference case to correspond to the EPP demand forecasts described in Chapter 2, we faced considerable difficulty. Although six possible supply projections are described by the EPP[1], only HG3 retains some credibility in the light of recent projections by the U.S. Geological Survey (USGS) of domestic oil resources[2] (Appendix A discusses these and other projections). Table 3-1 shows the six EPP scenarios and displays approximate cumulative production between 1973 and 2000 for these scenarios. For this baseline analysis the synthetic fuels originally postulated by the EPP have been shifted to the category of imports. The estimates of possible domestic oil production shown in the table were made prior to the recent USGS projections. Even the comprehensive Federal Energy Administration, Project Independence Blueprint[3] was based upon the out of date USGS resource estimates shown in Appendix A, Table A-2. As discussed in Appendix A, it is now necessary to abandon estimates of future crude oil production which show impossibly large cumulative production estimates. Among the scenarios of the EPP, HG3 projects the lowest cumulative production rates into the next century.

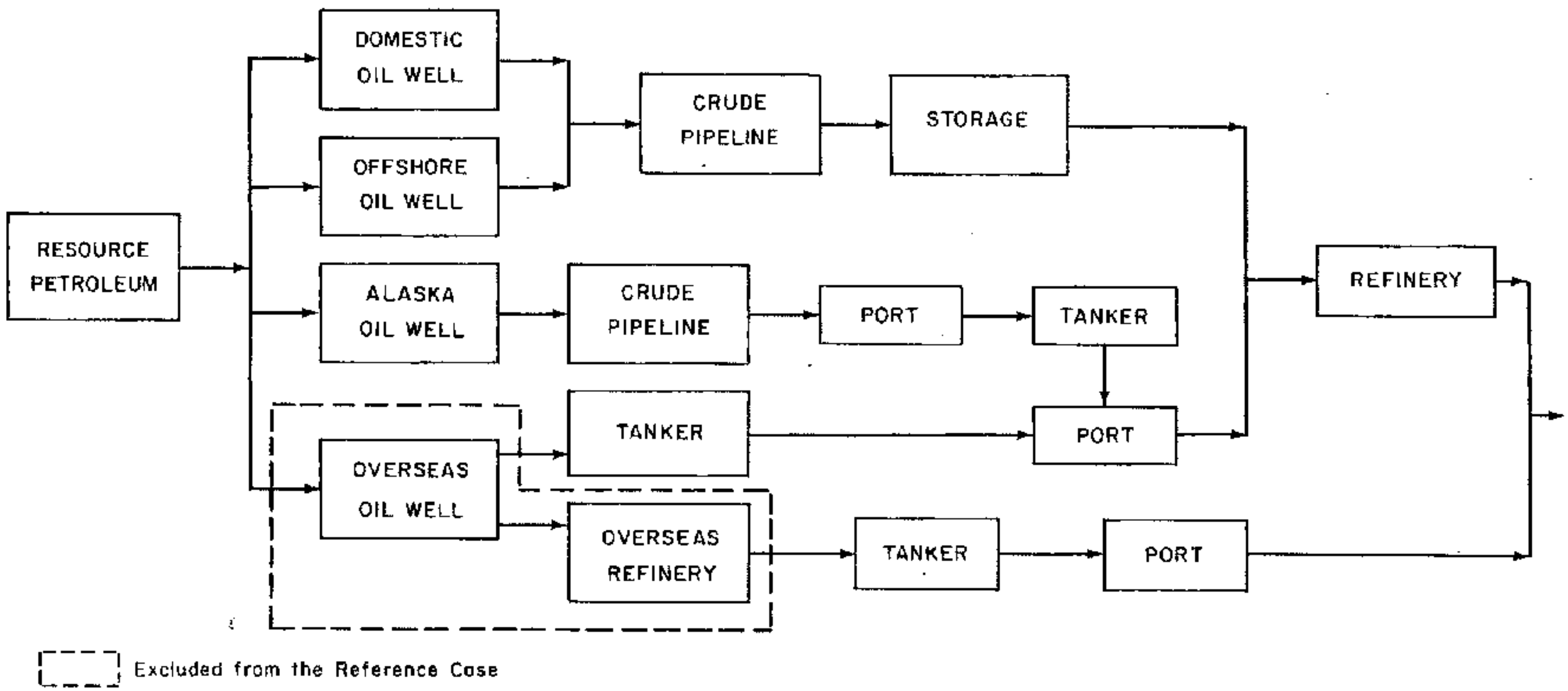

FIGURE 3-1. REFERENCE CASE PETROLEUM FUEL SYSTEM

Table 3-1

CONVENTIONAL DOMESTIC OIL SUPPLY PROJECTIONS

Supply Source	Annual Projections in Millions of Barrels per day (Quadrillion Btu per Year)				Cummulative Projections in Billions of Barrels
	1973	1974	1985	2000	1973-2000
Domestic Oil					
HG1*	11.0 (22)	10.5 (21)	15.9 (32)	20.9 (40)	160
HG2			15.9 (32)	17.7 (34)	150
HG3			13.4 (27)	13.4 (27)	127
TF1			14.9 (30)	17.9 (36)	150
TF2			14.4 (29)	17.4 (35)	140
ZEG			13.9 (28)	14.9 (30)	130
Oil Imports†					
HG1	6.0 (12)	6.0 (12)	6.5 (13)	12.0 (24)	
HG2			6.5 (13)	12.0 (24)	
HG3			11.5 (23)	18.5 (37)	
TF1			3.5 (7)	6.0 (12)	
TF2			6.0 (12)	8.0 (16)	
ZEG			4.5 (9)	4.5 (9)	

*HG1: Historical growth
HG2: High nuclear
HG3: High imports
TF1: Self-sufficiency (rapid coal development; cut imports in half)
TF2: Environmental controls (no synthetic fuels; offshore production forbidden in new areas until after 1985)
ZEG: Zero energy growth

†5.5 x 10^6 Btu/barrel

Source: Reference 1, Tables 3, 13, 24.

A problem with HG3 that had to be overcome for the reference case is that it contains no corresponding regional supply projections which are necessary for impact analysis. Accordingly, the relative regional oil supplies from Project Independence Oil Task Force Report[4] were applied to the aggregated domestic supply projection under HG3 to give regional supplies for our impact analysis requirements. Unfortunately, no regional supply projections to the year 2000 using the most recent USGS resource estimates have been made public, and the Project Independence projections were based on discredited resource estimates and were not extended past 1988. We have, however, assumed that the relative distribution among future producing regions given in Project Independence remain valid.

3. Summary of Conclusions

The major conclusions drawn from the reference case are the following:

- Under all of the EPP scenarios the demand for liquid fuels exceeds the HG3 domestic supply of conventional crude oil.
- Even with much higher crude oil prices, domestic petroleum supplies are extremely unlikely to meet domestic demand, even a demand as low as in ZEG.
- In the absence of synthetic crude oil, continued imports will be necessary unless demand for crude oil is reduced below the production level of HG3.
- Producing oil at the HG3 subscenario rate requires considerable increase in oil production from offshore and Alaska, and a massive tertiary recovery program onshore. Tertiary recovery offshore and in Alaska would also be needed. Yet domestic oil production from conventional sources will begin a long term decline before 2000.
- Capital investment in domestic crude oil exploration and production must increase to over $12 billion (1973 constant

dollars) annually by 2000 if production is to approximate that projected under HG3.

- Labor requirements for drilling will more than double between 1977 and 2000.
- Steel requirements for crude oil production will increase to over 3.5 million tons (3.2 billion kg) annually in 2000.
- The coastlines will be a major focus for the environmental impacts from offshore resource development and from oil import activity.
- Alaska will be a second major focus for the environmental impacts from developing oil resources in offshore areas and along the North Slope. A second TAPS is necessary for transporting North Slope oil under HG3.
- The potential for large scale environmental disaster resulting from a large oil spill along the coastal regions is significant. Based on an extrapolation of past spill statistics, perhaps 13 spills of over 100,000 barrels can be expected.

The significant implications of these conclusions are the following:

- Without synthetic fuels from coal and oil shale, imports of petroleum will grow to over 18 million barrels per day under demand levels of Historical Growth, and will grow to over 10 million barrels per day under Technical Fix, since these demand levels cannot be met by the HG3 supply.
- Supplying domestic oil at the HG3 rates will require considerable capital investment. Recent investment and supply projections made by Texaco and published in the Oil and Gas Journal[5] show 1990 crude oil production at about 13 million barrels per day with annual investment in crude oil and natural gas production at over $30 billion (1975 $). This production and investment projection supports our conclusion that the $12 billion required annually under HG3 is a lower limit to the investment necessary to bring about oil production at the HG3 levels.